# COMBINED CONGRESS



# ABSTRACTS

# KEYNOTE ABSTRACT

# HARVEST WEED SEED CONTROL AND THE WEED CONTROL REVOLUTION IN AUSTRALIAN CROPPING SYSTEMS

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The introduction of harvest weed seed control (HWSC) techniques into Australian grain production systems represented a novel weed control technology that could be routinely used at a unique weed control timing in cropping fields. The development of HWSC began in Australia in the 1990s and has been driven by widespread multipleherbicide resistance in weed populations, especially annual ryegrass (Lolium rigidum). During the 1990s, Australian grain growers and researchers began experimenting with techniques targeting annual ryegrass seeds and other important weed species during grain harvest. The opportunity to target weed seed production during harvest is created by high seed retention, where a significant proportion of the seed production of weed species is retained on mature plants at a height that enables collection by harvesters. Research identified high seed retention levels for annual ryegrass (85%), wild radish (99%), brome grass (77%), and wild oats (84%) at wheat crop maturity in Western Australia. This result established the high potential efficacy for HWSC and promoted the development of several systems that target these weed seeds during grain harvest. Chaff carts, bale direct, narrow windrow burning, impact mills, chaff lining and chaff tramlining systems have been developed to date. Australian growers routinely use them as an integral component of weed management programs. Testing of these systems during commercial harvest conditions has determined that when operating effectively, with suitable harvester setup, they are all capable of very high (>90%) weed seed control efficacy. The use of HWSC systems is an end-of-season weed control technique that targets inputs to the weed seed bank in a pre-emptive approach to restricting future weed emergence. Consequently, the impact of HWSC on subsequent weed populations is initially influenced by the size of the established seedbank. Focus field studies have determined that with very large seedbanks, it may take several years before the impact of HWSC can be observed on infield weed populations. These studies also determined that when HWSC is used as a component of a herbicide-based weed management program, weed populations will be markedly reduced (>90%) compared to when herbicides alone are relied on. Across the Australian wheatbelt, the use of HWSC has likely contributed to lower annual ryegrass population densities, thus mitigating the impacts of herbicide resistance and slowing further resistance evolution. In addition, these lower weed densities have enabled the introduction of site-specific weed control technologies and the opportunity to precisely target in-crop weeds with non-selective and alternative weed control techniques. With an awareness of the evolutionary potential of weed species to adapt to all forms of weed control, there is an understanding that HWSC treatments need to be used judiciously as a component of a weed management program in grain cropping systems to ensure their ongoing efficacy. The successful use of Australian-developed HWSC systems has attracted global interest, and there is now a considerable international research effort aimed at introducing this alternative weed control approach and timing into the world's major cropping systems.

# SOIL SCIENCE ABSTRACTS

# AGRICULTURAL ASSESSMENT WITHIN EIA REGULATIONS AND THEIR REAL-WORLD APPLICATION

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# INTRODUCTION

Agricultural assessments within Environmental Impact Assessments (EIA) in South Africa serve multiple purposes, including assisting farmers in evaluating soil and crop suitability and fulfilling legal requirements. These legal mandates include assessments for proposed cultivation on virgin soils under the Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) "CARA" and environmental authorizations for development projects under the National Environmental Management Act, 1998 (Act No. 107 of 1998) "NEMA". This paper primarily explores the role of agricultural assessments within the context of environmental authorizations, with the current legislation and the pitfalls experienced.

Agricultural assessments are a mandatory component of Environmental Authorizations, governed by NEMA and the Environmental Impact Assessment (EIA) Regulations of 2014. In accordance with GN960 of 2019 and Section 24(5)(a) of NEMA, an Environmental Screening Report (ESR) is generated using the National Web-based Screening Tool for authorization applications. The ESR categorizes the agricultural sensitivity of the area as Low, Medium, High, or Very high sensitive within the Agricultural theme. Subsequently, the requirement for a compliance statement or an Agro-Ecosystem report is determined based on sensitivity, and these reports adhere to the specialist assessment protocol and minimum report content standards for assessing environmental impacts on agricultural resources (GN320 of 2020). Therefore, screening is important as it determines the detail of the assessment.

#### DISCUSSION

The discussion delves into the accuracy of the screening tool, identifying areas where it excels and where certain land types are inaccurately classified. Case studies various Cb landtypes found in the Eastern Cape and Western Cape coastline will be used as examples for discussing the difficulties. Much of the screening and authorization processes are reliant on land capability assessments. Differing land capability classifications, including the Government land capability standard (Department of Agriculture, Forestry and Fisheries, 2017), which forms the basis of the screening tool, can be incongruent with alternative classifications. Therefore, proposals for better alignment and evaluation of Land capability are presented.

# CONCLUSIONS

This presentation offers insights into the current landscape of agricultural assessments, shedding light on the practical challenges faced by consultants in their execution. Furthermore, it encourages a discourse on the various approaches employed by both consultants and regulatory authorities. By doing so, this presentation aims to contribute to the ongoing conversation surrounding agricultural assessments with the EIA process.

Keywords: Agricultural Assessments, Land capability, Environmental authorizations.

# EVALUATING THE SOIL HEALTH STATUS OF CONSERVATION AND REGENERATIVE AGRICULTURE ACROSS MULTIPLE ECOTOPES

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#### INTRODUCTION

Conventional agriculture degrades soil health and fertility through excessive synthetic fertiliser use, intensive tillage, and monoculture crop production (Sanaullah et al. 2020). Transitioning to conservation (CA) and regenerative agriculture (RA) is advised to mitigate and reverse this degradation (Newton et al. 2020). Conservation agriculture practices include minimal tillage, crop diversification, and permanent soil cover, while RA adds integration of cover crops and livestock grazing. However, information on these systems' potential soil health and fertility benefits remains limited, especially considering South Africa's many ecotopes. Therefore, this study aimed to evaluate the physical, chemical, and biological properties of soil health under the implementation of CA and RA across multiple ecotopes. Furthermore, singular soil properties were evaluated as affordable proxy indicators of soil health status.

## MATERIAL AND METHODS

On-farm CA and RA trials were replicated in the Maluti (Marquard) and Mpumalanga Highveld (Kinross and Standerton) regions and monitored during the 2020/2021, 2021/22 and 2022/2023 summer growing seasons. Soil sampling occurred approximately 100 days after planting. Collected samples were sent to Ward Laboratories (USA) to conduct the Soil Health Tool analysis. Additional parameters including soil texture and permanganate oxidizable carbon (POXC) were tested at the North-West University. Soil health parameters were used to generate principal coordinate analysis (PCoA) plots and evaluate the relationship between ecotopes, intervals, agricultural systems, and soil health parameters. Furthermore, distance-based linear modelling was used to detect singular indicators of soil health status.

#### **RESULTS AND DISCUSSION**

The PCoA plots showed that the ecotopes formed clusters, indicating distinctive characteristics related to the soil health of each ecotope (Hensley et al. 2019). Uncultivated soils plotted separate from the clusters for all three intervals. In the context of soil health, apart from Hendrik Odendal (HO), which showed a marked contrast to Nant Yzel (NY) and New Farm (NF), no significant differences have been observed between treatments across the three intervals. Distance-based linear models, using abiotic and biotic parameters as predictive variables, revealed that organic matter has the greatest potential as a soil health indicator. Other variables including organic carbon to nitrogen ratio and microbially active carbon were also identified as potential proxy indicators of soil health.

#### CONCLUSIONS

The results confirmed that the studied soils remained mostly degraded under the investigated agricultural systems. This suggests that soil health may take multiple years to restore after transitioning to CA and RA. Fortunately, alternative and more affordable indicators such as organic matter content can be used to monitor soil health restoration.

# EVALUATION OF SUNFLOWER, SOYBEANS AND MAIZE CROP ROTATION WITH MONO-CROPPING

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# INTRODUCTION

Research on the in-field rainwater harvesting (IRWH) technique with respect to crop rotation has not been conducted previously and can help in providing answers to resource-poor farmers who can rotate oilseed crops to get maximum results in terms of crop yields. The main objective of the study was to conduct a crop rotation experiment with sunflower, soybean and maize within the IRWH technique and also compare yields with mono-cropping using conventional tillage (CON).

# MATERIALS AND METHODS

An on-station field experiment was conducted at the Glen Agricultural Institute, on the Glen/Bonheim ecotope (28°57` S, 26°20` E). The experiment was conducted over a period of five growing seasons (2006/07 – 2010/11). Maize (cultivar PHB33A1B; 22000 plants ha-1), sunflower (cultivar PAN7351; 33333 plants ha-1) and soybeans (cultivar PAN 421R; 133333 plants ha-1) were planted as indicator crops in mono-cropping and rotation within the IRWH system and CON. Soil water content (SWC) was monitor at depths of 150, 450, 750 and 1050 mm during the fallow and growing seasons with a neutron water meter. Standard agronomic practices were followed. Biomass, grain yield and rainwater productivity (RWP), were measured and calculated following standard procedures.

# **RESULTS AND DISCUSSION**

IRWH treatments produced significantly higher biomass yields at flowering, seed and biomass yields at harvest and RWP values compared to CON. When comparing mono-cropping (CON vs. IRWH) results indicated that IRWH mono-cropping increased biomass at flowering on average by 65%, 144% and 140% compared to CON mono-cropping for maize, sunflower and soybeans, respectively, during the experimental period. The IRWH mono-cropping also increased maize, sunflower and soybean yields on average with 114%, 149% and 194%, respectively, compared to CON mono-cropping. IRWH mono-cropping produced on average with maize, sunflower and soybean for every mm of rain that occurred 2.79, 1.2 and 2.01 kg more grain yield per hectare, respectively compared to CON mono-cropping. Reasons for this phenomenon were due to the ability of IRWH to stop ex-field runoff completely, to minimize evaporation from the soil surface and to harvest additional rainwater from the untilled 2 m runoff area and therefore maintain higher SWC compared to CON.

# CONCLUSIONS

Soybean is a suitable crop to plant in rotation with maize and sunflower to increase maize and sunflower yields. However, soybeans planted in mono-cropping (1267 kg ha-1) outperformed the soybeans that were planted in rotation with maize (1238 kg ha-1) or sunflower (1014 kg ha-1). Maize is the most productive crop on the Glen/Bonheim ecotope. Average RWP values for maize, soybean and sunflower were 3.86, 2.05 and 2.01 kg ha-1 mm-1, respectively.

KEYWORDS: Conventional tillage, crop rotation, in-field rainwater harvesting, mono-cropping

# ACKNOWLEDGEMENTS

Agricultural Research Council for funding and Free State Department of Agriculture and Rural Development for supplying agricultural land.

# ESTIMATION OF SOIL EROSION USING GIS AND REMOTE SENSING INTEGRATION WITH RUSLE MODEL IN UMGENI CATCHMENT, SOUTH AFRICA.

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#### INTRODUCTION

Soil erosion is a major problem that causes significant damage worldwide, leading to loss of arable land and clogging of waterways. The Umgeni catchment area is particularly susceptible to soil erosion due to heavy rains and floods. One way to estimate soil erosion and sediment yield is through modeling, which provides a quantitative and consistent approach. The aim of this research is to use the Revised Universal Soil Loss Equation (RUSLE) model in combination with remote sensing and GIS methods to assess the risk of erosion in the Umgeni catchment area.

# MATERIALS AND METHODS

The Revised Universal Soil Loss Equation (RUSLE) model was utilized in conjunction with GIS and remote sensing techniques in the region of Umgeni. To identify areas at risk of soil erosion, rainfall, land use, land cover maps, and the SRTM digital elevation model (DEM) were considered. Using a raster calculator within a GIS environment, the average annual soil loss was determined by multiplying R, K, LS, C, and P factors.

#### **RESULTS AND DISCUSSION**

. Accordingly, the study basin was categorized into six soil loss severity classes in terms of t ha<sup>-1</sup>year<sup>-1</sup>: Low (0-7) Moderate (8-15), high (16-25), very high (26-45), severe (46-0), very severe (>60) risk classes. The section of the basin's lower plain has been discovered to be least affected by soil loss with mostly below 7 t ha<sup>-1</sup>year<sup>-1</sup>. The higher streams of the Umgeni basin are more impacted by soil erosion than the lower basin sections, mostly due to topography and topographic factors with over 60 t ha<sup>-1</sup>year<sup>-1</sup>, according to the results of the RUSLE model. The soil erosion potential map's regional distribution indicates that the threat of soil loss in Umgeni fluctuates with changes in topography.

# CONCLUSIONS

In order to identify the soil erosion-prone zones for conservation planning in the Umugeni Catchment, soil loss has been assessed at the pixel level using the RUSLE model. The areas around the Umugeni River in the valley showed the severe soil erosion risk above 45 t/ha/year than the other parts of the catchment. The rangelands are relatively less affected by soil erosion. The RUSLE model estimates annual soil losses in Umugeni Catchment to be 5,575,892.746 t/yr. The results of the study area can be helpful to the policy makers in Umgeni to implement effective soil management and conservation practices in the basin area.

KEYWORDS: Conservation, GIS and Remote Sensing, RUSLE, Soil Erosion, Umgeni catchment.

#### ACKNOWLEDGEMENTS

Centre for Water Resources Research for providing data and information needed.

# TERMITE MOUNDS: ENDANGERED CARBON PUMPS OF THE SEMI-ARID WEST COAST REGION?

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# INTRODUCTION

Dryland ecosystems, despite having lower soil organic carbon than their more humid counterparts, cover over 40% of the global land surface and thus have an important impact on CO<sub>2</sub> drawdown or release. Termites are dominant dryland macroinvertebrate decomposers (Jouquet et al., 2011) but their role in carbon dynamics and storage is lacking. This is particularly important along the west coast region of South Africa where large mounds associated with the southern harvester termite (*Microhodotermes viator*) occupy up to 27% of the land surface. These mounds are enriched in calcite despite the surrounding soils being non-calcareous, suggesting biogeochemical processes are involved in calcite formation. This study determined the soil organic (SOC) and inorganic C (SIC) contents, distribution and stocks of mound soils in three rainfall regions along the west coast to inform C stock modelling as well as the potential carbon-loss impacts of land use change.

#### MATERIAL AND METHODS

Large trenches were excavated through three mounds in Piketberg (m.a.p 300-400 mm), Klawer (m.a.p 100-200 mm) and Buffels River (m.a.p <100 mm). Trench walls were grid sampled and analysed for bulk density, organic (Walkley-Black) and inorganic C (Combustion method) content. Carbon stocks were calculated using C content, bulk density and coarse fragment content.

#### **RESULTS AND DISCUSSION**

Mound soils had significantly higher SOC and SIC compared to surrounding soils. Total C was strongly correlated ( $\rho$ >0.9; p<0.001) with SIC in the arid mounds and SOC ( $\rho$ >0.75; p<0.001) in the higher rainfall mound. For all mounds, SOC was highest in topsoils with a second clear peak in subsoils (> 1 m) that was associated with termite channels and burrows. Total C stocks for the intermediate rainfall mound (Klawer) were estimated at 14.6 tons per mound, with 1.1 tons SOC. Subsoils contributed substantially (36-41%) to the total C stock of mound soils and although mounds only occupy 27% of the total land area, they contribute 44% of the total SOC stock to a depth of 80 cm.

# CONCLUSIONS

This study highlights the disproportionate contribution termite mounds make to carbon stocks of the west coast and demonstrates the importance of deep soil carbon for C modelling. Termite activity should be recognized as a major contributor to C stock variability both laterally and at depth and accounted in land-use change.

# REFERENCES

Jouquet, P., Traoré, S., Choosai, C., Hartmann, C., & Bignell, D. (2011). Influence of termites on ecosystem functioning. Ecosystem services provided by termites. European Journal of Soil Biology, 47(4), 215–222.

Keywords: carbon sequestration, heuweltjies, isopteric soils

# CREATING A NEAR-INFRARED SPECTROSCOPY CALIBRATION ALGORITHM FOR SOIL ORGANIC CARBON CONTENT FOR SOUTH AFRICA

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#### INTRODUCTION

Accurate quantification of soil organic carbon (SOC) content is essential in agriculture, and conventional methods, such as Walkley-Black wet-oxidation (WB) method or total dry combustion (TDC) (also called LECO) method, are typically employed for this purpose. Alternatively, the use of infrared (IR) light reflectance spectroscopy as an advanced technology has shown promise as a rapid and cost-effective alternative for SOC conventional analysis.

The study assessed the feasibility of using NIR spectrometers as field instruments for possible development of accurate SOC calibration algorithms for South Africa on multiple scales.

# MATERIAL AND METHODS

Soil samples were collected at field, regional, and national scales. For the field scale, two farms at Ottosdal and Vrede, that practice regenerative agriculture were selected, while for the regional scale, four catchments at UMngeni, Sabie, Olifants and Tsitsa, with variable SOC content were selected. For the national scale, the samples from the field scale and regional scale were combined. The soil samples were scanned using a NIR spectrometer in-field and afterwards at a laboratory prepared state. The SOC content was determined using the TDC method. Combining spectral data with soil laboratory data, various machine learning (ML) models were employed, including Partial Least Squares Regression (PLSR), Random Forest (RF), Cubist, Artificial Neural Networks (ANN), and Support Vector Machines (SVM). Spectral pre-processing, such as outlier removal also took place. Key statistical parameters, including RMSE, r<sup>2</sup>, R<sup>2</sup>, RPD, and RPIQ, were used for model validation and assessment of calibration algorithm accuracy.

# **RESULTS AND DISCUSSION**

For the field scale, the dry Ottosdal dataset exhibited the most accurate performance or validation (RMSE = 0.04%, RPIQ = 2.5), while the Vrede farm showed poorer overall performance due to higher SOC variability influenced by soil texture, land management, and environmental conditions. For the regional scale, the wet Tsitsa dataset presented the best performance (RMSE = 0.1, RPIQ = 10.23), while on the national scale, the dry national dataset emerged as the most accurate calibration algorithm for SOC content (RMSE = 0.11, RPIQ = 7.87). However, the national dataset was limited to samples with  $\leq$  5% SOC.

#### CONCLUSIONS

The study successfully achieved its aim of creating NIR calibration algorithms for SOC content at multiple scales. The dry Ottosdal dataset was accurately calibrated at field scale and NIR spectroscopy could be used for further analysis at this farm, while on regional scale, the wet Tsitsa dataset also showed promise for further use of NIR spectroscopy. While NIR spectrometers offer advantages, further exploration is needed to fully utilize them as field instruments, with sample preparation and drying essential for improved calibration algorithm performance. Future research could focus on expanding the sample size and refining algorithms with additional environmental and management variables.

Keywords: carbon sequestration, greenhouse gas emissions, regenerative agriculture, soil inorganic carbon.

# INVESTIGATION OF LIMING AND NITRIFICATION SUPPRESSION POTENTIAL OF LOCAL BIOCHARS

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#### Introduction

Soil acidification is a natural process which is accelerated by agricultural practices such as the use of ammonium fertilizers which promote soil nitrification. Previous studies have shown that the application of biochars (pyrolyzed biomass) not only limes the soil but may also suppress nitrification (Teutscherova et al. 2017; Shi et al. 2019). The aim of this study was to determine the liming and nitrification suppression effectiveness of local pine wood, black wattle wood, macadamia shell biochars and pine wood fly ash containing 30% black carbon, in comparison to pure lime and a control (no lime, ash or biochar).

#### Materials and methods

A 30-day lime incubation study was conducted with an acid sandy soil ( $pH_{(H2O)}$  4.8) with or without the addition of ammonium sulphate (200 mg kg<sup>-1</sup>). Commercial biochars made from pine wood, black wattle wood, macadamia shell, as well as pine wood fly ash and pure calcium carbonate were used to achieve a  $pH_{(H2O)}$  of 6.5. The soils were incubated at 70-80% field water capacity at room temperature. The  $pH_{(H2O)}$  and  $pH_{(KCI)}$  was measured using a 1:2.5 soil to solution ratio, EC was measured using distilled water, exchangeable acidity was determined by titration using NaOH, and ammonium and nitrate ions were extracted using 2 M KCI and measured with an automated UV spectrophotometer.

#### **Results and discussion**

At 30 days, the control showed little or no nitrification due to low  $pH_{(H2O)}$  (4.6). All biochar and lime treatments significantly increased soil pH, with the biochars resulting in significantly higher  $pH_{(H2O)}$  values (5.4-5.9) than lime (5.0). The lime and fly-ash treatments resulted in 73% and 48% of ammonium being nitrified, respectively. While the biochars resulted only in 13-17% of ammonium being nitrified, despite increasing soil pH which promotes nitrification. Extent of nitrification was correlated (R = 0.73, p < 0.05) with initial pH of the biochar. The biochars were found to immobilize 17-28% of total mineral N, which likely also contributed to reduced nitrification. While lime increased total mineral N by 23% over the 30-day period. Due to enhanced nitrification, the lime treatment resulted in lower pH and higher exchangeable acidity than the biochar treatments after 30 days.

#### Conclusions

All commercial biochars used in this study effectively buffered the soil pH and reduced nitrification in comparison to calcitic lime and thus show promise for mitigating acidification due to ammonium fertilizers.

## References

Shi R, Ni N, Nkoh Nkoh J, Li J, Xu R, Qian W. 2019. Beneficial dual role of biochars in inhibiting soil acidification resulting from nitrification. Chemosphere 234: 43–51.

Teutscherova N, Vazquez E, Masaguer A, Navas M, Scow KM, Schmidt R, Benito M. 2017. Comparison of lime- and biochar-mediated pH changes in nitrification and ammonia oxidizers in degraded acid soil. Biology and Fertility of Soils 53: 811–821.

Keywords: Biochar, Lime, Nitrification, Soil acidity

# THE USE OF DIGITAL SOIL MAPPING (DSM) TO IMPROVE CONVENTIONAL SOIL MAPPING FOR PRECISION AGRICULTURE IN SOUTH AFRICA.

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#### INTRODUCTION

In South Africa, soil mapping for precision agriculture (PA) is still based on doing soil classification and soil sampling on a grid system to gather the soil information needed for decision making and management. The density of these grid surveys ranges from one observation per hectare to one observation per two hectares. With this method variability on a smaller scale is missed. The fixed grid approach lacks the data to accurately predict all soil characteristics, as the interpolation process is very sensitive to the number of samples, the distance between samples and the spatial variation of the soil property concerned. Machine learning based digital soil mapping (DSM) can be used to predict the soil variability and characteristics within the field at farm scale. The aim of this study was to test the use of DSM methods to improve conventional soil mapping for precision agriculture in South Africa.

# MATERIAL AND METHODS

The study was located on 104 hectares of arable land in the Free State province of South Africa. The data used includes the topsoil properties and soil classification data on a one-hectare grid, proximal sensed gamma-ray data and terrain and spectral data from Sentinel satellite images. Independent validation points were selected with conditioned Latin hypercube sampling to represent 25% of the total points. DSM methods were used to map the soil type and soil properties using 33%, 66% and 100% of the remaining datapoints as training data. The Multinomial Logistic Regression model was used for soil type and the Random Forest and Cubist models for soil property mapping.

#### **RESULTS AND DISCUSSION**

The best soil type mapping was achieved using 66% of the training data with an accuracy of 66% and a Kappa value of 0.5. The Cubist model best predicted the percentage clay with 100% of the training data with a Lin's concordance correlation coefficient (CCC) of 0.73. The Random Forest model best predicted Ca and Mg with 100% of the training data, Ca have a CCC of 0.70 and Mg a CCC of 0.82. The other soil properties yield CCC values below 0.5.

# CONCLUSIONS

DSM does show potential to be used in large scale soil mapping needed for PA, but more work needs to be done on the required covariates, as well as ideal soil sampling placement.

# REFERENCES

Keywords: Digital soil mapping, precision agriculture, proximal sensing, soil maps, soil properties.

# EFFECT OF GYPSUM SOURCE AND FORM ON SOIL CHEMICAL PROPERTIES AND EARLY CANOLA (*BRASSICA NAPUS*) GROWTH IN AN ACIDIC SANDY SOIL.

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# INTRODUCTION

In acidic, sandy soils calcium (Ca) and sulfur (S) deficiencies are a common phenomenon which can be amended by gypsum. Various mined and by-product gypsum sources, as well as new products such as granular gypsum, are available in South Africa. Most local studies focused on the effect of a single gypsum source on crop response, often on highly weathered soils with substantial amounts of rainfall. The objectives of this study were to investigate the effect of different sources and forms of gypsum on the chemical properties of an acid, sandy soil and assess their effects on canola growth and nutrient uptake.

# MATERIALS AND METHODS

In a greenhouse pot trial, six gypsum products (FGD gypsum, mine water gypsum, phosphogypsum, granulated phosphogypsum, mined recrystallised gypsum and mined gypsum) were surfaced applied to an acidic, sandy soil (5.1% clay) to raise soil Ca levels to 400 mg kg<sup>-1</sup>. Canola (Blazer TT cultivar) plants were grown in the pots and harvested after 7 weeks. Shoot and root biomass, foliar nutrient content soil chemical properties were then determined.

# **RESULTS AND DISCUSSION**

All gypsums increased soil pH and decreased acid saturation in the top 50 mm, but only granulated phosphogypsum and mined recrystallised gypsum ameliorated acidity below 50 mm. This also resulted in larger root biomasses in these treatments, indicating that they were superior in terms of correcting acidity compared to the other gypsums in the short-term. The differences in pH increase achieved by the gypsum sources could not be explained by gypsum properties such as particle size or origin of the gypsum, however the granulated gypsum contained approximately 1% microfine CaCO<sub>3</sub> as a binding agent, which helps explain its superior acid neutralising capacity. There were no differences in Canola shoot Ca and S contents between the gypsum treatments, and all were higher than the control. All gypsum treatments resulted in higher dry shoot and root biomass compared to the control, except for phosphogypsum. The poorer performance of phosphogypsum can be attributed to the weaker alleviating effect on soil acidity.

# CONCLUSIONS

In the short-term, granulated phosphogypsum and mined recrystallised gypsum were superior in terms of correcting acidity and improving root growth compared to the other gypsums, but all gypsum sources adequately addressed Canola Ca and S deficiency.

Keywords: soil chemistry; phosphogypsum; pelletised gypsum; canola

# COMPARISON OF THE EFFECTIVENESS OF MINED AND BY-PRODUCT SOUTH AFRICAN GYPSUM MATERIALS FOR SOIL SODICITY REMEDIATION

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#### INTRODUCTION

Various mined and by-product gypsum sources are available in South Africa. Studies evaluating the effectiveness of South African gypsum sources are scarce or outdated (Frenkel and Fey 1989), as new products, such as pelletized and liquid gypsums, have been introduced. The efficacy of calcium (Ca) nitrate and micro-fine (MF) calcitic limes in comparison to gypsums has also never been evaluated. The aim of this study was to compare the effectiveness of mined and by-product gypsums and other Ca sources in terms of soil sodicity remediation and saturated hydraulic conductivity (K<sub>sat</sub>) improvement.

#### MATERIALS AND METHODS

In a controlled laboratory study, 12 mined and by-product gypsums sources, MF calcitic limes and calcium nitrate were surface-applied to a sodic, sandy loam soil to achieve exchangeable sodium percentage (ESP) of 5% to a depth of 10 cm. The soils received 300 mm simulated rainfall over 6 weeks and then soil chemical properties and K<sub>sat</sub> were determined.

# **RESULTS AND DISCUSSION**

All gypsum sources significantly reduced the soil ESP (< 15%) compared to the control. Finer by-product gypsum sources (liquid, flue gas desulphurisation (FGD) and phosphogypsum) exhibited faster dissolution rates and superior performance in correcting soil ESP and pH compared to Class A mined gypsums. Only the liquid, phospho-, FGD gypsums and calcium nitrate significantly improved soil K<sub>sat</sub>. There was no significant difference in the effectiveness of pelletized phosphogypsum and non-pelletized phosphogypsum. The MF calcitic limes had no effect on the sodic soil properties due to low solubility.

# CONCLUSIONS

When gypsum application is adjusted for Ca purity, its effectiveness in mitigating soil sodicity in the short term largely depends on particle size distribution. MF limes are not effective to remediate sodicity in the short term. These findings can assist producers and consultants when selecting gypsum or Ca sources for sodic soil remediation.

#### REFERENCES

Frenkel H, Fey M.V. 1989. Rate of dissolution of gypsum from different sources and its effect on water infiltration of soil. *South African Journal of Plant and Soil* 6.3: 191-196.

**Keywords**: soil chemistry; ultrafine gypsum; phosphogypsum; pelletised gypsum; liquid gypsum; pelletised lime; saturated hydraulic conductivity

# SHORT-TERM EFFECTS OF CONSERVATION AGRICULTURE ON SOIL HEALTH DYNAMICS: A MULTI-YEAR STUDY IN OTTOSDAL, SOUTH AFRICA

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# INTRODUCTION

Conservation agriculture (CA) is a sustainable farming approach that aims to improve soil and environmental health by implementing practices including minimal soil disturbance, crop rotation, and permanent soil cover. While the long-term benefits of CA are well-established, there is limited research on its short-term effects on soil health. Therefore, this study investigated the short-term dynamics of soil physicochemical and biological constituents following the implementation of CA in the Ottosdal region of South Africa.

# MATERIAL AND METHODS

The study site was a multi-year research trial with two crop production systems: maize monoculture and CA (rotation of maize, sunflower, and cover crops) and an uncultivated grassland (reference system). Soil samples were collected during three consecutive summer growing seasons and analysed for aggregate stability, soil texture, nutrient availability, organic matter (OM) content, nematode-based indices of soil ecosystem status, and microbial community structure [as indicated by phospholipid fatty acids (PLFAs)]. Statistical methods were used to assess the effects of crop production system, crop sequence, and sampling time (year) on soil health parameters.

# **RESULTS AND DISCUSSION**

The study revealed significant soil health changes between the cultivated and uncultivated systems with total available phosphorus, OM content, and PLFAs as the key indicators, showing the potential of these parameters to inform soil health dynamics. Crop sequence also influenced these dynamics with especially the cover crop-maize sequence revealing improvement in soil health. Furthermore, a temporal shift from abiotic to biotic factors was observed with biotic factors playing an increasingly important role as the main differentiators between the studied systems. In the first year of the study, abiotic factors such as total available phosphorus and nitrogen, soil structure, silt and sand were the primary drivers of soil health differences. However, by the third year, biotic factors such OM content, PLFAs, and nematode-based indices became increasingly important. The shift from abiotic to biotic factors as primary system differentiators over time highlights the importance of soil biology in CA systems.

# CONCLUSIONS

The findings of this study suggest that CA can improve soil health in the short term, but that physical, chemical, and biological properties are affected differently over a temporal scale. Further research is needed to fully understand the mechanisms involved in the short-term improvement of soil health under CA.

Keywords: ecosystem functioning, microbial community structure, nematode-based indices, sustainable agriculture

# STRATEGICALLY INTEGRATING LEGUMES IN MAIZE CROPPING SYSTEMS

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## INTRODUCTION

Smallholder farmers in sub-Saharan Africa integrate legumes into maize-based cropping systems to increase production of diverse nutrient-dense grains, improve soil fertility and maximize on land and water use efficiency. Inclusion of legumes in cropping cycles is essential for sustainable management of farming systems and reducing the nitrogen (N) fertilizer requirement especially for maize production.

#### MATERIAL AND METHODS

A study was conducted for three seasons of 2018, 2019 and 2020 to evaluate the adaptability of drought tolerant maize genotypes to lowland and mid-altitude ecologies in rotation (maize, cowpea and soybean), and intercropping (maize:cowpea) systems with legume focusing on N utilization in Mozambique. Mineral N application in the intercropping systems was at 30 kg N ha<sup>-1</sup> on cowpea and 100 kg N ha<sup>-1</sup> on Maize while only respective inoculants were applied to legumes in the crop rotation system. Three rotational cycles and seasonal intercropping benefits of maize following soybean and cowpea were quantified on land equivalent ratio (LER).

# **RESULTS AND DISCUSSION**

Yield trends, LERs and Nitrogen Use Efficiency (NUE) for the cereal legume integration were also analyzed for the cropping systems. Crop yield was distinct with seasonal rotations as well as yearly intercropping. The intercropping system in lowland altitude ecologies of Manica and Nampula provinces for 2018 season had comparable results. Application of 100 kg N ha<sup>-1</sup> to pure stand of maize with a yield of 1677 kg ha<sup>-1</sup> did not result in statistically different yield gain from maize with no inputs (1954 kg ha<sup>-1</sup>) although maize benefited more from the 1:1 (maize:cowpea) arrangement with over 2824 kg ha<sup>-1</sup> yield and an intercropping LER of 1.7 while cowpea productivity was highest (769 kg ha<sup>-1</sup>) with the 2:1 maize:cowpea system with no additional inputs. The value of residual N was more evident in mid altitude ecologies of Zambezia province. The yield of maize in 2019 following soybean at 4683 kg ha<sup>-1</sup> or cowpea at 3698 kg ha<sup>-1</sup> was statistically higher than mono-cropping system at 1848 kg ha<sup>-1</sup>.

#### CONCLUSIONS

The magnitude of maize productivity was higher immediately after a legume. In both farming systems, crops interaction with resources and time increased resulting in higher yield and better NUE signifying the advantage of integrating legume and cereals production that result in a higher LER.

### REFERENCES

Chikowo R, Chirwa R, Snapp S. 2022. Cereal–legume cropping systems for enhanced productivity food security and resilience. Sustainable Agricultural Intensification; A Handbook of Practice. East South. Africa, 33–47. https://doi.org/10.1079/9781800621602.0003.

Moore KJ, Dixon PM. 2015. Analysis of combined experiments revisited. Agronomy Journal 107: 2. 763–771. http://dx.doi.org/doi:10.2134/agronj13.0485.

Vanlauwe B, Kihara J, Chivenge P, Pypers P, Coe R, Six J. 2011. Agronomic use efficiency of N fertilizer in maize-based systems in sub-Saharan Africa within the context of integrated soil fertility management. Plant Soil 339: 1. 35–50. https://doi.org/10.1007/s11104-010-0462-7.

Thierfelder C, Cheesman S, Rusinamhodzi L. 2012. A comparative analysis of conservation agriculture systems: Benefits and challenges of rotations and intercropping in Zimbabwe. Field Crop Research 137: pp. 237–250. https://doi.org/10.1016/j.fcr.2012.08.017.

Keywords: Cowpea, Intercropping, Land use efficiency, Soybean, Nitrogen, Rotation, Yield.

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# CREATION OF NEAR-INFRARED SPECTROSCOPY CALIBRATION ALGORITHMS FOR SOIL WATER RELATED PROPERTIES

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# INTRODUCTION

Water is arguably the most important human resource, and fresh water is becoming increasingly scarce. Conducting accurate measurements of soil water content is paramount in making productive decisions in water management. The problem, however, is that traditional methods of water content measurement in soils, are time-consuming, labour intensive, or immobile. Near infrared spectroscopy (NIRS) can provide a solution to the need for a rapid, accurate, and cost-effective method in measuring soil moisture content. A calibration algorithm is however needed by NIRS in order to identify observations. There are unfortunately no such freely available calibration algorithms for soil water content measurement for South African soils. Additionally, the accuracy of such calibration algorithms was determined at catchment and regional scale and compared with the best freely available international calibration algorithm (OSSL).

# MATERIAL AND METHODS

Two hundred and thirteen undisturbed soil core samples were taken at predetermined locations across five catchment areas of South Africa. The samples were scanned with a handheld NeoSpectra NIR scanner at different known moisture contents. The dataset was split into a training and validation dataset. Calibration algorithms were then created using the training dataset. The machine learning algorithms cubist, random forest and partial least squares were used, together with several pre-processing methods. Validation was conducted using the independent validation dataset.

# **RESULTS AND DISCUSSION**

For the regional dataset for volumetric water content, the best results were obtained by using a combination of Savitzky-Golay pre-processing and Random Forest, with an RMSE of 6.9%, R<sup>2</sup> of 0.62, bias of 0.75, Concordance correlation coefficient (rhoC) of 0.75, and RPIQ of 1.8. Algorithms for Dry Bulk Density (DBD) were also created. The best DBD results were a combination of removed outliers, Savitzky-Golay pre-processing with a Cubist model provided the best results with an RMSE of 0.16 g/cm<sup>3</sup>, an R<sup>2</sup> of 0.72, a bias value of 0.01, an rhoC of 0.82, and an RPIQ of 2.31. The results were constant in that each catchment calibration algorithms outperformed the regional algorithm, which in turn outperformed the international OSSL model.

# CONCLUSIONS

The results show that it is possible to calibrate the NIR to measure both volumetric water content and dry bulk density, and that local models outperformed regional models which outperformed international models. This shows the critical value of local calibration of NIRS to enable its usage in South Africa.

Keywords: Bulk density, Cubist, OSSL, Volumetric water content, NIRS

# AFLATOXINS IN SOIL ECOSYSTEMS: DEFINING ITS FATE AND TOXICOLOGICAL RISK TO SOIL ORGANISMS

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#### INTRODUCTION

Aflatoxins are well-known fungal toxins produced by specific strains of soil fungi (*Aspergillus sp*). These toxins are mainly found in soil and food storage systems. Due to its carcinogenic nature, extensive research has been done on the impact of post-harvest aflatoxin contamination, with little consideration at pre-harvest stages. Aflatoxin contamination in the production and food industry remains a challenge with recent studies suggesting that it might become a bigger problem in the future. However, limited information is available about its toxicological consequences in the soil ecosystem. This research aimed to define the risk of aflatoxin contamination in soil ecosystems by investigating how environmental variables altered by changing temperatures and soil moisture conditions might influence its occurrence and toxicity.

# MATERIAL AND METHODS

Laboratory toxicity tests were conducted using a standardised soil medium (OECD soil) at different combinations of air temperature (21 and 26 °C) and soil moisture (30 and 50% water-holding capacity). The soil contained 70% sand, 20% kaolinite clay and 10% organic matter (sphagnum peat). Adult earthworms (*Eisenia andrei*) were used as bioindicator species in the soil and established biomarkers were selected, including growth, reproductive success and genotoxicity. Additionally, the biological control of aflatoxins by earthworms was investigated.

# **RESULTS AND DISCUSSION**

Negligible effects were observed on earthworm survival, growth, and reproduction at concentrations between  $10 - 100 \mu g/kg$ , but a concentration-dependent increase in DNA damage was observed. Temperature and moisture altered the exposure effect outcomes of aflatoxin in soil. Drought conditions (30% WHC) negatively affected earthworm reproductive and genetic status. Aflatoxin forms a conjugate with the soil-binding sites in soil with high organic and clay content, making it resistant to natural microbial degradation and may result in aflatoxin persisting in the soil for much longer. Aflatoxin degradation increased in the presence of earthworms and increased temperatures and was attributed to the earthworm activity and excretions that stimulated higher microbial activity.

#### CONCLUSIONS

This study highlighted the possible risk of environmentally relevant aflatoxin levels to the functional ability of important soil organisms. It indicated the influence of changes in temperature and moisture on the exposure effect outcomes of aflatoxin in soil, highlighting the importance of reviewing standard toxicity protocols for laboratory studies to include wider environmental conditions during ecotoxicological studies. Many aspects of aflatoxin degradation and exposure in soil are still unknown and remain an important area of research for soil health and productivity.

Keywords: aflatoxins, earthworms, soil ecotoxicology, soil moisture, temperature

# USING DIGITAL SOIL MAPPING METHODS FOR PRECISION AGRICULTURE

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# INTRODUCTION

The agricultural industry is pressured to yield more produce, as a result of increasing world population. Precision agriculture (PA) can contribute to solving this issue as its implementation can lead to increased yields. However, PA requires the use of soil mapping to enable decisions to be made for variable rate application. Currently, conventional soil mapping methods require data that is acquired from a high number of soil samples at a high cost. Digital soil mapping (DSM) has been shown to produce accurate soil property maps at regional scales, using machine learning and environmental covariates. The hypothesis tested in this study is that using DSM methods, soil property maps commonly used for PA can be created using significantly less soil samples, thus lowering the cost, but at an equal or better accuracy than conventional methods.

#### MATERIALS AND METHODS

Soil property maps were created using conventional interpolation on a 1 ha grid, as well as DSM methods using only 50% of the available data points. The two types of maps were visually and statistically compared with one another. The properties tested were extractable magnesium, potassium, phosphorus content, pH, as well as the clay percentage. Semivariograms were created for the chosen properties using the R statistical programme.

# **RESULTS AND DISCUSSION**

The semivariograms of the properties show that the 100-meter grid sizes are too big to allow for accurate interpolation, except for P and Mg. For the rest of the properties, interpolation is not scientifically sound as all the points are weighted equally over the whole distance of the semivariogram. The interpolated maps using 100% of the points were most accurate for the pH, P and clay (RMSE: pH=0.308, P=0.00003 mg/kg, Clay=2.333%), while the DSM maps created using 50% of the points achieved comparable accuracy (RMSE: pH=0.311, P=3.588 mg/kg, Clay=3.624%) or improved accuracy (RMSE K=53.331 mg/kg, Mg=26.103 mg/kg) than the interpolated maps created using 100% of the points (Interpolated 100% RMSE Values K=105.478 mg/kg, Mg=37.926 mg/kg).

#### CONCLUSION

DSM maps performed better than interpolated maps using the same amount of data points, and were comparable to the interpolated maps using 100% of the available data points, thus, the hypothesis is accepted. DSM is a viable alternative to 100 m grid sampling for PA.

Keywords: Precision agriculture, soil mapping methods, machine learning, soil forming factors, semivariograms.

# VALIDATING NEMATODE-BASED INDICES AS AN ECOLOGICAL TOOLSET OF SOIL ECOSYSTEM STATUS IN MAIZE PRODUCTION SYSTEMS

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#### INTRODUCTION

There is an urgent need for increased food production and promoting soil health is recognized as a cornerstone of sustainable agriculture (Doran, 2002). However, current frameworks for assessing soil health are largely focused on physical and chemical soil properties, while functioning soil ecosystems (representing the biological component) are key to reducing our reliance on external inputs. To evaluate and monitor soil ecosystem status, a bioindicator group like nematodes represents a potential solution. This study aimed to validate nematode-based indices as an ecological toolset of soil ecosystem health and functioning in maize-based cropping systems. Furthermore, the study aimed to incorporate selected physicochemical parameters and consider local environmental conditions for a comprehensive understanding.

# MATERIALS AND METHODS

Various ecotopes (one in Kwazulu-Natal, four in the Free-State, and one in Mpumalanga) were selected based on edaphic and climatic factors. Within each ecotope, three study systems were included, namely a conventional agriculture (CV), conservation agriculture (CA), and regenerative agriculture (RA) system, respectively. Sampling and fieldwork were undertaken in March 2023 and will repeat for two consecutive summer seasons. Nematodes were extracted, counted, and morphologically identified to the genus level, and the online NINJA tool was used to calculate nematode-based indices. Furthermore, physicochemical parameters (soil texture, moisture, nutrient availability, pH, and EC) were analysed to provide additional context for interpreting the ecological data. Finally, Analysis of Variance (ANOVA) tests were used to test for significant differences in measured parameters between ecotopes and systems.

### **RESULTS AND DISCUSSION**

The system-ecotope interactions demonstrated how nematode communities changed in response to their environmental context. Between ecotopes, Vrede represented the highest mean maturity index and Reitz the lowest, where RA systems indicated the highest mean maturity and CA systems the lowest. The Bergville ecotope indicated the highest mean enrichment and Viljoenskroon the lowest, with CA systems having the highest mean enrichment and CV the lowest. Regarding physiochemical parameters, the Bergville ecotope lost the highest mean soil moisture together with CV systems, and Viljoenskroon the lowest together with CA systems. CA systems represented the highest mean active carbon and the Bergville ecotope, with Vrede having the lowest. This corresponds with CA practices of permanent soil cover and no or minimum soil disturbance.

#### CONCLUSIONS

The first interval's recorded data indicated that nematodes can be used as bioindicators of soil ecosystem health and functioning due to their ubiquitous characteristics and sensitivity to changes in the environment (Du Preez *et al.*, 2022). Future interval data will be included and monitored over time to conclude the findings of this study. Further investigations are needed to include parameters such as soil respiration, water-holding capacity, and aggregate stability to broaden our understanding of the functioning and health of soil ecosystems under various agricultural systems and conditions.

**KEYWORDS:** conservation agriculture, nematode-based indices, regenerative agriculture, soil health, sustainable agriculture

# ASSESSING THE MATURITY AND INOCULATION POTENTIAL OF JOHNSON SU COMPOST USING NEMATODES AS BIOINDICATORS

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# INTRODUCTION

Soil organisms are responsible for the breakdown of organic matter and the cycling of nutrients (Postma-Blaauw *et al.* 2010). However, intensive land use decreases the functionality of soil biology. Counteracting this problem, farmers are using the fungal dominated, Johnson Su Compost to inoculate soils with beneficial organisms that promote soil ecosystem functioning (Johnson & DeSimio, 2021). Knowing when the Johnson Su compost is ready for use is critical in achieving its expected benefits. Therefore, the aim of this study was to validate nematode-based indices as a measurement of Johnson Su compost maturity.

# MATERIAL AND METHODS

The study was conducted by establishing six replicates of Johnson Su bioreactors comprising of 70% grass, 20% wood shavings and 10% horse manure at the NWU campus in January 2023. Microirrigation and temperature monitoring systems were installed to manage temperature and moisture levels. With the use of a sampling auger, compost samples were collected monthly for nematode community and physicochemical (pH, EC, and moisture content) analyses. Nematodes were extracted using the sugar centrifugal method and counted and identified to genus level using light microscopy. Nematode-based indices of compost maturity were calculated using the NINJA online tool.

# **RESULTS AND DISCUSSION**

During the first period, the compost maturity index remained constant. However, after 7 months a significant increase in omnivorous and fungivores nematode populations were recorded likely because of increasing food availability (Renčo et al., 2010). Similar observations were made by Steel *et al.* 2010 with fungivores dominating more mature composts. Furthermore, from initiation and during the summer months a rise in temperatures up to 28°C was recorded, which indicates increased microbial activity. Thereafter, a drop in temperature during the winter months down to 7°C indicated a reduction in microbial activity and the completion of the thermophilic phase (Ajay *et al.* 2009). Evaporation was caused by the heat generated during decomposition, but for the organisms to thrive, the compost moisture levels were maintained at 60-70% (Ajay *et al.* 2009). The compost maintained a pH value between 6-7 which is beneficial for decomposition.

#### CONCLUSIONS

Nematode communities play a critical role in the decomposition of organic material. The recorded data indicated that there was successional development in the nematode communities during the experimental period. Further investigations on nematode communities and physicochemical factors will determine whether nematodes can act as appropriate bioindicators of compost maturity.

#### **KEYWORDS**

Compost maturity, Johnson Su Compost, Microorganisms, Nematode-based indices

# NITRIFICATION RATE IN THE SOIL AS INFLUENCED BY WHEAT LANDRACE VARIETIES

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#### Introduction

A wheat field trial is presently ongoing with 10 bread and 10 durum varieties. The objective of this study is to investigate nitrification rates as influenced by 20 wheat varieties, with the overall aim being to introduce landrace genes for future breeding of wheat hybrids. The project is ongoing across six other countries including England, Germany, Spain, Belgium, China and Italy, where the same wheat varieties are planted.

#### Materials and Methods

An on-station field trial is being conducted at the ARC experimental farm near Brits ( $25,5849^{\circ}$  N,  $27,7692^{\circ}$  E), on the Kimberley soil form (with 64% sand and 34% clay). The trial is a randomized block design, with three Nitrogen application rates. The topsoil labile nitrogen was reduced by planting oats during winter of 2022. Wheat was planted in October 2022, and rhizospheric soil samples were taken by digging out five wheat plants per plot with a fork, then shaking the soil into a bag. The soil was incubated for a week at 60% water-holding capacity (WHC). Eight milligrams N or 0.3771 g (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> was added to each soil sample in solution, to bring the WHC up to 80%. Nitrates were measured using the EDT direction QP459 meter with the 3021 – Nitrate ISE probe. Measurements were done at 0, 1, 3, 7 and 14 days (Sibley *et al.* 2010).

#### **Results and discussion**

At time zero there was a large variation in nitrate levels of the soils due to the different landrace varieties. The nitrate levels dropped by between 28 and 55% in the first 24 hours, then the levels increased steadily until 14 days. The long-term effect on microbial communities due to nitrogenous fertilizer application is a change in community composition and abundance. In the short term there is a change in enzyme activity and microbial activity. Furthermore, the drop in the nitrate levels could initially be attributed to micro-organisms using some of the available nitrates (Ouyang & Norton 2020; Tang *et al.* 2020).

#### **Conclusion and recommendations**

The landrace varieties use labile nitrogen in the soil and fertilizer at different rates. The landrace varieties affect the enzyme and microbial community in the rhizosphere differently, which results in the different rates of nitrification of  $(NH_4)_2SO_4$  in the soil. It is recommended that the landrace varieties that have the optimum nitrogen use efficiency be evaluated further for genes that may be utilized in future breeding of N-efficient wheat hybrids.

#### References

• Ouyang, Y. & Norton J.M 2020. Short-term nitrogen fertilization affects microbial community composition and nitrogen mineralization functions in an agricultural soil. *Appl Environ Microbiol* 86:e02278-19. https://doi.org/10.1128/AEM.02278-19.

• Sibley K.J., Brewster G.R., Astatkie T., Adsett J.F. & Struik P.C. 2010. *In-field measurement of soil nitrate using an ion-selective electrode*. Advances in Measurement Systems. IntechOpen, Bod Third Party Titles. DOI:10.5772/8741

• Tang H., Li C., Xiao X., Shi L., Cheng K., Wen Li. & Li W. 2020. Effects of short-term manure nitrogen input on soil microbial community structure and diversity in a double-cropping paddy field of southern China. *Scientific Reports*, 10:13540, https://doi.org/10.1038/s41598-020-70612-y

#### Key words

Ammonium sulphate, nitrification rate, rhizosphere, wheat landrace varieties, WishRoots

#### Acknowledgements

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# LOCAL IS LEKKER: WHY WE NEED LOCALLY CALIBRATED SOIL SPECTROSCOPIC PREDICTION MODELS.

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#### INTRODUCTION

Globally, soil spectroscopy is rapidly being developed and seeks to replace traditional soil analysis methods that are expensive and time consuming. Soil spectroscopy has recently been mentioned as a cheaper, more time effective alternative, but it requires accurate calibration algorithms. Prediction models have been produced by the Open Soil spectral Library (OSSL) for public use. This study aims to emphasize the need for locally calibrated soil spectroscopic prediction models for soil properties routinely used in South Africa.

#### MATERIAL AND METHODS

Mid infrared spectra were obtained from samples using a Bruker Alpha II with DRIFTS attachment, alongside laboratory measurements of pH (KCl), NH4Oac extractable exchangeable base cations, and Bray-1 P. Calibration algorithms were created using the Cubist, Partial Least Squares Regression (PLSR), and Random Forest (RF) machine learning algorithms to develop local prediction models. Additionally, a subset of spectra was also submitted to the newly developed global soil spectral database of OSSL with prediction models to obtain its predictions based on the locally measured spectra.

#### **RESULTS AND DISCUSSION**

Accurate prediction models for soil properties require a ratio of performance to inter-quartile distance (RPIQ) > 2. The prediction results from the OSSL did not meet the accuracy criteria, with the RPIQ values for all soil properties predicted being < 1. The globally calibrated models underpredicted on all soil properties. Additionally, the OSSL collection of prediction models does not include a pH (KCI) model. The pH (KCI) is routinely used in South Africa while, this method is not internationally recognized like pH (H<sub>2</sub>O). The results demonstrate promising outcomes for local predictions at regional scale. Accurate predictions for pH, calcium (Ca), and magnesium (Mg), with values surpassing 2.13 were achieved. However, predictions for phosphorus (P), potassium (K), and sodium (Na) did not meet reliability requirements.

# CONCLUSIONS

Soil spectroscopy prediction models calibrated for local soils outperformed the global soil spectroscopic prediction models considered. Global prediction models need to sufficiently include spectral data that contain the unique spectral features of local soils. By prioritizing regional and soil property specific prediction models, this work can contribute to the evolution of agriculture by informing decision making on agronomic practices which could lead to better yields, reduction of fertilizer use, improved monitoring of soil health and to the development of soil spectroscopy and precision agriculture methods in South Africa.

Keywords: Cubist, Partial Least Squares Regression, random Forest, Soil Spectral Inference, South Africa, Spectral library

# AGRICULTURAL IMPACT ASSESSMENTS IN SOUTH AFRICA – THE WAY FORWARD

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# INTRODUCTION

Arable land resources are extremely scarce in South Africa and therefore require protection from competing land uses. There are various pieces of legislation that aim to protect these resources. Legally required agricultural impact assessments provide an opportunity for agricultural scientists to make valuable inputs to inform land use decisions that determine the fate of agricultural land. This presentation identifies challenges in the operation of the assessment process and poses ideas for potential future improvements.

# MATERIAL AND METHODS

This is not a traditional presentation of agricultural research. Rather, it reflects on the efficacy of agricultural impact assessment in South Africa, based on the author's 26 years of experience as a consultant in this field. It presents the author's thinking on the question of what an agricultural impact assessment needs to achieve and how the assessment process could best operate to achieve it.

# **RESULTS AND DISCUSSION**

The requirements for an agricultural impact assessment are regulated by the recently proclaimed Agricultural Protocol of the National Environmental Management Act. Some of the challenges related to the Agricultural Protocol include the following. It is required to be applicable to all types of development and across extremely diverse agricultural environments. This can result in the requirements being unnecessarily onerous under certain conditions. There is an emphasis on the concept of sensitivity over the more important impact significance. There is a reliance on prescriptive categories of sensitivity. Agricultural concerns occupy a somewhat uncomfortable position in the environmental assessment field and are often in direct opposition to the concerns of the other disciplines. Furthermore, there is a tendency in the environmental authorization process to emphasize bureaucratic compliance over what is of more fundamental importance. I experience that, due to these challenges, there is a tendency for the essence of agricultural impact assessment to get lost so that the outcomes of the assessment process do not align with its fundamental aims.

# CONCLUSIONS

This presentation inputs ideas to stimulate the discussion that is needed to articulate and reach a common understanding of the fundamentals of agricultural impact assessment so that it can most effectively conserve our country's limited arable land resources. It is important that experienced agricultural scientists are part of shaping a way forward for agricultural impact assessment in South Africa.

**Keywords:** Agricultural impact assessment, agricultural protocol, land capability, preservation of arable land

# SOUTHERN AFRICAN SOIL, LAND COVER AND WEATHER GENERATOR FILE DATABASES FOR SWAT APPLICATIONS

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#### INTRODUCTION

One of the biggest challenges to set-up and run the SWAT model in Southern Africa is to obtain appropriate input data, especially soil data. The objective of the study is to interpret/format multiple geo-spatial datasets at a multinational scale for use as baseline input to run ArcSWAT or QSWAT in Southern Africa. The input datasets consist of more detailed and higher resolution soil data than the Global databases.

#### MATERIAL AND METHODS

The portal formatted the following geo-spatial input datasets:

- SWAT catchment outline data (tertiary and quaternary) including the hydrologically corrected SRTM DEM of Southern Africa at 90 m resolution (Weepener et al., 2012);
- Land cover maps at 30 m resolution including South African National Land Cover (SANLC 2014; 2018; 2020) and Finer Resolution Observation and Monitoring of Global Land Cover for Africa version 2 (2020) linked to SWAT land cover codes;
- Soil maps with SWAT attribute data derived from pedotransfer functions of the Land Type Database of South Africa (Land Type Survey Staff, 1972 – 2006) useable at a scale of 1:250,000, as well as Soil and Agronomy Data Cube for Africa at 30 m resolution;
- Weather statistics (WGN) files for 12 weather stations obtained from the Agricultural Research Council.

#### **RESULTS AND DISCUSSION**

The input database is stored in the Water Research Observatory (WRO) data portal:

https://www.waterresearchobservatory.org/data-and-resources/hydrological-data-and-modelling.

Performance of the Southern African baseline data was determined by comparing streamflow and sediment outputs with previous modelled catchment data models, as well as comparison of the hydrological accuracy against measured streamflow data. Although the catchment data models were slightly superior compared to the national data models, the national datasets were capable of modelling streamflow and sediment dynamics at a catchment scale.

#### CONCLUSIONS

Modellers will be able to use the input data 'as is', or alternatively supplement, improve and/or replace the input data with their own recent/sophisticated data. Such an input dataset is an important step forward in the application of SWAT to assist soil and water management in Africa.

#### REFERENCES

Land Type Survey Staff (1972 – 2006). Land Types of South Africa: Maps (69 sheets) and Memoirs (39 books). Agricultural Research Council -Soil, Climate and Water, Pretoria.

SANLC. 2014; 2018; 2020. National Land Cover Data of South Africa 1990 and 2013-14. Department of Environmental Affairs: Pretoria, South Africa. Available from

https://www.environment.gov.za/projectsprogrammes/egis\_landcover\_datasets

Weepener HL, Van den Berg HM, Metz M, Hamandawana H. 2012. *The development of a hydrologically improved Digital Elevation Model and derived products for South Africa based on the SRTM DEM. WRC report 1908/1/11*. Water Research Commission: Pretoria, South Africa. ISBN 978-1-4312-0217-1.

Keywords: ArcSWAT, QSWAT, input data, data portal, open-source, Southern Africa.

#### ACKNOWLEDGEMENTS

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# IMPACT OF WATTLE TREE SPECIES ON SOIL PHYSICOCHEMICAL PROPERTIES AT MATATIELE IN EASTERN CAPE, SOUTH AFRICA

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# INTRODUCTION

Black wattle (Acacia mearnsii) and silver wattle (Acacia dealbata) threaten indigenous habitats by competing with vegetation, replacing grassland communities, diminishing native biodiversity, and increasing water loss in riparian zones. Black wattle is in the 'top 10' invading species in South Africa, developing wild on 2,500,000 ha, whereas silver wattle occurs within the 'top 25' (Le Maitre et al., 2000; Nel et al., 2004). Acacia species have been shown to cause simultaneous changes in the above- and below-ground communities, microclimates, soil moisture regimes, and soil nutrient levels (Marchante et al., 2003, 2008a). Therefore, the objective of this study was to assess soil physicochemical properties under wattle tree; cleared sites which were previously invaded by wattle trees, and adjacent grazing land.

# METHODS

Two sites, namely, Tsitsong and Belfort, in Matatiele had been identified for the purpose of this study. The treatments in Tsitsong are invaded (silver wattle), cleared 1 year ago, cleared 2 years ago, and uninvaded (grassland). Whereas in Belford the treatments are black wattle invaded, silver wattle invaded, cleared 6 years ago and uninvaded (grassland). The transect walk method was used in soil sampling with four invasion classes, including invaded (black & silver wattle), uninvaded grazing land (control for the study), and cleared in different years (1, 2, and 6 years) identified in each study site. Each site followed the RCBD with three replications. The soil physicochemical properties that have been measured include soil organic carbon (SOC), bulk density, pH, and electric conductivity (EC).

# RESULTS

In Tsitsong, SOC was significantly (P<0,0001) higher (2.8%) in the soil under the silver wattle compared to soils cleared 2 years ago (2.5%). The soil pH was significantly higher (P< 0,0001, pH = 4.89) in non-invaded soils compared to soils under the silver wattle (4.85). Similarly, soils invaded by silver wattle were strongly acidic (3.9) compared to soils cleared 6 years ago (4.3).

# CONCLUSION

The study demonstrated that soils under both wattle species had significantly higher SOC and significantly lower pH.

# Keywords:

Invasive species, acacia mearnsii, acacia dealbata, soil properties, organic carbon

# ACKNOWLEDGEMENTS

I would like to thank NRF-NWO for funding this project.

# SHORT-TERM TILLAGE, PLANTING DATE, CULTIVAR AND ROTATION EFFECTS ON GRAIN SORGHUM GROWTH ON SANDY SOILS IN TWO DIFFERENT CLIMATIC CONDITIONS IN SOUTH AFRICA

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#### Introduction

The sustainability of crop production in Africa is threatened by low soil fertility, poor water holding capacity (especially on sandy soils), poor management strategies and climate change. Sorghum is one of the major crops grown in Africa and is drought- tolerant. This study investigated the short-term tillage, planting date, cultivar and rotation effects on sorghum growth on sandy soils under two different climatic conditions.

#### Material and methods

The study was conducted at Mphanama in Limpopo province and Clau-Clau in Mpumalanga province. The experiment was carried out using a randomized complete block design arranged in a strip-split-plot treatment structure with three replicates. The treatments consisted of tillage (conventional tillage [CT] with crop residue removal and no-till [NT] with residue retention), planting date (early and late), and the two sorghum cultivars (Pan 8816 and Macia). Plant height, yield, and 1000 seed weight were measured.

#### **Results and discussion**

Plant height was significantly affected by planting date with taller plants observed when planted early than when planted late (average 129 cm and 104 cm, respectively) in the first growing season at Mphanama. Early planted sorghum had 41% higher yield than late-planted sorghum in the first growing season at Mphanama. Significantly heavier seeds were observed for early-planted sorghum plants than those planted late (41.50 g and 31.67 g, respectively) in the first growing season at Mphanama. Significantly heavier seeds were observed for early-planted sorghum plants than those planted late (41.50 g and 31.67 g, respectively) in the first growing season at Mphanama. Significantly higher yield was observed when sorghum was planted early under NT (1.87 t/ha) and under CT (1.56 t/ha) compared to when the sorghum was planted late under both NT and CT (0.86 t/ha and 0.55 t/ha, respectively) in the first growing season at Mphanama village. The 1000 seed weight was significantly heavier for Pan8816 cultivar than Macia cultivar (55.42 g and 40.50 g, respectively) in the second growing season at Clau-Clau. The early rainfall could have significantly influenced the plant height, yield and 1000 seed weight at Mphanama village. The heavier seed weight on Pan8816 could be attributed to the cultivar's genotype adaptation and tolerance to climate compared to the Macia cultivar at Clau-Clau. Similarly, Pan8816 plants performed better than Macia in the study conducted by Manyathi (2014). The results could also be influenced by the positive correlation with the plant height and yield.

#### Conclusion

The results show that early planting promotes better plant performance in terms of height, yield and seed weight, regardless of the variety of sorghum cultivars at Mphanama. In contrast, choosing the right cultivar is more important at Clau-Clau. More time will be required for the study to observe the effects of other treatments, such as tillage and rotation effects, on the sorghum growth.

#### References

- Manyathi T. 2014. Water productivity of selected sorghum varieties (Doctoral dissertation). University of Kwazulu-Natal.
- Malobane ME, Nciizah AD, Mudau FN, Wakindiki II. 2020. Tillage, crop rotation and crop residue management effects on nutrient availability in a sweet sorghum-based cropping system in marginal soils of South Africa. *Agronomy*, 10(6), p.776.

Keywords: Conventional tillage, no-tillage, planting date, Pan8816, Macia

# SHORT-TERM EFFECT OF CONSERVATION AGRICULTURE ON SOIL CHEMICAL PROPERTIES OF HUTTON SOIL IN OR TAMBO DISTRICT OF THE EASTERN CAPE PROVINCE

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# INTRODUCTION

Tillage techniques and fertilizer management affect soil chemical properties and influence nutrient availability and uptake. This has the potential to reverse soil degradation, increase crop yields and improved food security (Sithole *et al.*, 2018). In contrast conventional tillage disrupts soil structure, accelerating surface runoff and soil erosion which are constituents of soil degradation. In OR Tambo District soil degradation is largely characterised by the existence of sheet erosion and gully erosion on the hilly arable lands. Soil erosion contributes to the loss of soil organic carbon and soil fertility (Craven *et al.*, 2020). These losses have been linked to reduction in crop productivity and yields. The adoption of properly managed CA can reverse soil degradation, restore soil quality, improve soil fertility, enhance productivity, and improve food security. The main objective of the study was to conduct experiment with maize and bean intercropping within NT and CT technique and determine the effect in soil chemical properties.

# MATERIALS AND METHODS

The study was conducted in Nkanga village (31.467783<sup>o</sup> S and 29.189126<sup>o</sup> E), Libode, Nyandeni Municipality, in the OR Tambo District in Eastern Cape. The study was laid out as split plot with three replications, tillage techniques were the main plots. Two tillage techniques were applied, no-till (NT) and conventional tillage (CT). Sole maize, sole beans and intercropped maize-bean were randomly allocated in sub-plots plots. Soil organic carbon and some base cations were analysed at the end of the growing season.

# **RESULTS AND DISCUSSION**

Organic Carbon (OC) was significantly different between all treatments, the maize-bean intercrop had a 0.5% higher OC than sole maize and beans treatments. Additionally, cation (P, Ca, and Mg) contents significantly differed within the treatments, P and Ca were different in all the treatments and intercropped treatment had 50%, 25% and 55% higher Ca, Mg and P content under NT. Sole maize had the lowest P and Ca content. Magnesium content was significantly different between sole maize treatment and the intercropped treatment

# CONCLUSIONS

Maize-bean intercropping on no-till had the most improved soil organic carbon contents. However, sole maize planting negatively affected soil OC and cation content during the experiment period.

KEYWORDS: Conservation Agriculture, No-till, Conventional tillage, intercropping

# REFERENCES

Craven M., Mokoena P. T., Morey L., Saayman-Du Toit A. E. 2021. Effect of glyphosate application time on yield parameters of South African glyphosate-resistant maize cultivars. South African Journal of Science, 117(7/8).

Sithole, N.J., Magwaza, L.S., Mafongoya, P.L. and Thibaud, G.R., 2018. Long-term impact of no-till conservation agriculture on abundance and order diversity of soil macrofauna in continuous maize monocropping system. Acta Agriculturae Scandinavica, Section B—Soil & Plant Science, 68(3), pp.220-229.

# OPTIMIZING CHILLIES (CAPSICUM ANNUM L.) GERMINATION RATE THROUGH NUTRIENT SEED PRIMING WITH KNO3 AND ZNO

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#### Introduction

*Capsicum annum.L* (Chillies) seeds have a low germinating capacity, which may lead to low crop yield. Seed priming is a pre-sowing treatment that enables seeds to germinate more efficiently through enhancement of physiological state of the seeds. Nutrient seed priming (NSP) results in improved metabolic functions, repairs damaged DNA and promotes uniform germination. Therefore, this technique improves the production and quality of crops under normal and unfavourable environmental conditions. However, the effectiveness of NSP depends on the concentration of the priming agents and soaking duration. This study aimed to determine the effects of nutrient seed priming duration and concentration on germination indices of chillies.

#### **Materials and Methods**

The study was conducted in May 2023 at the Agricultural Research Council– Natural Resources & Engineering (ARC-NRE) campus in Arcadia, Pretoria, South Africa. The experiment was carried out in a completely randomised design with a  $4 \times 3 \times 3$  factorial treatment structure. Four ZnO concentrations, three KNO<sub>3</sub> concentrations and three priming durations (6h, 12h and 24h) replicated three times, were used. Seeds for the control treatment (no-soaking) and hydro priming (soaked in distilled water) for the same durations.

#### **Results and Discussion**

There were no significant differences in germination rates (GR) among different ZnO and KNO<sub>3</sub> concentrations. However, there was significant (P < 0.05) effect of priming duration on GR. Soaking seeds for longer durations resulted in higher GR. This was because longer priming duration allows the seed to absorb nutrients and moisture, which enhances the metabolic processes and the ability to break seed dormancy. There was significant interaction between nutrient concentration and priming duration on germination energy GE, ranging between 75.45 and 93.92 kJ, which highlights the sensitivity of variations in nutrient concentrations. ZnO<sub>3</sub> 20mg/l and KnO 10g/l may result in higher energy levels during germination A higher concentration provides a conducive condition to achieve higher germination energy. The significant interaction effects on GR proves that the combined influence of nutrient concentrations and durations contributes to the overall seedling vigour. This emphasizes that both nutrient concentration and priming duration play important roles in determining the early stages of chilli seed germination. The lack of significant differences in germination rates between different ZnO and KNO<sub>3</sub> concentrations may be from the fact that chilli seeds have a sensitivity threshold to nutrient concentration. The variation in GR and GE highlights the role of time and concentration in optimizing chilli seed germination.

#### Conclusion

The results show that priming duration and nutrient concentration optimize chilli seed germination, especially on germination energy the interaction implies that the combined influence of nutrient levels and priming duration plays an important role in determining expanded energy during germination.

Keywords: Capsicum annum L., chilli, germination, nutrient seed priming

# EVALUATION OF THE MICROBIOMETER® FIELD TEST KIT FOR SOIL BIOLOGY AND OTHER LABORATORY SOIL TESTS AT THREE DIFFERENT LOCATIONS IN THE WESTERN CAPE PROVINCE

Anélia Marais, Mardé Booyse

#### Introduction

There are many possible tests that are supposed to be indicators of a soil's health, but the majority of these tests currently available in South Africa is laboratory-based and necessitates transportation and storage of soil samples that can alter soil biology. The microBIOMETER<sup>®</sup> is a field test kit that can measure microbial biomass, percentage of fungi and bacteria, as well as the fungal: bacteria ratio in minutes, using a mobile phone application. The aim of this study was to test this soil kit in three different locations in the Western Cape Province as well as comparing it to other laboratory-based soil tests. The hypothesis was that the microBIOMETER<sup>®</sup> would be a good indicator of soil biology under field conditions.

# Materials and methods

Soil samples were collected from cultivated soil as well as adjacent natural veld at each of three different locations in the Western Cape Province (Moorreesburg, Lambert's Bay, George). The protocol for the microBIOMETER<sup>®</sup> was followed in the field at each location, while five currently available laboratory-based tests were later carried out on the collected samples, namely: active carbon (KMnO<sub>4</sub> oxidation), wet soil aggregate stability, microbial activity (fluorescein diacetate, or FDA), protozoa (most probable number, or MPN), as well as CO<sub>2</sub> respiration (Solvita<sup>®</sup> CO<sub>2</sub> – Burst). Total organic carbon content (Walkley-Black) and ammonium nitrogen (Kjeldal) were also determined.

#### **Results and discussion**

All the tests were able to distinguish some of the locations and land use types. Only two tests could distinguish the three different locations, and only in the natural veld, namely the microBIOMETER<sup>®</sup> (523.67<sup>b</sup>; 352.11<sup>c</sup>; 644.33<sup>a</sup>) and the test for active carbon (752.34<sup>a</sup>; 501.06<sup>b</sup>; 297.5<sup>c</sup>). At the George location, ammonium nitrogen could distinguish land use types (0.216<sup>c</sup>; 0.367<sup>b</sup>; 0.488<sup>a</sup>; 0.146<sup>d</sup>), while it showed no significant differences at the Moorreesburg location (0.127<sup>a</sup> 0.135<sup>a</sup>; 0.151<sup>a</sup>; 0.153<sup>a</sup>). It seems as if the location and land use type influenced the results of the different tests differently. Perhaps a set of soil tests could, with time, be identified as being the best for a particular location or land use type.

# **Conclusion and recommendations**

The microBIOMETER<sup>®</sup> was easy to use. The different tests in this study measured different aspects of the soil. It is recommended that as many soil tests as is practical should be used and that comparisons be done only within location and land use type and over the course of seasons.

Keywords: active carbon, aggregate stability, microbial activity, microBIOMETER®, protozoa, Solvita®

CO<sub>2</sub>-Burst.

# EFFECT OF DIFFERENT FIRE FREQUENCIES ON THE COMPOSITION AND DIVERSITY OF SOIL FUNGI UNDER SEMI-ARID SAVANNA RANGELANDS IN THE EASTERN CAPE PROVINCE

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# INTRODUCTION

Prescribed fire frequencies have been widely used to reduce the risk of severe wildfire occurrences. There is a lack of empirically based knowledge concerning the impact of fire frequency on soil microorganisms. This study assessed the effect of different fire frequencies on the diversity and composition of soil fungal communities in a semi-arid savanna rangeland.

# MATERIAL AND METHODS

Soil samples were collected on an ongoing long-term trial which was initiated in 1980 by the Department of Livestock and Pasture Science at the University of Fort Hare Research Farm. The trial was divided into six treatments: no burn, annual, biennial, triennial, quadrennial, and sexennial burn. These treatments were arranged in a completely randomised design with two replications. Three samples were taken from each of the 12 plots to make a total of 36 soil samples and stored in an insulated box with ice. Following, samples were transported to the laboratory and crushed to pass a 2 mm sieve. A fungal ITS gene region was selected as the target sequences to identify bacterial species. The data were analysed using permutation multivariate ANOVA for comparison of fungal diversity indices using R software (version 4.1.2). Significance between treatments was tested using the Turkey Honest Significant Difference (TurkeyHSD) test at 5%.

# **RESULTS AND DISCUSSION**

The Observed, Chao1, Shannon-Wiener and Inverse Simpson diversity indexes were used for composition and diversity analysis. The highest diversity was found in biennial plots, whereas the lowest diversity was observed on the no-burn plots. It was shown that the highest soil fungal microbial diversity was found in highly burnt treatment plots (annual, biennial, triennial). Regarding the taxa, *Ascomycota* was the most identified phyla. In arid environments, *Ascomycota* fungi play a key role in the cycling of carbon and nitrogen. These fungi serve important roles in soil stability and plant biomass breakdown.

# CONCLUSION

The different fire frequencies had an influence on soil fungi diversity and taxonomic composition in semiarid savanna rangelands. However, it is suggested that more studies should be done in other biomes which could assist in decision-making regarding conservation of species, fire safety and management.

Keywords: fire-prone biome, fungal richness, fungal diversity

# ASSESSING THE INFLUENCE OF REHABILITATION STRATEGIES ON SOIL QUALITY AT MOKALA NATIONAL PARK, SOUTH AFRICA

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#### INTRODUCTION

Soil quality is described as the competence of soil to perform fundamental ecological functions in sustaining both biotic and abiotic productivity. These ecological functions are driven by site-specific physical, chemical and biological properties of soil which serve as the most viable indicators for assessing soil quality because they are highly sensitive to soil alterations. This study aimed to investigate differences in soil indicators between various rehabilitation strategies applied within the national park, which may serve as a benchmark to restore degraded areas.

# MATERIALS AND METHODS

Sixty topsoil samples were collected from rehabilitated areas within the park, representing different strategies applied and terrain attributes. These strategies were categorized as brush packing and silt fences. Total carbon was determined with the Leco TruSpec CNS, while active carbon (AC) was determined using potassium permanganate (KMnO<sub>4</sub>) oxidation. Microbial activity was determined with the fluorescein diacetate hydrolysis (FDA) method, while aggregate stability was measured with the wet-sieving method. Soil phosphorus, exchangeable cations and CEC was determined using the Olson method, ammonium acetate (NH<sub>4</sub>OAc) and sodium acetate (NaOAc), respectively. ANOVA was performed using SPSS and means were separated using the Student's t-test.

# **RESULTS AND DISCUSSION**

Topsoil were uniformly classified as sandy loam with a mean neutral  $pH_{(H2O)}$  of 7.15. Positive Pearson correlations ( $p \le 0.01$ ) existed between AC and CEC (r = 0.55) as well as microbial activity and AC (p < 0.05). These relationships may be useful in identifying indicators suitable for an index to assess rehabilitation strategies. The mean total carbon, AC, CEC, exchangeable cations, phosphorus, aggregate stability and microbial activity between the brush packing and silt fence rehabilitated areas was used to determine which strategy improved the soil quality when compared with degraded areas. It was evident from the results that brush packing is more effective compared to silt fences as significantly higher total carbon, AC, CEC and microbial activity was determined. Contrastingly, the latter had significantly higher exchangeable cations and phosphorus concentrations. Both strategies promoted stable macro-aggregates that had a positive influence on the soil quality as compared to degraded area.

# CONCLUSIONS

The study concludes that brush packing and silt fences are effective rehabilitation strategies applied within the national park, however the soil indicators identify brush packing as the most beneficial for soil quality.

Keywords: Soil quality, rehabilitation, degraded areas, national park

# SOIL FERTILITY TRENDS IN THE SOUTH AFRICAN SUGARCANE SECTOR: A COMPREHENSIVE LOOK FROM 2017 TO 2022

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#### Introduction '

Assessing the fertility status of soil is a crucial step in managing soil health and ensuring proper crop nutrition, particularly in the cultivation of sugarcane. In ensuring that proper crop nutrition is maintained in the sugarcane production sector, Fertiliser Advisory Service (FAS) of the South African sugarcane Research Institute plays a pivotal role in assisting sugarcane growers by providing tools to evaluate the nutrient status of both the soils and crops. The aim of the present study was to use the FAS topsoil and subsoil data to investigate the soil fertility status in the different extension regions of the South African sugar industry, with the intention of providing a 'snapshot' of the soil fertility status for the survey period, as well as to consider the changes that have occurred since the previous survey, five years ago.

#### **Material and Methods**

This paper utilises the FAS soil analysis database to examine the soil fertility status within the South African sugarcane industry. Routine top- and subsoil fertility analysis data for sugarcane crops were extracted from the FAS database for the period 2017 to 2022. The data were grouped according to the extension regions, which included the northern irrigated Komatipoort, Malelane, Pongola and rainfed Umfolozi, Zululand North, Zululand South, North Coast, South Coast, Lower South Coast, Midlands North and Midlands South regions, as used by Mthimkhulu and Miles (2017).

#### **Results and Discusion**

The analysis reveals that soil phosphorus (P) levels on average surpassed the established sufficiency thresholds, however, there was a notable prevalence of sub-optimal P levels in various regions, reaching up to 70% in some cases. Interestingly, a small but significant percentage of samples (1-4%) exhibit extremely high amounts of P suggesting potential over-application of P fertilisers. Potassium (K) levels fell within the sufficiency ranges, though deficiencies were more frequently observed in soils with less than 30% clay content, particularly in sandier soils. In some regions, excessively high soil K levels were noted with values reaching up to 5500 mg/L. Calcium and magnesium and most micronutrients excluding zinc (Z), exhibit infrequent deficiencies. However, sub-optional Z levels were prevalent across many areas. Similarly, there was a high occurrence of sub-optimal sulphur levels, primarily associated with sandier soils. Sodicity defined as an exchangeable sodium percentage greater than 7% was generally low with notable concentration in irrigated regions. Soil acidity remains a potential constraint in rainfed regions, with average acid saturation values across all regions falling below 20%. However, a quarter of the samples still exhibited excessive acidity levels, indicating room for improvement in soil health and nutrition management.

#### Conclusion

The results of this review echoes the trends observed in the 2012-2016 review, suggesting that opportunities persist for enhancing and refining soil health and nutrition management practices in the South African Sugarcane Industry.

#### References

Mthimkhulu SS and Miles N (2017). The fertility status of soils of the South African sugar industry – 2012 to 2016: An overview. Proc. S. Afr. Sug. Technol. Ass. 90: 92-103.

Keywords: Acidity, Crop Nutrition, Fertiliser Advisory Service, Soil Fertility

# THE EFFECT OF INVASIVE ALIEN PLANT BIOCHARS ON SANDY SOIL QUALITY AND CAULIFLOWER YIELD

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### INTRODUCTION

Woody invasive alien plants (IAPs), including black wattle (*Acacia mearnsii*) and eucalypt (*Eucalyptus camaldulensis*) species, are a major environmental problem in South Africa. The clearing of IAPs can serve as feedstock for biochar production to enhance soil carbon sequestration and quality, and crop production, particularly in acid sands (Dai et al. 2020). The aim of this study was to investigate the effect of biochars produced from IAPs (black wattle and eucalypt) feedstocks at different pyrolysis temperatures on soil physical, chemical, and microbial quality and vegetable crop growth.

# MATERIALS AND METHODS

An acid (pH 5.9), sandy topsoil from an agricultural field near Stellenbosch was selected for the pot trial. The biochars were produced at a range of temperatures (500, 600, 700 and 800 °C) from eucalypt and a single temperature (600 °C) from black wattle biomass using low-vacuum pyrolysis. Biochars were applied at 1.5% (wt.) and cauliflower (*Brassica oleracea* var. *botrytis*) was cultivated in a fertilized and irrigated pot experiment. At maturity, cauliflower curd and biomass yields, and nutrient content were determined. Soil chemical, physical and microbiological properties were determined at planting and harvest.

# **RESULTS AND DISCUSSION**

All biochars increased soil pH and buffer capacity especially the higher temperature biochars. Only eucalypt biochars produced at 500 and 600°C increased soil cation exchange capacity (CEC), S-value and total N. All biochars decreased plant available water due to high microporosity which increased with pyrolysis temperature. Water extracts of the 700 and 800 °C eucalypt and 600 °C black wattle biochars were highly phytotoxic to cauliflower germination, whereas 600 °C eucalypt stimulated germination. The 600 °C eucalypt biochar increased cauliflower yields by 53%, attributed to higher soil CEC and N retention. Whereas the 700 and 800 °C eucalypt, and 600 °C black wattle biochars decreased curd yields (26-79%) attributed to phytotoxicity, alkalinity, and available B suppression.

# CONCLUSIONS

The 600 °C eucalypt biochar showed the most promise for enhancing sandy soil fertility and crop yield. This study demonstrates the importance of AIP biochar properties in determining crop response.

#### REFERENCES

Dai Y, Zheng H, Jiang Z, Xing B. 2020. Combined effects of biochar properties and soil conditions on plant growth: A meta-analysis. *Science of the Total Environment* 713: 136635.

Keywords: biochar, invasive plants; organic amendments; soil fertility; soil chemistry

# PLANTING DATE, TILLAGE, AND CROP ROTATION EFFECTS ON THE GROWTH AND NUTRIENT USE OF TWO SORGHUM CULTIVARS GROWN ON SANDY CLAY LOAM SOILS IN SUB-HUMID AND SEMI-ARID REGIONS IN SOUTH AFRICA

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#### Introduction

The need to increase food production as climate continues to change has resulted in sorghum emerging as a viable crop option because it exhibits drought resilience and its ability to thrive on marginal soils with lower demand for limited resources. Understanding the combined effects of planting date, type of tillage and rotations on the productivity of sorghum under contrasting climatic conditions is valuable for the effective management of the crop under changing climatic conditions.

#### Materials and methods

A short-term study was carried out to investigate the growth and NPK uptake of two cultivars of sorghum in different climatic regions (Free State - FS and KwaZulu Natal - KZN) of South Africa over two seasons (2020/21 and 2021/22). The two cultivars (Pan8816 and Macia), were sown in December (PD1) and in January (PD2) under conventional tillage (CT) and no-till (NT) and with two rotations (Sorghum-Cowpea-Sorghum and Sorghum-Sorghum) resulting in 2×2×2×2 factorial experiment.

#### **Results and discussion**

During the 2020/21 season, planting date had a significant impact (p < 0.05) on crop yield in FS. Early-planted sorghum had 2.3 times more yield than late-planted sorghum. During the same season in KZN, planting date, tillage and cultivar had significant effects on yield. Early planted (1.22 t/ha) CT (1.25 t\ha) and Pan8816 (1.42 t/ha) resulted in significantly higher yield than their counterparts which produced 0.63, 0.59 and 0.43 t/ha respectively. During the 2021/22 season, only planting date had significant effects on yield in FS, while cultivar had a significant effect on yield in KZN. In FS, early planted sorghum yielded 3.44 times higher than late-planted sorghum whilst Pan8816 resulted in 3.53 times higher yield than Macia in KZN. In FS, planting date was the most influential factor affecting all the three nutrients in both seasons (P < 0.05), with early planted crops using more nutrients. In KZN, the interaction of tillage and cultivar had a significant (P < 0.05) effect on all the nutrients in the first season, with CTxPan8816 performing better. In the second season, the four-way interaction (PD x Tillage x Cultivar x Rotation) had significant effects on N and P Uptake but not on K.

#### Conclusion

These findings suggest that selecting the appropriate cultivar is crucial in KZN, whereas the timing of sowing plays a more significant role in FS. Conventional tillage also appeared to produce better yields, which could be because of relatively short-term nature of the study, with the benefits of reduced tillage not yet apparent.

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# HEAVY METAL PHYTOREMEDIATION OF MINE CONTAMINATED SOILS USING SELECTED INDIGENOUS CROPS.

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# INTRODUCTION

Mining has resulted in a large amount of environmental pollution including soil contamination, thus causing problems to public health, soil health and associated impacts. Heavy metals are one of the commanding contaminants in the environment. As a result, different approaches such as phytoremediation have been developed which will minimise contaminations into the soil. This study was conducted to explore the use of selected indigenous crops for heavy metal phytoremediation of mine contaminated soils.

#### MATERIAL AND METHODS

Soils for the study were collected from Tikhontele cooperatives, a sugarcane farm in Barberton, Mpumalanga. A pot study was conducted at the Green Biotechnology Research Centre (GBRC) at the University of Limpopo, treatments comprised of: *Amaranthus hybridus* (A), *Cleome gyanandra* (C1), *Bidens pilosa* (B), *Cucumis africanus* (C2) and control (C0) which contained only soil. The pots were irrigated with deionized water to prevent contamination from the water. Pre and post phytoremediation soil samples were analysed for soil texture (pre sample only), pH (KCl and H<sub>2</sub>O), EC and bioavailable non-essential heavy metals (As, Cd, Cr, Pb) were quantified on ICP-OES. Data was subjected to basic statistics and ANOVA using Genstat 18.

#### **RESULTS AND DISCUSSION**

The treatments effects were found to be highly significant (P≤0.01) on As, Cr and Pb; while Cd was significant. Remediation with the selected indigenous crops increased both pH (KCl and H<sub>2</sub>O) and EC. pH (H<sub>2</sub>O) after phytoremediation ranged between 7.92 and 8.52, pH (KCl) ranged between 6.14 and 6.72 while the EC ranged from 107.2  $\mu$ S/cm to 177.5  $\mu$ S/cm on average. Following phytoremediation, As, Cd, and Pb bioavailability of heavy metals in the mine-contaminated soils was most significantly decreased by *Amaranthus hybridus*, but *Cleome gyanadra* lowered the bioavailability of Cr. The most reduced heavy metal was lead, which had a relative impact of between 44–49% for the various native crops. In general, higher soil pH or organic matter are associated with lower metal bioavailability; on the other hand, low soil pH and root exudate production are associated with increased metal bioavailability.

#### CONCLUSION

The results showed that the chosen native crops were successful in reducing the levels of heavy metals in the soil; contaminated soils treated with *Amaranthus hybridus* showed the highest levels of remediation, with lead being the most reduced heavy metal in the soil.

Keywords: heavy metals, indigenous crops, phytoremediation, soil contamination.
## OXALATE SALT CONCENTRATIONS OF VEGETATION AND TERMITE FRASS IN THE GREATER CAPE FLORISTIC REGION OF SOUTH AFRICA

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#### INTRODUCTION

There is increasing evidence that carbon sequestration occurs via the oxalate-carbonate pathway (OCP) in soils of the Greater Cape Floristic region of South Africa (Francis & Poch, 2019) which converts calcium oxalate (CaOx) to calcite. Oxalate concentrations of organic materials need to be measured (Vermonti, 2022) to assess the importance of CaOx inputs in large mounds (*heuweltjies*) occupied by the southern harvester termite, *Microhodotermes viator* (Clarke et al., 2022). The aim of this study was to determine the CaOx content in vegetation and termite excrement (frass) collected from termite-affected and matrix soils across different biomes by an infrared spectroscopic method.

#### MATERIAL AND METHODS

Oxalate salts in frass and vegetation samples were extracted in water (soluble oxalate) and hydrochloric acid (total oxalate). Chemically derivatized extracts were quantitatively analyzed by liquid chromatography-mass spectroscopy. Reference chemical and spectral data were used to calibrate mid-infrared spectroscopic models to predict concentrations of oxalate species in frass samples. Oxalate salt concentrations of vegetation and termite frass were compared between samples collected from *heuweltjie* soils and the surrounding areas (matrix), as well as between samples collected from regions of contrasting climatic conditions on the southwestern coast of South Africa.

#### **RESULTS AND DISCUSSION**

Direct spectral analyses of dried, milled frass samples yield accurate CaOx concentrations. While different vegetation types have similar CaOx concentrations, the mean CaOx content of frass is lower in regions with higher rainfall relative to lower-rainfall areas, and in heuweltjie soils compared to matrix soils. This indicates either (1) faster degradation of CaOx in soils with greater moisture content, or (2) differences in functional biodiversity of oxalotrophic microbial communities present in these ecosystems. Both vegetation and frass samples collected from the Fynbos biome have a lower mean soluble oxalate content than those from the Succulent Karoo biome, which may be linked to a greater proportion of halophytic succulent vegetation in the Succulent Karoo biome to synthesize anti-herbivory oxalate salts.

#### CONCLUSIONS AND RECOMMENDATIONS

The mid-infrared spectroscopic technique described in this work is suitable for measurement of CaOx in dried frass samples and vegetation extracts. This study highlights the effect of rainfall regime on CaOx dynamics in various climatic zones of the Greater Cape Floristic Region of South Africa. This is an important factor to consider in the evaluation of carbon sequestration due to the OCP in termite-affected soils, as this research suggests greater CaOx inputs via plant material in the Succulent Karoo compared to the Fynbos biome. Analysis of CaOx in frass and vegetation by infrared spectroscopy is applicable to various oxalate-rich ecosystems and offers a standardized approach to assess the contribution of OCP to soil carbon sequestration universally.

**KEYWORDS:** frass, Greater Cape Floristic Region, infrared spectroscopy, insoluble oxalate, oxalatecarbonate pathway, soluble oxalate

#### ACKNOWLEDGEMENTS

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# OCCURENCE AND CONCENTRATION LEVELS OF SELECTED EMERGING CONTAMINANTS AND THEIR METABOLITES IN REPRESENTATIVE AGRICULTURAL LANDS AROUND GAUTENG PROVINCE, SOUTH AFRICA

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#### INTRODUCTION

Concerns over human and environmental health in relation to traceable levels of emerging contaminants in agricultural lands have grown in recent years. Despite this concern, there is currently no available data on background concentration levels of these contaminants in South African agricultural lands. As such, this study aimed to investigate the occurrence and concentration levels of select emerging contaminants and their metabolites in representative agricultural lands within the Gauteng region.

## MATERIALS AND METHODS

The study was conducted on 21 agricultural lands from three districts (Tshwane, Ekurhuleni, and West Rand) in Gauteng province, South Africa. The agricultural lands consisted of two farming systems (rainfed and rainfed+irrigated), three fertilizer types (inorganic fertilizer, animal manure, and municipal sludge), and three cropping systems (cereal, legume, and vegetables). Soil samples were collected from each agricultural land at 20 cm intervals, reaching a depth of 100 cm, using a galvanised metal auger. To avoid contamination, the auger was thoroughly washed with deionised water and rinsed with methanol after every layer of sampling. At least 14 subsamples were collected from each agricultural land and mixed according to their respective layers to prepare composite representative samples per layer. The composite samples were transferred to aluminium foils, freeze-dried, sieved, and stored at -20 °C until analyses. The EPA method 1694 was employed to extract contaminants and their metabolites from soil samples. Using the Waters ® LC-MS/MS instrument, the target emerging contaminants and their metabolites were quantified from the extracts.

#### **RESULTS AND DISCUSSION**

The results of a study conducted on agricultural lands in Gauteng indicate the presence and concentration of emerging contaminants and their metabolites. The study revealed that only caffeine and bisphenol A were detected, with levels ranging from 0.80 to 20.21 ng g<sup>-1</sup> and 30.2 to 248.55 ng g<sup>-1</sup>, respectively. Notably, these contaminants were found frequently, regardless of farm location, farming systems, fertilization types, and cropping systems. Specifically, caffeine and bisphenol A were detected in 90.5% and 76.2% of samples tested, respectively, suggesting a widespread contamination issue of agricultural lands in Gauteng.

#### CONCLUSION

It can be inferred that emerging contaminants and their metabolites have been detected in agricultural lands across Gauteng Province, South Africa, under diverse farming, fertilization, and cropping systems. Nevertheless, the levels of concentration observed were low and may not pose significant risks to the health of humans and the environment.

KEYWORDS: Emerging contaminants, metabolites, soil

#### ACKNOWLEDGEMENTS

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# COMPARING MACHINE LEARNING AND KRIGING FOR PREDICTING TOPSOIL ORGANIC CARBON DISTRIBUTION IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA

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#### INTRODUCTION

Soil organic carbon (SOC) is crucial for providing insights into soil fertility and health, mitigating climate change, and aiding in sustainable land management. Limited studies have attempted to map SOC using digital soil mapping (DSM) methods in South Africa. This study aimed to predict topsoil SOC distribution in the Western Cape province based on Random Forest (RF) and Regression Kriging (RK).

#### MATERIALS AND METHODS

A total of 955 SOC measurements were used and weighted averaging was used to calculate SOC measurements at a depth of 50 cm. Twenty-seven (27) environmental covariates were used. These included Landsat 7 derived vegetation indices, terrain derivatives obtained from the 90m Suttle Radar Topography Mission digital elevation model (SRTM DEM), and climate variables such as mean annual precipitation (MAP) and temperature (MAT). The sample dataset was randomly split into 60% for training and 40% for validation. The Random Forest and krige packages found in R statistical software environment were used for RF and RK modelling. The Boruta wrapper was employed to select an optimal subset of important variables. Furthermore, for accuracy assessment, both models were assessed using R<sup>2</sup>, root mean square error (RMSE) and mean absolute error (MAE).

#### **RESULTS AND DISCUSSION**

The Boruta wrapper identified 15 important variables, such as surface texture, MAP, soil brightness index (BI), solar radiation, Enhanced Vegetation Index (EVI) and visible bands, to mention some. RF outperformed RK on the training, validation, and optimal subset, producing R<sup>2</sup> values of 0.92, 0.45 and 0.46, respectively, while also obtaining RMSE values of 0.28, 0.58 and 0.56. In contrast RK achieved R<sup>2</sup> values of 0.39, 0.40 and 0.40, and the RMSE of 0.61, 0.59 and 0.59 for the training, validation, and optimal subset datasets, respectively. The significant drop in RF prediction on the validation dataset indicates model overfitting, while RK shows consistency across the three datasets. R<sup>2</sup> values in this study are in line with previous studies where values ranging from 7 – 57% were recorded. The RMSE followed similar trend as those of R<sup>2</sup> and RMSE for RF and RK. Additionally, SOC environmental controlling factors (for example climate, variability, scale, spatial resolution of covariates, relief, and parent materials) are key to the prediction of SOC and appear to have impacted the results in this study.

#### CONCLUSIONS

Although the RF results on validation datasets are moderate at best, the study provides a point of departure for future research. Future studies can incorporate higher resolution climate and DEM data, improve sampling strategies to capture the variability of SOC, incorporate SOC controlling covariates based on scales and explore deep learning to improve accuracy.

**KEYWORDS:** Digital soil mapping; environmental covariates; random forest; regression kriging; soil organic carbon

# ALTERNATIVE USE OF INVASIVE PLANTS RELATING TO MORINGA FOR BIOCHAR TO IMPROVE SOIL QUALITY: CASE STUDY OF SWISSCHARD (*BETA VULGARIS* L.)

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#### INTRODUCTION

The introduction of various invasive trees biochar in this study may help in reducing the widespread of these invasive trees being underutilised and considered as a major weed on marginal soils threatening the ecosystem and posing serious threat to human health. Pyrolysis of invasive plants to prepare biochar, has been considered as an alternative way to protect the ecosystem and also for efficient use of waste for vegetable production as soil amendment. However, with the potential biochar has been depicting it is further commended to improve nutrient availability and water retention in soil, as well as reduce the leaching of nutrients and agricultural chemicals. Furthermore, the application of biochar believed in increasing water infiltration and root penetration. However, incorporation of biochar from various invasive plants to probe the growth effect of Swisschard was never investigated. Therefore, the objective of this study was to examine the response of invasive plants biochar to improve soil quality and Swisschard production.

#### MATERIALS AND METHODS

Initially, feedstocks of Moringa and various invasive plants wood chips were weighed (2kg each), respectively. After preparation, the obtained biomass materials were put into a biochar kiln for pyrolysis at a  $(300 - 400^{\circ} \text{ C})$ . The heating rate was maintained for 2h after reaching the target temperatures, to produce biochars derived from different plants. Thereafter, a glasshouse experiment was conducted at the Agricultural Research Centre (ARC-VIMP) using feedstocks produced from Moringa, Lantana, Neem and Bugweed biochar as treatments. Treatments were arranged in a randomised complete block design, with six replications. Uniform one-month old Swisschard seedlings, at four leaf stage, were transplanted into 25-cm diameter pots, filled with loam soils that were mixed with Hygromix-T at 3:1 ratio (v/v). 20 g biochar from the different sources per plant was applied. Sixty days after initiating the treatments, plant variables were collected and subjected to analysis of variance (ANOVA).

# **RESULTS AND DISCUSSION**

The treatments had significant ( $P \le 0.05$ ) effects on chlorophyll content and dry shoot mass, contributing 79.7 and 67.1% in total treatment variation (TTV) of the respective variables. However, there was no significant effect on number of leaves, plant height and fresh shoot mass, contributing 32.4, 21.4 and 40.8% TTV, respectively. Generally, Swisschard performed the best in both Lantana and Moringa biochar compared to Neem and Bugweed biochar. Both Demisie et al. (2014) and Nelissen et al. (2015), discovered that the application of biochar in soil increases the organic carbon content. In addition, numerous studies have shown that biochar increases plant biomass, total organic carbon and its labile fractions, which subsequently increases microbial activity, soil aggregation and carbon sequestration, improving overall soil quality.

#### CONCLUSION

Results of this study empirically confirmed that soil incorporated with Moringa or Lantana biochar improved the growth and quality of Swisschard compared to biochar made from other plants. Therefore, it is recommended that both Lantana and Moringa biochar be used in rural marginal communities to improve soil quality, enhance production and help inorganic environmental pollutions.

# TEN-YEAR EFFECT OF TILLAGE, CROP ROTATION AND CROP RESIDUE MANAGEMENT PRACTICES ON SELECTED SOIL PHYSICAL PROPERTIES IN THE SUB-HUMID REGION OF EASTERN CAPE, SOUTH AFRICA

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#### Introduction

Unsustainable agricultural practices, such as mono-cultural production, intensive tillage, and residue removal, can lead to the degradation of soil physical properties over time. However, conservation agriculture (CA) that follows three linked principles, namely minimum soil disturbance, crop residue retention, and crop rotation sequences, can significantly minimize soil degradation. Although most studies on CA have focused on the short term, this study aims to evaluate the medium-term (10-year) effects of CA on selected soil physical properties in the sub-humid region of Eastern Cape, South Africa. It was hypothesised that no-tillage, rotational cropping, and residue retention can improve soil physical properties and hydraulic properties overtime.

#### Materials and methods

The evaluation was done on an ongoing CA field trial at Phandulwazi ( $32^{\circ} 39'$  S and  $26^{\circ} 55'$  E) established in 2012. The experiment was laid out in a split split-plot design with 16 treatment combinations and three replicates per treatment. The main plots were allocated to tillage (no-till (NT) and conventional tillage (CT)), sub-plots to crop rotations (maize-fallow-maize (MFM); maize-fallow-soybean (MFS); maize-wheat-maize (MWM) and maize-wheat-soybean (MWS)) and the sub sub-plots to residue management (residue removal (R-) and residue retention (R+). Soil samples from 0 – 10, 10- 20 and 20– 30 cm depths were collected using an auger. Bulk density (BD) was measured using core rings, saturated hydraulic conductivity using SATURO dual head infiltrometer, soil aggregate stability (AGS) using both wet and dry sieving method, and penetration resistance (PR) using a dynamic cone penetrometer. gravimetric ( $\phi$ ) and volumetric ( $\theta$ v) water content at field capacity were calculated from the weighed masses following their standard formulars. Statistical differences were tested using ANOVA and JMP software analyzed the data. Mean comparison was done with Student t-tests.

#### **Results and discussion**

The results showed that tillage practices have a dominant significant effect over crop rotations and residue management on bulk density (BD), porosity( $\phi$ ) and aggregate stability (AGS) as there were higher differences between NT and CT plots. High bulk density under CT is due to severe tillage practices that destroy soil aggregates and structure (Dikgwatlhe *et al.* 2014), these observations contradict those of Zuber *et al.* (2015); Haruna *et al.* (2018); Moraru and Rusu (2013). NT treatment plots had a greater PR compared to CT, these findings correspond with those of Schwartz *et al.* (2003) and Alvarez *et al.* (2009). Soybean rotation treatments (MFS and MWS) had a significant effect on BD and AGS, likely due to the quick decomposition of soybean residues and the resulting higher soil organic matter (SOM) content compared to wheat or maize residues. This contrasts with a short-term study by Gura *et al.* (2022), where crop rotations had little effect on soil properties compared to tillage and residue management. Additionally, residue-retained plots had higher gravimetric water content ( $\theta$ m) and volumetric water content ( $\theta$ v) due to the substantial amount of SOM returned by residue decomposition, which enhances soil quality, as seen in Cherubin *et al.* (2021). There were no significant differences observed in Ks, which could be attributed to the nature of the particle size distribution, as water moves more easily on sandy soils.

#### Conclusion

According to this study, Conservation Agriculture (CA) has been shown to effectively reduce soil physical degradation by enhancing specific soil physical properties like AGS, BD, and  $\phi$ . Furthermore, incorporating soybean crops into crop rotations and retaining residue can significantly promote soil development and decrease degradation rates over time. To fully assess the efficacy of these treatments, it is strongly advised to conduct long-term evaluations, as time is a critical factor in soil reintegration via Conservation Agriculture practice.

#### References

- Gura I, Mnkeni PNS, Du Preez CC, Barnard JH. 2022. Short-term effects of conservation agriculture strategies on the soil quality of a Haplic Plinthosol in Eastern Cape, South Africa, *Soil and Tillage Research* 220, 105378: 0167–1987.
- Nyambo P, Chiduza C, Araya T. 2022. Effect of conservation agriculture on selected soil physical properties on a haplic cambisol in Alice, Eastern Cape, South Africa, Archives of Agronomy and Soil Science, 68:2, 195–.208.

Keywords: Conservation agriculture, soil degradation, soil physical properties,.

# PERSISTENCE OF SOIL PROFILE CARBON FRACTIONS UNDER TEN YEARS OF CONSERVATION AGRICULTURE SYSTEMS IN SUB-HUMID EASTERN CAPE, SOUTH AFRICA

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#### Introduction

Numerous studies have reported a positive effect of conservation agriculture (CA). However, most studies have been conducted on the topsoil, furthermore the studies focused on the short-term effects of conservation agriculture. Therefore, the time required for CA to express its benefits is not fully realized. An experiment was conducted to determine the effect of medium-term CA practice on soil organic carbon, soil organic matter, soil carbon stocks and as well on carbon sequestration in the sub-humid areas of the Eastern Cape province, South Africa.

#### Materials and methods

An experiment was conducted on an ongoing trial at Phandulwazi Agricultural High School on the Phandulwazi Jozini ecotope ( $32^{\circ} 39'$  S and  $26^{\circ} 55'$  E) which was initiated in 2012. The trial was laid in a split-plot design with 16 treatments combinations and three replicates per block. Main plots were allocated to tillage, sub-plots to crop rotation and the sub sub-plots to residue management. The soils were sampled from 0-20, 20-40 and 40-60 cm depth respectively during the 2022/23 winter season. Soil organic carbon was analyzed following the modified Walkley-Black method. The Soil organic matter was calculated using the formula Total organic carbon x 1.72. Ellert and Bettany (1995) method was adopted for soil organic carbon stocks, whereas carbon sequestration was calculated by conversion factors of 3.67 as Carbon sequestration = SOC stock × 3.67.

#### **Results and discussion**

Tillage treatments had a significant influence (p < 0.05) on SOC, SOM, SOC stock and C-sequestration at 0-20 cm depth. However, tillage, crop rotation and residue management did not show any significant difference at 20 – 40 cm and 40 – 60 cm depths. When comparing conventional tillage to no-till, no-till had a higher improvement than conventional tillage, the reason for this is that the soils under no-till are minimal disturbed more nutrients are trapped on the soil surface.

#### **Conclusion and recommendations**

The current study showed that conservation tillage is a better tillage practice than conventional tillage. It is recommended that future studies should be done on a long-term basis as this study was conducted on a 10-year-old trial.

#### References

Franko U and Ruehlmann J. 2018. SOC sequestration as affected by historic and present management. *Geoderma*. 321. 15–21.

Lal R. Restoring Soil Quality to Mitigate Soil Degradation. Sustainability. 2015; 7(5):5875-5895.

Keywords: Conservation agriculture, Conventional tillage, No-till, SOC, SOM

# IMPACT OF ACCUMULATED PATHOGENIC BACTERIA FROM TREATED WASTEWATER ON SELECTED FERTILITY VARIABLES AND BENEFICIAL BACTERIA IN AGRICULTURAL SOIL

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# INTRODUCTION

The use of treated wastewater (TWW) as a potential source to alleviate water shortages has led to the accumulation of pathogens in the soil. However, the effect of pathogens on soil fertility variables and beneficial bacteria remains unknown. This information could help derive TWW and tap water (TP) dilution levels, which can maintain the soil fertility status and beneficial bacteria counts when used for irrigation, while saving on fresh TP. Thus, this study investigated the relationship between accumulated pathogens and the fertility status together with beneficial bacteria in agricultural soil irrigated with diluted TWW.

# MATERIALS AND METHODS

A 2 x 5 factorial arranged in a randomised complete block design (RCBD) was conducted at the University of Limpopo (UL). There were two temperature conditions [controlled temperature (incubator) and uncontrolled temperature (shade house)] and five irrigation treatments (100%TWW, 75%TWW + 25%TP, 50%TWW +50%TP, 25%TWW + 75%TP, and 100%TP) each having different counts of pathogens. Selected groups of pathogenic and beneficial bacteria were isolated from the water combinations and soil samples. In addition, phosphorus (P), nitrogen (N) and potentially mineralisable nitrogen (PMN) were analysed from the pre- and post-irrigation soil samples. Pearson's correlation analysis was performed to assess the relationship between the accumulated pathogenic and beneficial bacteria, and between the pathogens and fertility variables.

#### **RESULTS AND DISCUSSION**

The results revealed that the accumulated pathogenic bacteria led to a significant decrease (p<0.01) in the counts of nitrifiers, PMN and N. This observation was due to the competition for N between the nitrifiers and pathogens during both trials. Hence a negative correlation between the pathogenic and beneficial bacteria was observed. However, a significant increase (p<0.01) in P and phosphate solubilizing bacteria was observed in the soil showing that there is little to no competition for P between the pathogens and phosphate solubilising bacteria. Diluting TWW reduced the counts of the accumulated pathogens in the soil and their competition with beneficial bacteria for nutrients.

#### CONCLUSION

In this study, the use of undiluted TWW resulted in the highest accumulation of pathogenic bacteria which increased the competition for nutrients in the soil and negatively affected both the beneficial bacteria and fertility status of the soil. However, the dilution 50%TP+ 50%TWW was favoured since it had minimal effects on counts of nitrifiers and phosphate solubilising bacteria.

Keywords: Bacteria, soil fertility, treated wastewater

# ACKNOWLEDGMENTS

National Research Foundation for funding and University of Limpopo for infrastructure.

# EXAMINATION OF SOIL

# EXAMINATION OF SOIL HYDROLOGICAL BEHAVIOR IN GRASSLAND, RANGELAND, AND CROPLAND LAND USES USING HYDROPEDOLOGICAL INTERPRETATION IN THE SELECTED ECOTOPES OF THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

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# INTRODUCTION

The Eastern Cape Province in South Africa is dominated by semi-arid climate, highly dispersive soils, and inappropriate land use management practices. Soils are at the nexus of hydrological cycle, specific properties that contribute to the hydrological cycle are soil hydraulic and soil physical properties. Hydropedology is the complimentary result of the interaction between soil physics, pedology, and hydrological approach to examine the soil hydrological behavior. The aim of this study is to use the hydropedological approach to examine the soil hydrological behavior of grassland, cropland, and rangeland soils in three sub-catchment areas in the Raymond Mhlaba municipality, Eastern Cape Province.

# MATERIAL AND METHODS

The grassland, cropland, and rangeland were identified in Tyume, Keiskamma and Kat River subcatchment areas. A total of 324 soil samples were collected, 108 samples from A and B horizon were used to measure soil particle size distribution. The 324 soil cores were used to measure soil water content, and soil bulk density from the A, B and C horizons. Field measurements on the soil surface for soil hydraulic conductivity were measured using the automated dual head infiltrometer (SATURO). Soil bulk density was determined using the core method. The particle size distribution using the pipette method. The QGIS 3.24.1 software was used to create the study area, soil type, elevation, and land use cover map.

# **RESULTS AND DISCUSSION**

Land use and soil type were delineated on a map within the municipality and the three sub catchments highlighted. Bulk density was highest for the on the soil surface horizons in land uses. High soil hydraulic conductivity in grasslands ranging from 0,0170164 cm/s and 0,0035261 cm/s for Kieskamma and Upper Tyume sub catchments respectively. The results are indicative of high infiltration associated with high lateral water flow. High bulk densities were observed on cropland and rangeland which could contribute to overland flow as the dominant soil hydrological flow. The hydropedological interpretation of soil hydrological behavior using soil hydraulic properties was affected by the land use type. The results contribute to further understanding of sub catchment hydrological processes.

# CONCLUSIONS

The hydropedological interpretation of soil hydrological behavior using soil hydraulic properties was by land use type in Raymond Mhlaba municipality, emphasizing the relevance of land use on soil hydrology. As such, the data is useful for decision-making related to sustainable soil and water resource management, especially in fragile environments with limited water and land use management.

**KEYWORDS:** Catchment area, ecotopes, soil hydrological processes, sustainable management, water flow paths.

# ACKNOWLEDGEMENTS

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# COMPARISON OF NUTRIENT USE EFFICIENCIES IN CITRUS UNDER DIFFERENT FERTILIZATION AND IRRIGATION MANAGEMENT PRACTICES

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#### INTRODUCTION

Excessive applications of nitrogen (N) and phosphorus (P) can lead to soil acidification, runoff, leaching and water contamination. Additionally, the production of synthetic N fertilizers is a fossil fuel energyintensive process, while P fertilizers are derived from non-renewable sources. This underscores the need for the citrus industry to adopt more sustainable management practises, with focus on improving nutrient use efficiency (NUE). Despite extensive research on the NUE of annual crops such as cereal grains and maize in South Africa, little research has been conducted on perennial crops such as citrus (Edmonds *et al.* 2009). This study aimed to assess and compare the NUE of current fertilization and irrigation practices used in the citrus industry.

## MATERIALS AND METHODS

The study was conducted in four of the main citrus production regions (Citrusdal, Kirkwood, Nelspruit and Letsitele). Within each region, at least four orchards were selected with the following production systems: micro-sprinkler with granular fertilizer, micro-sprinkler with fertigation, conventional drip [1.6 l/h], and low flow continuous drip [< 1 l/h]. All orchards followed standard commercial practices. Data collected included soil, leaf and fruit nutrient samples, and orchard yield (kg/ha). The following NUE parameters were calculated, as defined by Doberman (2007): Partial factor productivity (PFP), partial nutrient balance (PNB) and internal utilization efficiency (IE).

#### **RESULTS AND DISCUSSION**

The micro-sprinkler with granular fertilizer system obtained the highest average yield (62 ton/ha) across all regions, followed by the conventional drip treatments (57 ton/ha). Additionally, the micro-sprinkler with granular fertilizer consistently produced significantly better PFP, PNB and IE values compared to the other treatments. Conversely, the low-flow continuous drip treatments displayed relatively lower NUE values, which was primarily attributed to its higher N application rates.

#### CONCLUSION

This study stands as an explorative study on NUE of irrigation and fertilisation systems used in the citrus industry of South Africa. Overall, the micro-sprinkler with granular fertilisation appeared to have better nitrogen NUE and the results suggest that higher N application rates in low-flow continuous drip treatments are not ideal in terms of NUE.

#### REFERENCES

Doberman, A. 2007. Nutrient use efficiency – measurement and management. In "IFA International Workshop on Fertilizer Best Management Practices", Brussels, Belgium, p1-28.

Edmonds DE, Abreu SL, West A et al. 2009. Cereal nitrogen use efficiency in sub–Saharan Africa. *Journal of Plant Nutrition* 32: 2107–2122.

Keywords: Nutrient use efficiency, citrus sinensis, fertilisation, irrigation, soil fertility

# VISUAL EVALUATION OF SOIL STRUCTURE UNDER LONG-TERM NO-TILLAGE SYSTEM

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#### INTRODUCTION

Soil structure is a sensitive and dynamic property that responds rapidly to management practices, land use changes, moisture and temperature regimes (Yudina and Kuzyakov, 2023). As a result, it requires frequent assessment and monitoring. Soil tillage systems are the major contributors to soil structural modifications [(Li *et al.*, 2019; Liu *et al.*, 2021; Pires *et al.*, 2017; Tian *et al.*, 2022). Traditional methods used for quantifying soil structural parameters are generally expensive, time consuming and require an in-depth knowledge of soil science. However the visual evaluation of soil structure method (VESS) has the potential to be used as an alternative. VESS will enable farmers and land users to frequently assess and monitor soil quality as it is cheap, easy to execute and rapid. Despite its reported effectiveness, VESS is not commonly used in South Africa. The objective of the study was to assess the long-term effect of No-tillage on soil structure quality using VESS method.

#### MATERIAL AND METHODS

The study was carried out at Tshivhilwi and Dzingahe e in Thohoyandou, Vhembe district, Limpopo province, South Africa. Soil samples were collect from no-tillage, conventional tillage and virgin fields. Five sampling points (30 cm depth) were randomly selected in 1000 m<sup>2</sup> of each field considering the homogeneity of the soil. The VESS method was used to assess soil structure quality (Sq score 1–5) (Ball *et al.*, 2007; Guimarães *et al.*, 2011). Soil bulk density, porosity, aggregate stability, organic carbon and clay content were also analysed. The data was analysed with IBM SPSS statistics 29.0 statistical software.

#### **RESULTS AND DISCUSSION**

VESS showed significant difference at Dzingahe only. The soil structure quality was poor for all the tillage systems (NT: Sq = 3.53; CT: Sq = 4.12; VG: Sq = 3.67) at Tshivhilwi. However, at Dzingahe it was fair (Sq = 2.25) in NT and poor fin CT (Sq = 3.57) and VG (Sq = 3.05). No-tillage had a better structure in both locations. VESS indicated a positive correlation with bulk density, organic matter, then a negative correlation with mean weight diameter and porosity. VESS and clay correlated positively and negatively at Dzingahe and Tshivhilwi respectively.

#### CONCLUSIONS

VESS was able to effectively differentiate between the impacts of tillage systems on soil structural quality. The soil structure quality was fairly good under long-term NT at Dzingahe.

#### REFERENCES

- Ball, B.C., Batey, T. and Munkholm, L.J. 2007. Field assessment of soil structural quality A development of the Peerlkamp test. *Soil Use and Management*, Vol. 23 No. 4, pp. 329–337.
- Guimarães, R.M.L., Ball, B.C. and Tormena, C.A. 2011. Improvements in the visual evaluation of soil structure. No. September, pp. 395–403.
- Li, J., Guo, Z. and Xu, Y. 2019. Soil structure and stability features under rotation tillage. *IOP Conference Series: Earth and Environmental Science*, Vol. 384 No. 1, available at:https://doi.org/10.1088/1755-1315/384/1/012213.
- Liu, Z., Cao, S., Sun, Z., Wang, H., Qu, S., Lei, N., He, J. and Dong, Q. 2021. Tillage effects on soil properties and crop yield after land reclamation. *Scientific Reports*, Nature Publishing Group UK, Vol. 11 No. 1, pp. 1–12.
- Pires, L.F., Borges, J.A.R., Rosa, J.A., Cooper, M., Heck, R.J., Passoni, S. and Roque, W.L. 2017. Soil structure changes induced by tillage systems. *Soil and Tillage Research*, Elsevier B.V., Vol. 165, pp. 66–79.
- Tian, M., Qin, S., Whalley, W.R., Zhou, H., Ren, T. and Gao, W. 2022. Changes of soil structure under different tillage management assessed by bulk density, penetrometer resistance, water retention curve, least limiting water range and X-ray computed tomography. *Soil and Tillage Research*, Elsevier B.V., Vol. 221, available at:https://doi.org/10.1016/J.STILL.2022.105420.
- Yudina, A. and Kuzyakov, Y. 2023. Dual nature of soil structure: The unity of aggregates and pores. *Geoderma*, Elsevier B.V., Vol. 434, available at :https://doi.org/10.1016/J.GEODERMA.2023.116478.

Keywords: Structure, tillage, VESS

# ASSESSING THE IMPACT OF VARIOUS PRESCRIBED FIRE FREQUENCIES ON SOIL BACTERIAL DIVERSITY AND COMPOSITION IN THE SEMI-ARID SAVANNA RANGELANDS

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#### INTRODUCTION

Prescribed burning has been used to effectively manage open landscapes, regulate dominant species, and reduce wildfire threats. Research on the effect of prescribed burning has paid little attention to soil microorganisms (bacteria). Bacteria perform a variety of critical ecological tasks, such as nutrient cycling. In fire frequent environments, the disturbance of bacteria in performing their functions during ecosystem recovery can be continuously hindered, which may further differ with the extent of the fire frequencies. The aim of this study was to determine the influence of different fire frequencies on bacterial communities in a semi-arid savanna rangeland.

#### MATERIAL AND METHODS

The study was conducted on a long-term prescribed fire trial of the University of Fort Hare initiated in 1980 using the following treatments: no burn, annual, biennial, triennial, quadrennial, and sexennial burn. Treatments were arranged in a completely randomised design and were replicated twice. Three soil samples were randomly taken from each treatment plot, mixed to form a composite sample, and stored in an insulated box with ice. Samples were transported to the laboratory and crushed to pass a 2 mm sieve. A bacterial 16S rRNA gene region was selected as the target sequences to identify bacterial species. The data were analysed using permutation multivariate ANOVA for comparison of fungal diversity indices using R software (version 4.1.2).

#### **RESULTS AND DISCUSSION**

The Observed, Chao1, Shannon-Wiener and InvSimpson indices were used for composition and diversity analysis. It was observed that the count of the number of taxa present (richness) was highest in triennial and the least count was observed in quadrennial burn treatment. Species richness increases with the increase in burning treatments was observed in this study. The most abundant phylum was *Actinobacteriota*, which can produce biologically active substances like enzymes, antibiotics, and vitamins. However, these bacteria are responsible for the decomposition of plants and animal materials.

#### CONCLUSIONS

The current study showed that the bacterial composition and diversity were affected by various fire frequencies. Although this is a long-term trial, the data in the current study was collected over one season, and it is recommended that future studies should collect data over a longer duration to assess the impact of prescribed fire frequencies on soil microbial communities over time.

Keywords: bacterial composition, bacterial diversity, climate change, taxa visualisation

# CALCULATING SOIL TITRATABLE ACIDITY FROM ROUTINE SOIL ANALYSES OF

# CULTIVATED SOUTH AFRICAN SOILS USING VARIOUS MODEL STRUCTURES.

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#### INTRODUCTION

Soil titratable acidity (TA) is determined through extraction with an acetate-buffered salt solution ( $K_2SO_4$ ) and is routinely used in the determination of soil lime requirement (LR) using the Eksteen method. Soil TA is not always reported by commercial laboratories but rather exchangeable acidity (1M KCl). Therefore, a need exists to use other routinely determined soil properties in a model to derive TA. Therefore, this study aimed to compare theoretically calculated TA using various model structures and Eksteen calculated TA to the actual measured TA so that an interpretable function for determination of TA from known soil properties can be generated.

#### MATERIAL AND METHODS

Routine soil analysis results from a commercial soil laboratory (n = 5915) were used to generate various model structures to calculate a theoretic TA value and to evaluate the accuracy thereof. Based on the correlation analysis using Pearson correlation coefficients, variables significantly related (p < 0.05) to measured TA were selected. A series of frequentist general linear models (GLM's), assuming linear, exponential, and polynomial (2<sup>nd</sup> and 5<sup>th</sup> order) functional forms were specified. A generalised additive model (GAM) and a range of machine learning algorithms, including multi-adaptive regression spline (MARS), decision tree (DT) and random forest (RF) models, were used to model possible non-linear relationships between TA and predictor variables. Selected variables were not included as interactions since this reduced interpretability and ease of use of the model.

# **RESULTS AND DISCUSSION**

Measured TA was found to be significantly correlated to the calculated TA using the Eksteen R-value, soil pH, organic carbon (OC), exchangeable Ca<sup>2+</sup> and Mg<sup>2+</sup> and a function of the interaction between pH and OC. Soil TA could most accurately be calculated using these factors in a multi-adaptive regression splines (MARS) model (R<sup>2</sup> = 0.69, MAE = 0.16) at TA values < 2 cmol<sub>c</sub> kg<sup>-1</sup>. However, exponential model calculations remained stable over a larger range of actual TA values up to 4 cmol<sub>c</sub> kg<sup>-1</sup>.

# CONCLUSIONS

There is value, in terms of prediction accuracy and robustness to overfitting, in using more sophisticated model structures to calculate TA such as the MARS and DT models, but that when ease of use and interpretability is important, simple model structures such as the exponential model can be considered.

#### REFERENCES

Eksteen L. 1969. The determination of the lime requirements of soils for various crops in the winter rainfall region.pdf. *Fertilizer Society of South Africa Journal 2*: 13–14.

Keeney DR, Corey RB.1963. Factors affecting the lime requirement of Wisconsin soils. *Soil Science Society of America Journal* 27: 277-280.

Keywords: soil exchangeable acidity, soil lime requirement, soil analysis, soil acidity, soil fertility

# PHOSPHORUS USE EFFICIENCY OF COMMONLY GROWN POTATO CULTIVARS IN SOUTH AFRICA

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#### INTRODUCTION

Phosphorus is an essential macronutrient required for various biochemical processes in potato (*Solanum tuberosum*) production. However, its limited availability in soil due to fixation and low solubility often makes it a limiting factor. Understanding phosphorus use efficiency (PUE) in potatoes is vital for maximizing yield while minimizing phosphorus fertilizer wastage.

#### MATERIALS AND METHODS

A pot experiment was conducted under greenhouse conditions at the North West University to evaluate the PUE of commonly grown potato cultivars in South Africa. Four potato cultivars namely Mondial, Sifra, Tyson and Sababa were selected together with three different phosphorus application rates: 0 kg P ha<sup>-1</sup> (as the control), 145 kg P ha<sup>-1</sup>, and 205 kg P ha<sup>-1</sup>. The treatments were replicated three times and arranged in a randomized complete block design resulting in a total of 36 experimental units. Various plant growth parameters were collected at tuber initiation stage namely: plant height, main stem numbers and Normalized Difference Vegetation Index (NDVI). At harvest, shoot biomass, root biomass and tuber yield measured, and PUE calculated.

# **RESULTS AND DISCUSSION**

Mondial and Sababa consistently demonstrated significantly higher tuber yields, NDVI values, and phosphorus use efficiency (PUE) values (P<0.05). Moreover, both cultivars exhibited the highest root-to-shoot ratio compared to Tyson and Sifra, emphasizing their efficiency in phosphorus allocation and utilization. Despite Sababa achieving the best yield when receiving 205 kg P ha<sup>-1</sup>, Mondial exhibited a higher PUE at a lower phosphorus application rate (145 kg P ha<sup>-1</sup>). This superior performance of Mondial and Sababa is indicative of their remarkable ability to optimize phosphorus resources and employ an efficient phosphorus allocation strategy, as underscored by their elevated root-to-shoot ratio.

#### CONCLUSIONS

These findings indicate that Mondial cultivar is more efficient in phosphorus utilization per kilogram P applied, making it a more cost-effective choice with regards to P fertilizer management relative to other cultivars tested in this study.

KEYWORDS: Potato cultivars, phosphorus use efficiency, tuber yield, South Africa

#### ACKNOWLEDGEMENTS

Wesgrow potatoes (Pty) Ltd for supplying potato seeds and the North West University for supplying greenhouse space to conduct the experiment

## SIX YEARS OF BUSH CLEARING OF COLOPHOSPERMUM MOPANE DEPLETES SOIL NUTRIENTS IN A SAVANNA GRASSLAND

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## INTRODUCTION

Bush encroachment leads to the widespread proliferation of woody plants (shrubs, trees) in open savanna grasslands, leading to a decline in grass productivity, biodiversity, and soil quality. Currently, bush clearing is the most common method of counteracting bush encroachment. This restoration method has been promoted to have the potential to improve and restore soil quality, thereby increasing the success rate of vegetation restoration efforts. However, the effects of bush clearing on soil nutrients remain understudied. This study aimed to determine the consequences of bush clearing of mopane (*Colophospermum mopane*) on soil nutrients in an encroached savanna grassland.

#### MATERIALS AND METHODS

The study consisted of two adjacent permanent sample plots (30 m × 60 m) established in 2015 on a homogeneous landscape position and soil type. In one plot, mopane trees (< 4 m) were manually cut at the base 2-3 times per year (2015-2021) to create a bush-cleared plot, whereas the other plot was left uncleared. For soil sampling and classification, three 10 m × 10 m plots were randomly established in each 30 m × 60 m plot, and three pits were dug to a depth of 1 m. Soil samples were collected up to a depth of 30 cm at 10 cm depth intervals and analysed for selected soil nutrients and inherent physicochemical properties.

#### **RESULTS AND DISCUSSION**

On average, bush clearing of mopane significantly (p < 0.05) depleted soil nutrients phosphorus (P), exchangeable calcium (Ca), magnesium (Mg), copper (Cu), and manganese (Mn) by 35%, 18%, 18%, 27%, and 27%, respectively compared to uncleared plot. The greatest depletion of Ca, Mg, Cu, and Mn was in the 0-10 cm layer, with recorded values of 30%, 36%, 45%, and 41%, respectively. Similarly, P was depleted by 40% in the 20-30 cm layer. Nutrient depletion in bush-cleared plots was associated with a decrease in soil organic matter, reduction in cation exchange capacity, and weakening of the soil structure.

#### CONCLUSION

This study demonstrated that bush clearing of mopane trees results in P, Ca, Mg, Cu, and Mn depletion, causing a negative trajectory for soil quality. Additionally, the findings provided insight into the influence of soil depth on the magnitude of soil nutrient depletion. This crucial quantitative data will serve as a reference for adaptive bush encroachment management.

KEYWORDS: Bush clearing, savanna grasslands, shrub encroachment, soil nutrients, mopane

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#### INTRODUCTION

Digital Soil Mapping (DSM) is a powerful tool that exploits soil point data and environmental covariates, that are put through machine learning methods to derive the relationship between the soil forming factors and soil properties. Traditionally, research approach involves first establishing a budget before determining the sample size and positions, with these parameters being constrained by the budgetary limitations. However, DSM allows us to develop sampling methodologies, designed to facilitate the precise determination of both the appropriate sample size and optimal sampling positions. Thus, resulting in the formulation of an informed budget for a good spatial distribution of soil data.

#### MATERIAL AND METHODS

The objective of this study is to develop sampling methodologies using DSM techniques, designed to facilitate the precise determination of both the appropriate sample size and optimal sampling positions.

To achieve this objective, various covariates (x) including Multiresolution Index of Valley Bottom (MRVBF), Normalized Difference Vegetation Index (NDVI) and Topographic Wetness Index (TWI) were collected for the study site and Conditioned Latin Hypercube (cLHC) sampling method was used to select various sample sizes (n). Resulting in the comparison of covariate space xi (i= 1, .... k) and 3 cLHC sample sets with sizes nj (j = 100, 500, 1000). Various sample size representativeness of the study site was assessed using statistical analysis including q-q plots and p-values.

#### **RESULTS AND DISCUSSION**

The preliminary results indicate that the p-values for all the covariates were higher than the threshold for statistical significance (0.05/5%) for the different sample sizes. This implies that there is a substantial statistical similarity between the covariate values of the study area and the values observed at the sampled points. Additionally, q-q plots were created, and Root Mean Square (RMS) computed as part of the analysis based on the 100<sup>th</sup>, 500<sup>th</sup>, and 1000<sup>th</sup> quantiles. The results indicate that the NDVI exhibited the lowest RMS value for the 100 samples. However, the other covariates displayed relatively high RMS values at both 100 and 200 samples. Notably, with a larger sample size of 1000, all the factors demonstrated low RMS values, suggesting greater representativeness of the study area.

#### CONCLUSIONS

DSM techniques allow for the determination of optimal sample size and sampling positions and the statistical analysis of the results to investigate the spatial representativeness of the acquired results. Therefore, resulting in good spatial distribution and coverage of the study area and better management of time and cost for researchers involved in fieldwork.

*Keywords:* Covariate data, Optimal coverage, Optimal Sampling strategies, Spatial distribution, Statistical analysis

# IMPACTS OF GLYPHOSATE ON SOIL MICROBIAL COMMUNITIES IN SOYBEAN SYSTEMS

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**Introduction**: Glyphosate [N-(phosphonomethyl) glycine] is the most widely used systematic nonselective herbicide in third-world countries due to its effective weed control in agriculture. Following the introduction of glyphosate-resistant (GM) crops such as canola, cotton, maize, and soybeans and the wide adoption of conservation agriculture the use of glyphosate increased. There are now concerns that glyphosate has impacts on soil microbial communities which can negatively affect soil functions, plant health, and crop productivity. However, extensive research has been done on specific genera or species rather than with broader measurements of soil microbial diversity and functions. Therefore, the overall objective of this study is to investigate the microbial shifts in the rhizosphere and endosphere of both bacterial and fungal communities in GM soybeans treated with glyphosate using next-generation sequencing with nanopore sequencing technology.

**Materials and methods:** The experiment was performed in a greenhouse. Sandy soil that was never exposed to glyphosate was used. The rhizosphere and root samples of GM soybean treated with glyphosate were collected at 2, 8, and 16 days after glyphosate treatments and stored at -20°c. From the rhizosphere and root samples, the microbial DNA was extracted and the 16S rRNA gene (for bacteria) and internal transcribed spacer (ITS) (for fungi) were amplified and sequenced using the Nanopore technology. Bacterial and Fungal  $\alpha$  (the measure of microbiome diversity) and  $\beta$  (the measure of the similarity or dissimilarity of two communities and the relation with the environmental factors) diversity will be analyzed by using several libraries in R studio. Lastly, nitrogen contents will be assessed on both soil and plants to determine nitrogen uptake by the crop.

**Results:** Herbicide glyphosate has significant impacts on both phenotypic and genotypic characterizations of the GM soybean systems. Briefly, glyphosate causes microbial succession in both the rhizosphere and endosphere of GM soybeans. Bacterial communities appear to be more affected by glyphosate treatments than fungal communities. Also, glyphosate affects nitrogen uptake by GM soybeans because glyphosate has the potential to reduce nitrogen-fixing bacteria and fungi that can improve plant nitrogen acquisition.

**Conclusion**: The findings of this study are essential to developing alternative approaches for glyphosate applications in GM soybean systems to overcome its effects on threatening beneficial soil microbial communities and GM soybean productivity. This study is also crucial to increasing soil health knowledge for sustainable food production.

**Keywords:** Endosphere; Glyphosate; GM-soybean; Next-generation sequencing; Soilmicrobial-communities; Rhizosphere.

# ARE SOIL LOADING LIMITS FOR AL AND FE IN IRRIGATION WATER QUALITY GUIDELINES NECESSARY?

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#### INTRODUCTION

Irrigation water quality guidelines are essential for safeguarding soils, crops, irrigation equipment, and human health. In the assessment of trace elements, most guidelines stipulate soil loading limits to minimise soil enrichment. However, due to the natural abundance and behaviour of Al and Fe, the use soil loading limits for these elements has been questioned. It is established that their plant availability is not controlled by total concentrations, suggesting that soil loading limits may be unnecessary. However, questions relating to the solubility and plant availability of the applied forms, especially at high loading rates have not yet been resolved, as well as those relating to the enhanced P-sorption capacity of irrigated soils as a result of the precipitation of reactive amorphous Al and Fe oxides. The main objectives of this study were to investigate: 1) plant availability of these elements in heavily loaded soils 2) the degree of P-fixation in such soils.

#### MATERIALS AND METHODS

Samples of a sandy clay loam soil with  $pH_{water}$  6.5, were loaded with soluble AI and Fe at various loading rates in triplicates as percentages of guideline soil thresholds (2500 mg/kg for both AI and Fe) from 6.25 %, increasing up to 200 % (5000 mg/kg). CaCO<sub>3</sub> was applied to counter the acid generating potential of each load and samples were left field moist to age for a year. Plant availability of these elements was assessed by the means of water soluble (E<sub>w</sub>) and Mehlich-3 (M<sub>3</sub>) extractions and the degree of P-fixation in treated soils was assessed by the means of M<sub>3</sub> and Bray-1 (B<sub>1</sub>) extractions. The extracts were analysed using the ICP- OES machine.

#### **RESULTS AND DISCUSSION**

Plant availability of Al and Fe did not depend on load. At 5000 mg/kg loading, the achieved soil pH<sub>water</sub> was 7.3. Initial results indicate that plant available Fe was within published optimum plant available levels ( $M_3$  Fe = 72 mg/kg, optimal range = 6 - 420 mg/kg). Interestingly, both  $M_3$  and  $E_w$  - Fe did not differ significantly with those of the untreated soil. Water soluble Al was lower than published toxic soil solution levels (< 3 mg/l). Even though the untreated soil ( $M_3$ -P = 17.18 mg/kg, B<sub>1</sub>-P = 9.52 mg/kg) had less than optimal plant available P ( $M_3$  = 51 – 100 mg/kg, B<sub>1</sub> > 35 mg/kg), these low levels were further reduced as a result of heavy loading with Al and Fe, resulting in 80 and 90 % decrease in  $M_3$  and B<sub>1</sub>-P respectively.

#### CONCLUSIONS

Based on these initial findings, it appears that there is a low risk of AI and Fe phytotoxicity as a result of soil enrichment. Follow up experiments investigating plant availability of these elements at even higher loading rates of up to 3200 % of the traditional guideline limits are being designed as well as a quantitative assessment of P-sorption; to investigate the feasibility of sustaining adequate levels of available P by fertilisation, in soils irrigated with AI and Fe rich waters.

**KEYWORDS:** Irrigation water quality, plant availability, P – sorption, soil loading limits

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# USING HYDROPEDOLOGY AS SOFT DATA TO REFLECT HYDROLOGICAL PROCESSES WITHIN SWAT+

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#### INTRODUCTION

Soils affect the distribution of hydrological processes by partitioning precipitation into different components of the water balance (Lal et al., 2021). Therefore, understanding soil-water dynamics at a catchment scale remains imperative to future water resource management. Hydropedology has been put forth as a potential source of soft data in hydrological modelling to improve internal hydrological processes (Bouma, 2016). The aim of this study was to calibrate the SWAT+ model to accurately simulate long-term monthly streamflow as well as to reflect internal soil hydrological processes using a novel calibration procedure focusing on hydropedology as calibration tool in a multigauge system.

#### MATERIALS AND METHODS

In this study the value of hydropedology as calibration tool is tested by using hydropedology as soft data to assist in the calibration of the SWAT+ model at five different catchment sizes (48 km<sup>2</sup>, 56 km<sup>2</sup>, 174 km<sup>2</sup>, 674 km<sup>2</sup> and 2421 km<sup>2</sup>) in the Sabie River catchment, South Africa. The methodology included conducting a sensitivity analysis using RSWAT to determine sensitive parameters using 2000 iterations within the model, where selected parameters were calibrated manually to improve streamflow predictions. The calibration approach also included the manual calibration of each hydrological soil type to reflect their respective hydrological response. This was done by adjusting specific parameters in the model relating to runoff (CN2), lateral flow (LATQ\_CO) and percolation (PERCO), to reflect hydrological processes more accurately.

#### **RESULTS AND DISCUSSION**

Results indicated that calibration improved streamflow predictions with improved R<sup>2</sup>, PBIAS, NSE and KGE values at four of the five catchment scales (48 km<sup>2</sup>, 56 km<sup>2</sup>, 174 km<sup>2</sup>, 674 km<sup>2</sup>) during both calibration and validation compared to the uncalibrated model. This resulted in substantial differences between the uncalibrated and calibrated models both in the volume and values of different hydrological processes. Results confirm that soil mapping units can be calibrated individually within SWAT+ to improve the representation of different hydrological processes and their spatial distribution throughout a catchment.

#### CONCLUSIONS

This research concludes that a manual calibration approach focussed on representing hydrological processes can be conducted to improve long-term streamflow predictions. The spatial linkage between hydropedology and hydrological processes, which is captured within the soil map of the catchment, can be adequately reflected within the model structure after calibration. This research should lead to an improved understanding of the value of hydropedology within the broader modelling community, where hydropedology may act as an important data carrier relating to soil hydrological processes.

#### REFERENCES

Bouma, J. 2016. Hydropedology and the societal challenge of realizing the 2015 United Nations Sustainable Development Goals. *Vadose Zone Journal* 15.

Lal R, Bouma J, Brevik E, Dawson L, Field DJ, Glaser B. 2021. Soils and Sustainable Development Goals of the United Nations: An IUSS Perspective. *Geoderma Regional* 25.

KEYWORDS: hydropedology, soft data, SWAT+

#### ACKNOWLEDGEMENTS

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## SHORT- AND LONG-TERM FIRE IMPACTS ON SOIL HYDRAULIC CONDUCTIVITY, SOIL C AND N IN KRUGER NATIONAL PARK

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#### INTRODUCTION

Fires play a crucial role in maintaining ecosystem health and biodiversity in many biomes worldwide. They can be caused naturally or by humans, and impact soil properties. In Kruger National Park, fires are used as a management tool to preserve the ecological role of fire in the park. However, there is a lack of research on how fires affect soil properties in this savanna ecosystem. Therefore, this study aims to investigate the short- and long-term effects of burning on soil hydraulic conductivity and soil total C and N.

#### MATERIAL AND METHODS

Kruger National Park has been carrying out a long-term fire experiment for almost seven decades, providing a unique opportunity to study the impact of different fire treatments on soil properties. Our study focused on sandy, granite-derived soils in southern KNP and compared pre- and post-burn soil hydraulic conductivity, soil C and N to investigate short-term fire impacts one month after burning. We also compared annually burned soils with unburned plots to understand long-term fire impacts. Additionally, we investigated the impact of vegetation structure, particularly under tall *Sclerocarya birrea* (marula) trees, *Combretum apiculatum* (red bushwillow) shrubs, and open, grassy areas, on soil hydraulic conductivity, soil C and . NSoil hydraulic conductivity was measured using a tension-disc infiltrometer and the modified falling head method. Soil samples were collected at a depth of 0-10cm and analyzed for total carbon and nitrogen using a LECO analyzer.

#### **RESULTS AND DISCUSSION**

Fires affect soil hydraulic properties differently in both the short- and long-term depending on soil pore size and geometry. In the short-term, fires affect finer soil pores (< 1mm diameter) by reducing water conductivity from 21.86 mm/hr to 13.68 mm/hr. However, this is short-lived and soils recover to pre-fire conditions within nine months post-fire. Both mean soil C (0.90 to 1.10 %) and N (0.02 – 0.04%) increased a month post-fire compared to pre-fire concentrations. After seven decades, mean soil C is ~1.5x greater in soils where fires are suppressed (1.19 %) than C found in soils burned every year (0.90 %). Similarly, mean soil N is double in unburned soils (0.04 %) compared to the annually burned soils (0.02 %). Trees and shrubs concentrate C and N below their canopies.

#### CONCLUSIONS

Fires can have varying effects on soil hydraulic conductivity, total carbon and nitrogen levels, depending on the time since the last fire and the structure of the vegetation. Despite the short-lived nature of many fire effects, the granitic soils in southern Kruger National Park (KNP) have proven to be resilient. However, further studies should focus on other soil types in different parts of KNP, and should also include other fire regimes, such as a peak dry season fire every three years. This will make the findings more relevant for park management, as it will cover a wider area within KNP. **KEYWORDS:** *Biocrusts, infiltration rates, prescribed burning, soil chemistry* 

# THE EFFECT OF NATURAL FIELD-AGING OF INVASIVE ALIEN WOODY PLANT BIOCHARS ON HYDRAULIC PROPERTIES OF SANDY SOILS

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#### INTRODUCTION

Biochar, a soil amendment that sequesters carbon, is also acknowledged for impacting soil hydraulic properties such as saturated hydraulic conductivity ( $K_{sat}$ ) and available water capacity (AWC) in sandy soils. Invasive alien plants (IAPs) in South Africa negatively impact natural ecosystems, surface, and groundwater recharge. However, woody IAPs can serve as a promising resource for biochar production. Limited information exists about the influence of biochar aging on soil hydraulic properties, specifically from IAP sources, produced at various pyrolysis temperatures. This study aims to investigate the effects of aged biochar on soil hydraulic properties, where aged biochar may have a positive effect by decreasing  $K_{sat}$  and increasing the AWC of sandy soils.

#### MATERIAL AND METHODS

The study produced biochar from eucalyptus at different pyrolysis temperatures (500, 600, 700, and 800°C) and black wattle biomass at 600°C. The biochar was then applied to acid-loamy sand soil at a rate of 1.5% (wt.). The soil and biochar mixture were aged in planting bags in the field for 12 months, and control treatments with no biochar were also included. The experiment was replicated five times. The total porosity,  $K_{sat}$ , and AWC in fresh and field-aged biochar-soil mixtures were measured. The total porosity was calculated from particle and bulk density,  $K_{sat}$  was determined by HYPROP equipment, and the AWC was determined using the pressure plate apparatus. Two-way analysis of variance to test for significant differences with a 95% confidence interval for statistical analysis.

#### **RESULTS AND DISCUSSION**

There was a significant ( $P \le 0.05$ ) increase in  $K_{sat}$  in all the fresh biochar-soil mixture treatments. However, field-aged biochar made from eucalyptus produced at 600°C, 700°C, and 800°C resulted in a significant ( $P \le 0.05$ ) decrease in  $K_{sat}$ . The AWC of fresh biochar-soil mixtures was significantly ( $P \le$ 0.05) lower than the control, but no significant differences were observed between the control and field-aged biochar-soil, except for eucalyptus field-aged biochar at 500°C. These results are consistent with those reported by Aller et al. (2017), where aged biochar had no effect on AWC in sandy loam soil. In contrast, they reported a significant positive effect of fresh biochar on AWC. The macroporosity of fresh biochar increased which negatively affected soil hydraulic properties.

#### CONCLUSIONS

In contrast to previous studies on fresh biochar, the fresh IAP biochars in this current study did not improve the soil hydraulic properties, whereas the field-aged biochars had no effect. Further long-term field studies are recommended, considering that the ageing process of biochar is a protracted one, extending over decades.

#### REFERENCES

Aller, D., Rathke, S., Laird, D., Cruse, R., Hatfield, J. 2017. Impacts of fresh and aged biochars on plant available water and water use efficiency. *Geoderma* 307: 114–121.

Keywords: Field-aged biochar, fresh biochar, soil hydraulic properties.

# ALPINE WETLAND DEGRADATION IN THE NORTHEN MALOTI-DRAKENSBERG MOUNTAINS: ON THE NEED FOR BASELINE RESEARCH

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#### INTRODUCTION

The montane and alpine wetlands of the Maloti-Drakensberg region hold immense significance as unique systems on the continent. They play a crucial role in water regulation and provision in southern Africa, serving as the foundation for the sustainable success of the Lesotho Highlands Water Project and ensuring water security within and beyond the Maloti-Drakensberg area. Despite their invaluable worth, these wetlands have been deteriorating at an alarming rate and are now critically endangered. However, our understanding of the causes and extent of their degradation remains limited, emphasizing the need for comprehensive baseline research. The objective of this paper is to contribute to the understanding of wetland degradation in the northern Maloti-Drakensberg and propose specific research priorities within an existing framework to address knowledge gaps. Additionally, it aims to raise awareness about the crucial importance of preserving these alpine wetlands in the face of environmental changes.

#### MATERIAL AND METHODS

In this review, we conducted searches using keywords related to "Alpine Wetlands in Lesotho" in various databases including Science Direct, Google Scholar, and ResearchGate, along with web searches. We also employed citation snowballing to find additional publications. Our interpretations of the literature were further supported by multiple site visits and the analysis of aerial and satellite imagery.

#### **RESULTS AND DISCUSSION**

While it has conventionally been believed that wetland degradation is primarily driven by livestock overgrazing within the *tragedy of the commons* narrative, the lack of baseline data to support this notion is alarming. It is essential to explore other potential drivers and assess their prominence, such as road infrastructure and the impact of ice rats. Several key research priorities, including measuring baseline ecological attributes, conducting socio-economic assessments of resource utilization, and monitoring temporal changes and landscape dynamics were identified in this paper. This baseline research will be the primary focus of the recently established Long-Term Socio-Ecological Research (LTSER) platform in the northern Maloti-Drakensberg, known as the Mount-Aux-Sources LTSER.

#### CONCLUSIONS

By addressing the existing knowledge gaps and advocating for the preservation of these alpine wetlands, this paper aims to contribute to the broader understanding of wetland degradation and promote sustainable management practices in the northern Maloti-Drakensberg region.

Keywords: Alpine areas, livestock management soil degradation, water security.

# DIGITAL SOIL MAPPING ENABLES INFORMED DECISIONS TO CONSERVE SOILS WITHIN PROTECTED AREAS

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#### INTRODUCTION

Protected areas are often considered as untouched and pristine land. However, in reality, these areas require effective management and rehabilitation to prevent further land degradation. Soil management is a crucial aspect of this, and it should be based on detailed soil maps. Unfortunately, creating soil maps in protected areas is a challenging task due to their vast size, limited accessibility, insufficient available soil data, and limited budgets for such projects. The primary objective of this paper is to showcase a novel method for digital soil mapping (DSM) that combines the expertise of soil experts and machine learning. This hybrid method can be used to create soil maps of large areas with limited accessibility, limited available soil data, and a small budget, which is often the case for protected areas.

#### MATERIAL AND METHODS

The case study location is situated at Benfontein, a 9900 ha protected area in South Africa. Forty-five soil profiles were classified and described be soil auger to a depth of 1.2 m. Soil samples were taken per horizon at modal soil profiles and analyzed for cations (Ca, Mg, K and Na) with the NH4OAc method, plant available P with the Olsen method, organic carbon with the Walkley Black method, sand, silt and clay content with the pipette method and water dispersible silt and clay with the double pipette method. Of these observations, 75% of the points were allocated as training data, with the remaining 25% being validation data, using the stratified random sampling method with soil association as stratifier. Additionally, soil landscape rules were used to determine virtual 42 soil observation locations which were added to the training dataset used by a multinomial logistical regression machine learning algorithm to create a soil associations map. Soil properties analyzed and interpreted soil indices, including the soil erosion K-factor, carbon sequestration potential and the dispersion ratio, were assigned to each soil association at 0.1, 0.5 and 0.9 percentile levels, to indicate the range of properties at an 80% certainty.

#### **RESULTS AND DISCUSSION**

The soil association map achieved an acceptable accuracy validation with a validation point accuracy of 79% and a Kappa value of 0.69. The soil property results show that Benfontein has a large carbon sequestration potential, the soils are relatively stable against water erosion and off-road driving should be prohibited on approximately half of the area.

#### CONCLUSIONS

The hybrid DSM method, combined with percentile soil property mapping, is a valuable tool that can be used to create useful soil maps. These maps can help inform management decisions in the unique settings of protected areas, which often have limited access, limited available data, and small budgets. This method can be applied and further tested in other areas with similar constraints that require soil maps to make informed management decisions. The accuracy of the soil-landscape rules constructed by the soil surveyor to determine the locations of the virtual observations is paramount to the success of the method.

Keywords: Benfontein, carbon sequestration, land restoration, soil erosion, soil degradation

#### ACKNOWLEDGEMENTS

We would like to thank the Department of Environmental Affairs of South Africa for funding this project under the National Resource Management Program.

# COUNTRIES' RIO CONVENTION COMMITMENTS RELATED TO THE SOIL INITIATIVE FOR AFRICA FRAMEWORK

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#### INTRODUCTION

The African Union Commission mandated the development of a Soil Initiative for Africa (SIA) Framework as an ambitious long-term effort to systematically improve the health and productivity of Africa's soils. Improved soil condition will be achieved by scaling proven and locally adapted technologies, including balanced and efficient (inorganic and organic) fertilizer application, to improve productivity for all farmers and, in many cases, sequester greenhouse gases by putting in place policies, programs, and institutional structures (i.e., an effective soil management system for Africa) needed to improve and maintain soil fertility across Africa into the future.

Sustainable land management actions to protect and sequester soil organic carbon (SOC) stocks AND increase agricultural productivity are increasingly advocated for their benefits to address climate change mitigation and adaptation, tackle food security, maintain biodiversity, and improve overall soil health. The purpose of this study was to understand the nature of African countries' national agricultural commitments related to SOC protection and sequestration and agricultural productivity in Nationally Determined Contributions (NDCs), Land Degradation Neutrality (LDN) targets, and Aichi (biodiversity) targets in relation to the SIA Framework.

#### MATERIAL AND METHODS

This study reviews African countries' agricultural commitments related to SOC, wetlands, peatlands, grasslands, agroforestry, erosion control, and agricultural production in LDN and biodiversity targets. Results are compared with similar targets in the latest NDCs and discussed in the context of the SIA Framework.

#### **RESULTS AND DISCUSSION**

This study identified at least 33 countries with LDN targets to protect or sequester SOC, and 28 countries with LDN targets to improve agricultural productivity. Twenty (20) countries set biodiversity targets for sustainable agriculture. Overlaps and differences in the assessed commitments were identified. The successful achievement of African countries' existing commitments related to SOC and agricultural production are important in the continental goal to improve soil health and increase sustainable agricultural productivity.

#### CONCLUSIONS

National assessment and coordination of soil-related planning, monitoring, and reporting processes is crucial. It is important to understand whether similar commitments in multiple national targets align and overlap. It is further important to identify the priority or most suitable sites for implementation to achieve the set targets and ensure integrated land use planning across agricultural subsectors to optimize planning, implementation, and monitoring.

#### REFERENCES

Wiese-Rozanov, L. (2022). Soil organic carbon commitments under three Rio Conventions: Opportunities for integration. Soil Security, 6, 100052. <u>https://doi.org/10.1016/j.soisec.2022.100052</u>

Keywords: Africa, agricultural productivity, agroforestry, grasslands, Soil Initiative for Africa, soil organic carbon.

# HORTICULTURE ABSTRACTS

# EFFECT OF VARIOUS SMOKE WATERS/ SMOKE WATER CONCENTRATIONS ON POST-GERMINATION GROWTH OF RYE, ONION AND GAZANIA

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#### INTRODUCTION

Smoke-water has been documented to contain substances that aid in the germination of many species in fire ecologies, but can also positively affect the germination of commercially grown crops. Similarly, no information seems available on the effect of these treatments on early growth and development of these crops.

# MATERIALS AND METHODS

An experiment was carried out comparing the effect of smoke-water obtained from black wattle (*Acacia mearnsii*), blue gum (*Eucalyptus globulus*), maize straw (*Zea mays* L.), as well as South African mesic grass species on germination and post-germination growth of cereal rye (*Secale cereale*), onion (*Allium cepa* L.) and gazania (*Gazania rigens*).

#### **RESULTS AND DISCUSSION**

More concentrated smoke-water solutions (1:5, 1:10) resulted in reduced germination and a low final germination percentage in all three crops, with base (1:5) smoke-water produced from maize straw and South African mesic grass species being 100% inhibitory to seed germination. Black wattle smoke-water (1:10) resulted in 53% germination of cereal rye seeds, 33.3% of onion seeds and 13.3% of gazania seeds. Blue gum (1:10) smoke-water was 100% inhibitory to cereal rye germination; however, onion and gazania seeds germinated (46.7% and 20%, respectively). Low concentrations (from dilution 1:500 v/v) of smoke-water were not inhibitory to seed germination, reaching 100% in some treatment levels. Treatment with low concentrations of smoke-water improved the germination rate and post-germination growth of cereal rye and gazania; however, this was not the case for onion.

#### CONCLUSIONS

This indicates that the optimal effect of smoke-water depends on the species it is derived from, with different species inhibiting and fostering germination at different dilution levels.

KEYWORDS: Smoke water, concentration, germination cereal rye, onion, gazania

# CHALLENGES AND SUCCESSES OF COMMUNITY DEVELOPMENT IN THE HONEYBUSH SECTOR

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#### INTRODUCTION

Honeybush (*Cyclopia* spp.) is one of South Africa's under-utilised endemic crops, with a small commercial industry, but it has the potential to capture a substantial global herbal tea market segment. The Agricultural Research Council (ARC) hosts a honeybush plant-breeding programme to support the growth of the industry. Improved genetic propagation materials are released from the programme to improve biomass yield potential and improve the tea quality. Funding received from the Department of Science and Innovation (DSI) and the Technology Innovation Agency (TIA) assisted with a project with the aim to commercialise these improved ARC genetic materials through SMMEs in communities.

## MATERIALS AND METHODS

Five communities were identified (two in the Western Cape and three in the Eastern Cape) and a business entity (Pty/Ltd) was registered for each community. Two SMMEs (Guava Juice (ePumeleni) and Friemersheim) focused on honeybush seed production, two (Thornham and Haarlem) on seedling propagation (nurseries) and one (Clarkson) on production (establishment of plantations). These SMMEs received financial support, infrastructure development, and training in honeybush production and business skills.

# **RESULTS AND DISCUSSION**

Originally five communities with 43 members benefited from the project, but today only four communities with 20 beneficiaries are still active. The first five years generated several temporary jobs with little income while they were learning new skills and trying to get the businesses up and running. One of the businesses decided not to continue any further. In 2022 a mentor was appointed to assist the businesses with the administration, legal compliances (Tax, UIF etc.), financial side and managing a business. The businesses went through ups and downs and especially during the Covid period they struggled to survive. Today 4 permanent and 12 semi-permanent jobs were created, but income generation is still low due to a poor market of honeybush tea. The progress, successes and limitations of this community development project will be discussed.

#### CONCLUSIONS

Several valuable lessons in community development have been learned in the past 10 years, that are now useful in planning for developing new businesses.

#### KEYWORDS: Communities, Cyclopia, honeybush, rural development, SMMEs

#### ACKNOWLEDGEMENTS

Department of Science and Innovation, Technology Innovation Agency, and Agricultural Research Council for funding.

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# DETERMINING EFFECTIVE POLLINATION PERIOD (EPP) FOR PLUM CULTIVARS IN SOUTH AFRICA

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#### INTRODUCTION

Fertility and adequate fruit set is key to the profitability of plum production. Effective fruit set is thus a combined interactive effect of agricultural practices, plant status and environment. EPP is defined as the number of days during which pollination is effective in producing a fruit and is determined by the longevity of the ovules minus the time lag between pollination and fertilization. EPP is impacted by climatic and physiological factors. (Keulemans, 1991). Guerra, et al. (2010) reported that only 5-14% of plum flowers develop into fruit. Thus, it is critical to try and understand factors influencing effective pollination and optimal fruit set.

The aim of this study will be to determine the EPP of the main commercial plum cultivars produced in the Western Cape of South Africa, over three years.

#### MATERIAL AND METHODS

The study focused on plum cultivars of commercial importance and flowering at different times: early September (African Delight, Angelino, Ruby Sun and Sapphire), mid-September (Fortune, Ruby Crisp and Songold) and end September (Laetitia and Ruby Star). The trial sites were in Worcester, Robertson and Bonnievale, Western Cape, South Africa.

To determine the EPP of the cultivars, controlled pollinations used standard protocols performed in the ARC's plum breeding program with viable pollen from cultivars (male parent) with different S-alleles than the cultivars (female parent) evaluated. The protocol involved 100 flower bearing units per cultivar covered with greaseproof paper bags to prevent natural insect pollination. After controlled pollination, natural fruit set were allowed, and evaluation were done at three times after last pollination. Statistically, the experimental design was a Randomized Block with significant differences revealed through various Anova analysis.

#### **RESULTS AND DISCUSSION**

Preliminary results indicate that plum cultivars do have different effective pollination periods that varies from two to ten days. It seems that Laetitia flowers still produce more than 5% fruit on flowers that opened 10 days prior to pollination, while Ruby Crisp, Songold and Ruby Star flowers have very short EPP.

#### CONCLUSIONS

The conclusion will be formalized after the third season.

#### REFERENCES

- Guerra, ME, Wünsch, A, López-Corrales, M and J Rodrigo. 2010. Flower Emasculation as the Cause for Lack of Fruit Set in Japanese Plum Crosses. J. Amer. Soc. Hort. Sc. 135(6) 135:556-526. DOI: https://doi.org/10.21273/JASHS.135.6.556
- Keulemans, J. 1991. Bloemfysiologische parameters als produktiebepalende factoren bij pruim (Prunus domestica L.). Doctoraatproefschrift nr. 203 aan de Fakulteit der Landbouwweternschappen van de K.U.Leven.

Keywords: plum, pollination, effective pollination period

# WATER USE AND CROP PERFORMANCE UNDER DRIP AND SELF-REGULATING, LOW ENERGY, CLAY BASED IRRIGATION (SLECI) SYSTEMS.

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**INTRODUCTION:** Crop failures are quite common under rain-fed farming in Sub-Saharan Africa. Similarly, small holder farming (SHF) in South Africa, as a water scarce country, is often characterized by low and highly variable yields because of limited irrigation resources. Water scarcity is considered a limiting factor in the development of the agricultural sector, given that the country is one of the driest countries in Africa and globally (Adetoro et al.,2022). Because of the often inadequate and uneven distribution of rainfall in South Africa, more inventive efforts are necessary to assist farmers to maximize food production. Water saving irrigation technologies can contribute significantly to limit crop failures, especially within SHF enterprises with limited access to irrigation water.

**MATERIAL AND METHODS:** The SLECI technology was compared with subsurface drip and standard drip irrigation to determine their effects on water use and crop performance of Moringa, intercropped with Cowpea. The trial was conducted in the open field during a summer growing season (October 2022-March 2023) at the Agricultural Research Council's Vegetable, Industrial, and Medicinal Plants (ARC-VIMP), Pretoria, South Africa. The experimental design was a Randomized Complete Block Design (RCBD) with nine treatments replicated four times. Data on water usage, crop growth, yield and physiological parameters was collected and subjected to ANOVA using GenSTAT. Crop yields and water use were compared for the different irrigation methods.

**RESULTS AND DISCUSSION:** Moringa and Cowpea crop yields reacted differently to the irrigation system types used. Moringa performed best with SLECI (880g fresh mass per tree) versus 200g fresh mass with standard drip, while Cowpeas performed best under standard drip irrigation (500g fresh mass) versus SLECI (200g fresh mass). Water use of the two crops were also affected by the irrigation system. On average, standard drip irrigation used significantly more water (164.895 m<sup>3</sup>) compared to subsurface (85.214 m<sup>3</sup>) and SLECI (66.363 m<sup>3</sup>) during the growth season.

**CONCLUSIONS:** SLECI irrigation system seems to be more suitable for Moringa (perennial crop) while Cowpea (seasonal crop) performed best with standard drip irrigation. SLECI showed significant potential to minimize water loss by evaporation, runoff and percolation and can be considered as a promising new irrigation technology to increase water use efficiency, especially for perennial crops.

**ACKNOWLEDGEMENTS:** The study was funded by the European Union's Horizon 2020 Research and Innovation Programme and the Agricultural Research Council.

# REFERENCES

Adetoro, A.A., Abraham, S., Paraskevopoulos, A.L., Owusu-Sekyere, E., Jordaan, H. and Orimoloye, I.R., 2020. Alleviating water shortages by decreasing water footprint in sugarcane production: The impacts of different soil mulching and irrigation systems in South Africa. *Groundwater for Sustainable Development*, *11*, p.100464.

Keywords: Drip irrigation, subsurface irrigation, water use efficiency, SLECI.

# USING XANTHAN GUM COATINGS AS CARRIERS OF PROBIOTIC BACTERIA TO RETAIN POSTHARVEST QUALITY AND ANTIOXIDANTS IN CANTALOUPE SLICES (CUCUMIS MELO L.)

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#### INTRODUCTION

Due to spoilage microflora and browning, minimally processed fresh-cut fruits have a short shelf life. Edible coatings can extend the shelf life and improve the safety of fruits and vegetables, and probiotics contain live bacteria that have health benefits. Therefore, in this study, xanthan gum coating was used as a carrier of probiotic bacteria (*Lactiplantibacillus plantarum* 75 and *Bifidobacterium longum*) to enhance retention of postharvest quality and antioxidants in fresh-cut cantaloupe slices stored at 5°C for 5 days.

#### MATERIALS AND METHODS

Cantaloupes were harvested from a commercial farm and under sterile conditions, melons were peeled, cut, deseeded, and then cut into cubes. Afterwards, 0.5% xanthan gum solution was mixed with *L. plantarum* 75 and *B. longum* bacteria pellets to obtain a final count of 8.0 log CFU/mL. Melon cubes were coated with xanthan (CXD5), xanthan – *L. plantarum* 75 (CXL75), xanthan – *B. longum* (*CXB5*) and uncoated cantaloupe as control (CU/CUD5). Then, the melons were aseptically packed into lock&lock fresh-keeping boxes and stored at 5 °C for 5 days.

## **RESULTS AND DISCUSSION**

Cantaloupe fresh-cuts coated with both lactic acid bacteria (LAB) had significantly higher viable bacterial counts on the 5th day at 5 °C, supporting the functional potential of the edible coating. Bacterial viable counts were less than 6.0 log CFU/g aerobic mesophilic bacteria in these samples, making them suitable for human consumption. Probiotic-coated cantaloupe (CXL75 & CXB5) effectively retained the levels of lutein and  $\beta$ -carotene in fresh-cut melons during storage, in contrast to the CXD5 or CUD5 treatments. The recommended daily level of lutein for good eye health is 10 mg/day, thus 476.19 g/ day of cantaloupe will fulfil the recommended levels for an adult [Moloto *et al.*, 2020]. Melons coated with CXL75 showed the highest 2,2'-azino-bis3-ethylbenzothiazoline-6-sulfonic acid (ABTS) scavenging activity due to exopolysaccharides from *L. plantarum*, indicating a strong antioxidant capacity. The proliferation of LAB in fresh-cut melon can negatively affect the product's organoleptic properties. However, panellists ranked probiotic coating CXL75 higher for colour, aroma, and taste than other treatments during organoleptic evaluation.

#### CONCLUSION

In conclusion, xanthan gum was proven to be a good carrier of probiotic bacteria *L. plantarum* 75, for retaining lutein,  $\beta$ -carotene, and antioxidant properties. Using probiotics in an edible coating improves food's functional and health properties.

#### **REFERENCES:**

Moloto, M.R., Phan, A.D.T., Shai, J.L., Sultanbawa, Y. and Sivakumar, D 2020. Comparison of Phenolic Compounds, Carotenoids, Amino Acid Composition, In Vitro Antioxidant and Anti- Diabetic Activities in the Leaves of Seven Cowpea (*Vigna unguiculata*) Cultivars. *Foods*, 12;9(9):1285.

KEYWORDS: antioxidants, Bifidobacterium longum, carotenoids, Lactiplantibacillus plantarum

#### ACKNOWLEDGEMENTS

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# CONSUMER ACCEPTANCE OF JAM FROM SELECTED NON-CULTIVATED INDIGENOUS FRUITS

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#### INTRODUCTION

There is enormous scope for the development of indigenous fruit products owing to their unique appearance and flavour. The aim of the study was to evaluate the consumer acceptance of jam from selected indigenous fruits including *Carissa edulis* (Simple-spined num-num), *Dovyalis caffra* (Kei apple), *Dovyalis longispina* (Natal apricot), *Englerophytum magalismontanum* (Stamvrug) and *Sclerocarya birrea* (Marula).

#### MATERIAL AND METHODS

Mature green marula fruits were collected from the ground, while all the other selected fruits were harvested from the tree when ripe, based on colour. The decayed fruits were discarded and the remaining fruits were washed and pulped using a mechanical pulper. The pulp was then used for jam-making using the standard jam-making procedure. Due to the natural acidity of kei apple fruit, various blends with commercial fruits, including banana, mango, litchi and papaya were investigated for jam-making. An untrained sensory panel was selected to determine the consumer acceptability of these jams based on the hedonic 9-point scale.

#### **RESULTS AND DISCUSSION**

The majority of the panel found the taste of the num-num, stamvrug, Mananga kei apple and marula jams to be acceptable. Natal apricot jam was less acceptable due to its acidity. The colour of the num-num jam was preferred by most panellists, followed by stamvrug and kei apple jams. The beige colour of the marula jam was considered unattractive. Overall, the stamvrug jam was found to be the most acceptable jam with 68% of the panellists indicating that they would buy the product, followed by the num-num jam (60%). Surprisingly, the marula and Mananga kei apple jams were found to be less attractive with 57% and 51% acceptance, respectively. In addition, the panellists preferred Mananga kei apple jam over jam made with other kei apple selections. The kei apple and mango combination jam was the favourite kei apple blend.

#### CONCLUSIONS

In conclusion, all the indigenous fruit jams evaluated have the potential to be developed into commercial products and to be sold as niche products. Commercial fruit pulp can be added to reduce the sour taste of kei apple when suitable selections are not available. However, prior to commercialization, the shelf life, safety and physicochemical properties of the indigenous fruit jams need to be determined.

Keywords: Consumer acceptance, indigenous fruits, jams

# CHEMICAL CHARACTERIZATION OF SELECTED INDIGENOUS SEED AND NUT OILS

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#### INTRODUCTION

Indigenous fruits are considered a valuable source of nutrition and could play a role in improving the lives of rural communities by adding value such as the extraction of seed oil.

#### MATERIAL AND METHODS

Seed oils were extracted from *Sclerocarya birrea* (Marula), *Trichilia emitica* (Natal mahogany), *Trichilia dregeana* (Forest mahogany), *Sterculia murex* (Lowveld chestnut) and *Oncoba spinosa* (Snuffbox). Oil parameters that were determined included percentage yield, free fatty acids, peroxide, iodine, saponification, and unsaponifiable values. The seed oil composition was determined using Gas Chromatography Mass Spectrometry. Solvent and cold press extraction were compared for *S. birrea* and *Trichilia spp.* 

#### **RESULTS AND DISCUSSION**

In general, all oil parameters for these two methods were similar, however, peroxide values for solvent-extracted oil were much higher than for cold-pressed oil. Acid values for *S. birrea, S. murex* and *O. spinosa* oils were low which indicates less free fatty acids and therefore lower rancidification. This was confirmed by the low peroxide values obtained. Low peroxide and free fatty acid values are indicators of oil stability. All the oils analysed contained high saponification values between 200 and 410 mg KOH/g and confirm the use of these oils in the cosmetic industry. The oil composition of the seeds varied considerably. *O. spinosa* oil was the only oil that contained significant levels of linoleic and linolenic acids. *S. birrea, O. spinosa* and *S. murex* contained  $\beta$ -sitosterol.

#### CONCLUSIONS

Indigenous seed and nut oils have the potential to be used in food and cosmetic products. Adding value to these fruits and nuts can result in job creation and improved quality of life in rural areas.

Keywords: Chemical characterization, indigenous seeds and nuts, seed oil

ACKNOWLEDGEMENTS ARC and DALRRD for funding

# ENHANCING NUTRITIONAL AND PHYSIOLOGICAL QUALITY OF SWEET PEPPER FRUIT THROUGH INCORPORATING BIOSTIMULANT, ORGANIC, AND INORGANIC FERTILIZERS

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#### INTRODUCTION

The heavy reliance of many growers on inorganic fertilizers has resulted in several negative side effects, potentially culminating in environmental deterioration and human health problems. Reducing the usage of inorganic fertilizers by blending fertilizer (using moringa leaf powder (MLP), organic, and inorganic fertilizer blends) is likely to reduce the environmental deterioration caused by applying solely inorganic fertilizer. Sweet pepper is a high-value crop that is cultivated world-wide and appreciated for its high nutritional value, as it contains high concentrations of vitamins and antioxidants. These phyto-nutrients are known to be beneficial to human health. The aim of this study is to produce high-quality sweet pepper fruits in a more environmentally friendly approach.

#### MATERIALS AND METHODS

The experiment was conducted in a glasshouse, MLP (20 g) was blended with chicken litter (CL) (30 g), and NPK (3:1:3) at different concentrations (10, 20, and 30 g), and applied at the root zone of sweet pepper plants. Yellow 'Kavango' sweet pepper was planted into 5L plastic pots filled with compost growing medium and fertilizer as well as biostimulants were thoroughly mixed with growing medium prior transplanting and again six weeks after transplanting. Vegetative growth parameters and fruit nutrient quality were analysed. Each treatment had three replications and the experiment were arranged in a complete randomised design (CRD).

#### **RESULTS AND DISCUSSIONS**

Treating sweet pepper with NPK (20 g) + CL (30 g) + MLP (20 g) resulted in the highest sweet pepper yield, with fruits containing increased phyto-nutrient concentrations (total carotenoids) compared with other treatments, whilst the vegetative growth parameters of this treatment were significantly higher compared to the control. Treating sweet pepper seedlings with NPK (3:1:3) (20 g) + CL (30 g) + MLP (20 g) enhances vegetative growth, which ultimately translates into higher fruit yield with increased phyto-nutrient quality compared to NPK (30 g).

# CONCLUSIONS AND RECOMMENDATIONS

To reduce the environmental deterioration impact caused by the over-use of inorganic fertilizers, sweet pepper growers should opt for blending inorganic fertilizers with organic fertilizers and MLP. According to this study, the preferable concentration of blending for sweet pepper fruits with high phyto-nutrients is NPK (3:1:3) (20 g) + CL (20 g) + MLP (20 g).

KEYWORDS: Biostimulants, carotenoids, inorganic fertilizers, moringa, organic fertilizers

#### ACKNOWLEDGEMENTS

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# THE EFFECT OF COMPOST AND MICROBIAL APPLICATIONS ON VEGETABLE CROP BIOMASS PRODUCTION

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#### INTRODUCTION

In recent years, public demand to reduce agricultural waste and the use of chemical fertilizers, while improving the global carbon footprint has greatly increased. Composting provides a safe way to dispose of excess organic matter and can reduce the need for chemical fertiliser inputs in crop production systems. Compost is currently underutilized in industry due to the complexity of integrating compost into production systems. Soil-based producers would however benefit greatly from utilizing compost to inoculate soil with microbes and thus improving their soil health. The main objective of this study was to determine how beneficial the use of compost and microbial bio-fertilizers are in a vegetable production system were to the soil health and overall productivity of the system.

#### MATERIALS AND METHODS

The study was conducted in a single-span tunnel on Welgevallen experimental farm in Stellenbosch (33°56'33.26"S 18°51'56.55"E). The tunnel was divided into 80 plots. Each plot was prepared by applying one of five different treatments, before one of two vegetables (beetroot or broccoli) were transplanted into the soil. These treatments included a control (fertiliser only), two compost treatments (one receiving half the fertiliser rate of the other treatments) and another two biofertilizer treatments (one made from liquid waste products such as milk and another that consists of cultured microbes). This makes a total of five treatments per vegetable type with eight replicates each. All five treatments received the same management practices. The vegetables were allowed to grow in the treated soils and the effects on plant growth and development was investigated.

#### **RESULTS AND DISCUSSION**

It was found that applying compost in addition to the recommended fertiliser application resulted in a trend towards higher biomass production The beetroot biomass production was 10% higher than that of the control. Applying compost, while using only half the recommended fertiliser application, yielded 13% less biomass than the control. The reduced biomass is most likely due to the reduced fertiliser rate. Reducing fertiliser input is however recommended due to high fertiliser prices and long-term environmental effects. These results indicate that applying compost in addition to, or as a partial replacement for, fertiliser could result in higher profitability for producers. The increase in biomass is however not statistically significant after the first season. It is known that improving soil health can take many years. The expectation for this long-term trial is to improve the significance of these findings.

## CONCLUSIONS.

Compost application in addition to fertiliser can improve vegetable biomass production. When compost is applied, fertiliser rates may be reduced while only observing a small biomass yield penalty. The potential increase in yield or reduction of input costs of these two treatments make composted agricultural waste an important option to increase profitability in vegetable production systems.

# THE IMPACT OF POSTHARVEST TREATMENTS ON THE INCIDENCE OF CHILLING INJURY IN SWEET ORANGES (*CITRUS SINENSIS*) IN CITRUSDAL, SOUTH AFRICA

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#### INTRODUCTION

Citrus fruit is susceptible to chilling injury (CI) when exposed to temperatures just above freezing. Cold sterilization protocols (< 2°C) required by export markets threaten rind quality. CI symptoms include rind pitting and scalding. Postharvest coatings provide the primary protection against CI during extended shipments. Hot-water dip treatments, alone or in combination with thiabendazole (TBZ), can reduce CI. The main objective of this study was to quantify the impact of coatings and flooder treatments on the incidence and severity of CI in sweet oranges in Citrusdal, South Africa.

#### MATERIALS AND METHODS

'Midnight' Valencia and 'Washington' navel oranges (*Citrus sinensis*) were collected from commercial packhouses in Citrusdal. Samples were collected before any postharvest treatments were applied. Coatings were applied on a packline with rotating brushes, spray nozzles, and a drying tunnel. Flooder treatments (dipped in 20 L mixture for 2 min) consisted of different concentrations of TBZ, at various temperatures ( $\pm 10^{\circ}$ C,  $\pm 30^{\circ}$ C,  $\pm 40^{\circ}$ C). Each treatment consisted of five replicates of 15 fruit. Fruit was stored at -0.6°C for 30-40 days, and 20°C for 7 days (shelf-life). Cl score: 0 (zero injury), 1 (<10% surface area), 2 (10-50% surface area) and 3 (severe injury, >50% surface area). Data analysis was performed using XLSTAT (2022.1.1) – one-way ANOVA at 5% significance level (Fisher LSD).

#### **RESULTS AND DISCUSSION**

Wax coatings reduced CI in 'Midknight' Valencia oranges by 94% compared to untreated fruit. In 'Midknight' Valencia and 'Washington' navel oranges, TBZ dip treatments at a rate of 4000 ppm significantly reduced CI compared to 250 ppm. Higher water temperatures (±40°C) in the flooder, at 4000 ppm concentration, significantly reduced CI incidence compared to cold temperatures (±10°C). The TBZ residue in fruit (4000 ppm treatment) was less than the current maximum residue levels (MRL) for the EU. 'Midknight' Valencia oranges are extremely prone to scalding symptoms. Sweet oranges without a postharvest coating, or cold water in the flooder, will significantly increase the risk of CI when exposed to cold sterilization treatments before/during export.

#### CONCLUSIONS AND RECOMMENDATIONS

The primary defence strategy against CI is postharvest wax coatings (polysynthetic, shellac, or veganbased). Higher concentrations of TBZ (4000 ppm), compared to the commercial rate (1000 ppm), are recommended to alleviate the detrimental effects of CI. Higher temperatures in the flooder mixture improved TBZ penetration into the rind, thereby increasing the protection against CI compared to cold temperatures. Thiabendazole is under pressure due to MRL requirements, thus alternative products need to be investigated.

**KEYWORDS:** *citrus, cold sterilization, export markets, scalding, thiabendazole, wax coatings* 

#### ACKNOWLEDGMENTS

Citrus Research International for funding this project; Stellenbosch University for providing research facilities; Corrie Muller (JBT) for providing wax coatings and Citrusdal Packhouses for providing fruit.

## OPTIMISING CITRUS OPENTOP CARTONS FOR EFFICIENT CONTAINER COOLING AND MINIMAL BOTTOM SAG DISPLACEMENT

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#### INTRODUCTION

The South African citrus industry recently designed and implemented a high-ventilation A15C ("Supervent") telescopic carton that significantly improves cooling performance during precooling (FAC) and shipping. This carton allows the industry to ship chilling-injury-sensitive fruit to phytosanitary markets (EU, China etc.) at higher set-point temperatures than in previous seasons. However, citrus fruit packed in Opentop (display) cartons do not have access to similarly warm set-points. The study aimed to design an "Ultravent" Opentop carton with an equivalent porosity, and mechanical strength, to the A15C "Supervent" carton. Conversely, the main challenge is overcoming bottom sag displacement due to the loss of structural strength as the ventilation area, along the bottom wall of the carton, increases.

#### MATERIALS AND METHODS

Finite-element method (FEM) analyses were applied to identify the optimal ventilation hole positioning. Three treatments were selected based on the FEM analysis: "No-vent" (0 mm<sup>2</sup>), "Standard" (2313 mm<sup>2</sup>) and "Ultravent" (28303 mm<sup>2</sup>). The resistance to airflow (inverse of cooling rate) was evaluated using a custom-built wind tunnel with pressure sensors, and plastic balls (80 mm diameter) in each carton. The mechano-sorptive creep (bottom sag) was tested experimentally for each carton design by loading carton stacks with 20 kg water bags and placing them in cold storage ( $\pm 0^{\circ}$ C, >95%) for 28 days with Tinytag loggers. Data analysis for a randomised complete block design was performed using XLSTAT (2022.1.1) – one-way ANOVA at 5% significance level (Tukey HSD).

#### **RESULTS AND DISCUSSION**

The key findings indicate that a ventilation area of  $28000 \text{ mm}^2$  is needed to reach the desired resistance of  $2000-2500 \text{ kg.m}^{-4}$  for optimal cooling. Bottom sag displacement was significantly higher for the "Ultravent" cartons ( $35.5 \pm 4.5 \text{ mm}$ ) compared to the "Standard Opentop" ( $26.0 \pm 3.0 \text{ mm}$ ) and "Novent" ( $23.3 \pm 2.8 \text{ mm}$ ) designs, which did not differ significantly from each other. However, slightly increasing the board strength significantly reduced displacement for the "Ultravent" design. Results indicate that mechano-sorptive creep is a problem for E15D Opentop cartons, regardless of the ventilation design or board type.

#### CONCLUSIONS AND RECOMMENDATIONS

The "Ultravent" design has a comparable porosity and airflow to the new A15C carton. The E15D cartons with zero ventilation and a stronger board type displayed the lowest degree of bottom sag displacement. The "Ultravent" E15D carton (ventilation = 28303 mm<sup>2</sup>) design had the highest degree of displacement, but stronger board types significantly reduced bottom sag. The "Ultravent" experiments showed great promise and should thus be extended to a commercial trial to validate the results.

**KEYWORDS:** *airflow resistance, carton strength, citrus fruit, cold sterilization, cooling performance, mechano-sorptive creep* 

#### ACKNOWLEDGMENTS

Citrus Research International for funding this project; Stellenbosch University for providing research facilities and APL Cartons (Pty) Ltd for providing the cartons for the research.

## DO NUT MATURITY, NUT DEVELOPMENT AND MINERAL NUTRITION PLAY A ROLE IN THE DEVELOPMENT OF THE SKIN ADHERENCE DISORDER IN MACADAMIA (CV. 'NELMAK 2')?

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#### INTRODUCTION

Skin adherence (identified as the presence of shell skin marks on kernel) is one of the factors contributing to the loss of premium grade kernel in the South African macadamia industry. This disorder tends to be associated with hybrid cultivars such as 'Beaumont', 'Nelmak 2' and 'A4'. Although the losses due to this disorder are relatively low in general, some combinations of growing region and cultivar can lead to losses of up to 1.5% of kernel on a DIS basis. Possible factors which may contribute to the development of the disorder include kernel developmental processes and/or nutritional deficiencies.

#### MATERIALS AND METHODS

This trial was carried out at two sites less than 10km apart in the KZN coastal area. Historically, one farm has a relatively high incidence of the disorder compared with the other. Both farms' nuts are dehusked and cured in the same facility, thus post-harvest practices are not expected to play a role in the development of the disorder. Soil, leaf and nut samples from sixteen randomised trees were collected from each farm and analysed for nutrients according to prescribed norms. Nuts were also assessed for maturity and skin mark incidence. For the nut development study, four nut size classes (10, 15, 20 and 25 mm diameter) were collected at each farm and various parameters measured, including nut in husk diameter, nut in shell diameter, kernel diameter and 'gap' width between shell and kernel.

#### **RESULTS AND DISCUSSION**

Although there were significant differences in content of some minerals such as nitrogen, calcium and boron, for soil, leaf and nut samples for both sites, there were no significant differences in terms of skin mark incidence. Calcium deficiency is related to a host of disorders in various crops and plays an important role in fruit quality and this mineral was a particular focus of the study. Similarly, there were no significant differences in terms of nut development at both sites indicating that the hypothesised differences in physical contact between the kernel and the brown shell membrane were false. Thus, the development of skin adherence disorder did not appear to be correlated with nut maturity, nut development or mineral nutrition during the study period.

#### CONCLUSIONS

Other factors such as weather (temperature and humidity) and excessive water availability in the late stages of kernel development may play a role in the development of this disorder. These factors are also being investigated.

Keywords: kernel, macadamia, quality, skin adherence

#### ACKNOWLEDGEMENTS

This work was funded by the Agricultural Research Council and Macadamias South Africa NPC (SAMAC).
# **COLOURED TOMATOES – ONE SOLUTION FOR NUTRITIONAL INSECURITY**

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# INTRODUCTION

Tomatoes are the second most important vegetable crop after potatoes in South Africa. It is not only cultivated commercially, but also commonly grown by subsistence, resource poor farmers and home gardeners. It contributed approximately 19% to the gross value of vegetable production (excluding potatoes) in South Africa. According to the FAO, South Africa produced 59 9306 tonnes of tomatoes to a value of 183 067 000 US dollars during 2020. The per capita consumption of tomatoes in South Africa is 12 kg per annum in metropolitan areas. The nutritional value of tomato is also well known and compounds found in tomatoes function as antioxidants when consumed in the human diet. These metabolites include folate, vitamins C, vitamin E and flavonoids, which have been demonstrated to play important roles in human nutrition. Tomato with higher levels of beta-carotene and folate has been developed in breeding programs in mainly Taiwan and the USA. Many of the coloured tomato heirloom cultivars also have high levels of micro-nutrients. South Africa is burdened with high levels of micro-nutrient deficiency, especially among young children. Tomatoes is also very popular under young children and can be used as one method to increase the micro- nutrient intake of young children. The aim of this project is to increase the local diversity of nutrient dense tomatoes and to promote the use nutrient dense tomatoes in order to assist in the alleviation of micro-nutrient deficiency.

# MATERIAL AND METHODS

Colored and nutrient dense tomato germplasm was obtained from various local and international sources. The germplasm include cherry, processing, table and beefsteak tomatoes with determinate and indeterminate growth types. Miniature germplasm suitable to grow in pots and hanging baskets were also included. Selected accessions from the germplasm collection were planted with households in Hammanskraal and Nkandla to expose them and their neighbours to the coloured germplasm. The attitude of the house hold members towards the coloured tomatoes were established with informal dissuasion and questionnaires.

#### **RESULTS AND DISCUSSION**

The women in the household all liked the coloured tomatoes and they would keep on growing it if seed of these cultivars are available. One lady commented that the different colours look very attractive in a salad. The children liked the cherry tomatoes and yellow pear tomatoes and considered them as sweeties. Most of these are heirloom cultivars that are available from seed traders that specialize in heirloom tomato varieties.

### CONCLUSIONS

The coloured tomatoes are readily accepted by rural woman and children. The rural woman and children are the most vulnerable when it came to micro-nutrient deficiencies. Therefor it can play a role in alleviating micro-nutrient deficiencies. Further research on these tomatoes include field and hydroponic trials in order to optimize the production practices and establish the yield potential.

Keywords: Tomato, Food security,

### ACKNOWLEDGEMENTS

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# COMPILING AND VALIDATING A MORPHOLOGICAL DESCRIPTOR LIST FOR SCENTED GERANIUMS

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# INTRODUCTION

Geraniums consists of ± 220 species within the genus *Pelargonium*, and 80% of them are confined to southern Africa, mostly in the south-western part of South Africa. The South African National Biodiversity Institute listed at least 20 *Pelargonium* species in their PlantZAfrica database (https://pza.sanbi.org/). There are also a wide range of scents associated with geraniums, however Rose geranium is the best-known scented geranium. Scented-leaf geraniums release their scent when their leaves are brushed or crushed. The fragrance is released by glands at the base of their leaf hairs where the scented oil is formed. Essential oils is very popular in the aromatic industry leading to increased production of essential oil plants. Several rose and other geranium variants exist and it is not always easy to distinguish between them morphologically. Morphological descriptors exist for hardy, regal and zonal pelargoniums but there is no morphological descriptor dedicated to scented geraniums. A potential descriptor list was compiled using the hardy, regal and zonal pelargoniums but there is no scented geraniums were also consulted in the compilation.

### MATERIAL AND METHODS

The descriptor list was preliminary validated by using it for the morphological description of the scented geranium accessions housed at the ARC-VIMP. The proposed scented geranium descriptors list has 55 different plant, leaf, stem and flower characteristics that are taken into account. However, the scent of the accession is not one of the descriptors as the human nose is normally not good enough to differentiate between minor changes in the composition of the similar accession. The accessions were grown in 50cm pots in a pan and fan glasshouse. The characteristics were taken from mature flowering plants.

### **RESULTS AND DISCUSSION**

There is a wide diversity within the ARC scented germplasm. The flower and leaf descriptors have the biggest discriminatory power. The descriptor list is able to distinguish between species as expected, however the descriptor power is less within species.

# CONCLUSIONS

The list needed to be tested on a bigger number of genotypes. The large number of descriptors make it cumbersome and time consuming to use. The key descriptors need to be identified to make the list more user friendly. The consolidated list must will then be use to confirm that it maintain its discriminatory power and also capture the diversity within the scented geranium collection

Keywords: Essential oil, Morphological descriptors, Pelargonium, Scented geraniums,

# ACKNOWLEDGEMENTS

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# BIOCHEMICAL PROFILING OF HONEYBUSH (*CYCLOPIA* SPP.) STOCK PLANTS AS RELATING TO SEASONAL VARIATION OF CUTTING ROOTING POTENTIAL

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### Introduction

Honeybush (*Cyclopia* spp.), native to South Africa's Western and Eastern Cape, is a popular herbal tea, mainly harvested from the wild. To ensure sustainability, this study explores the rooting success of honeybush cuttings, focusing on *C. genistoides* and *C. subternata*. It examines the seasonal mineral nutrient and biochemical profiles, addressing the need for optimised cultivation practices.

### **Materials and Methods**

Clonal plant material of *C. genistoides* was collected from the commercial farm, Toekoms, near Bredasdorp, whilst clonal material of *C. subternata* stock plants, was obtained from cultivated stands in the Kanetberg, near Barrydale. Stock plants of both species were cut back in summer allowing a regrowth period of 15, 18, 21, 24, 27 or 30 for *C. genistoides* and 12, 15 or 18 months for *C. subternata* after which cuttings were made. The research assessed the impact of mineral nutrient levels, particularly nitrogen and potassium, and biochemical profiles, ethanol-soluble sugars, polysaccharides, starch, and total phenolics, at the time the honeybush cutting were rooted. Iron, aluminium, and boron levels' influence on rooting responses was examined. Various spectrophotometric analyses determined biochemical content.

#### **Results and Discussion**

Optimal nitrogen (1.34-1.57%) and potassium (> 0.55%) levels in stock plants positively influenced *C. genistoides* rooting. High iron, aluminium, and boron negatively impacted both species, with *C. subternata* showing better tolerance. Polysaccharides and starch in stock plants played a crucial role in root growth for *Cyclopia* spp.

#### Conclusion

This study underscores the critical role of nutrient optimization and biochemical profiles in influencing phenology, cultivation practices, and seasons. Specific clonal selections of both species can achieve rooting success of > 90%. High-cutting biomass from the current season, coupled with elevated phenolic and polysaccharide content in stock plants, is essential in the rooting success of honeybush. These findings offer valuable insights for the honeybush industry, ensuring sustainable cultivation and addressing challenges posed by habitat depletion.

# FRUIT FIRMNESS: A NEW METHOD TO DETERMINE CITRUS QUALITY?

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# INTRODUCTION

Fruit firmness has been tested in the pome industry as a key indicator of maturity and a method to quantify fruit quality. The main determinants of fruit quality for citrus fruit are internal and external quality measurements, such as the sugar/acid ratio and external defects or colour. However, over the past few seasons, producers have questioned whether firmness should also play a role. Due to an increasing interest in firmness testing for citrus in the industry, a study was done to determine its use in maturity indexing.

# MATERIALS AND METHODS

Due to differences in rind anatomy, two cultivars of citrus were chosen for this experiment, namely 'Eureka' Lemons and 'Nadorcott' Mandarins. Fruit were brought to the lab after receiving a standard packhouse treatment with an 18% carnauba wax application. Fruit were divided into two groups, one half to be stored at -0.6°C, and the other at 2°C for thirty days. Before placing the fruit in cold storage, firmness measurements were taken. After 30 days, fruit were removed from cold storage and held at 4°C for 5 days before being transferred to "on-shelf" conditions of approximately 20°C. Firmness measurements were taken on days 1, 5, 10, 14, 21, 28, and 35, starting from when the fruit were removed from the storage temperatures (-0.6°C or 2°C). The firmness was measured with an automated penetrometer using a penetration distance of 5 mm for lemons, while mandarins were measured using 3 mm.

# **RESULTS AND DISCUSSION**

Mandarin showed a significant % change in firmness, with the fruit becoming less firm as the trial progressed. Lemons followed a similar trend, although not as significantly as the mandarins. A trend was observed for all fruit at both temperatures between the % rind disorders and % change in firmness. As fruit became less firm, there was an increase in the presence of rind disorders; however, no significant correlation was observed. The % change in firmness was also compared to the % weight loss. Significant positive correlations occurred for mandarins and lemons at both temperatures, especially for fruit stored at 2°C. This indicates that, as the fruit loses weight, it becomes less firm when compared to the initial firmness.

# CONCLUSIONS

Citrus firmness decreases as time progresses during storage at ambient temperature. As firmness decreases, an increase in rind disorders can be expected, although no direct correlation could be made due to other aspects involved (e.g., preharvest growing conditions). Firmness measurements are positively correlated with fruit weight loss, indicating that firmness is lost as fruit lose weight. As such, fruit firmness can be used to indicate citrus fruit quality.

KEYWORDS: Citrus, firmness, fruit quality, lemon, mandarin, maturity

#### ACKNOWLEDGEMENTS

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# **PROPAGATION OF JUNCUS LOMATOPHYLLUS: A JOURNEY WITH WATER PLANTS**

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# INTRODUCTION

There has been little documentation on indigenous South African aquatic plants for bioactivity and propagation. Leaf extracts of aquatic plant *Juncus lomatophyllus* have been proven to inhibit the tyrosinase enzyme that causes skin hyperpigmentation. Propagation methods have however not been explored and these are essential for commercialization. The aim of the study was thus to develop some propagation and cultivation techniques.

#### MATERIALS AND METHODS

The difficulty to acquire enough plant material for trials highlighted the importance of establishing propagation protocols. Seed was not available and was collected from plants during flowering. Seed germination was tested in petri-dishes (randomized complete block design with 4 replicates) at constant temperatures of 15, 20, 25 and 30°C (in constant darkness and later in constant light) and followed up with histology studies to explore reasons for non-germination. The effect of 5 different growth media mixes on the growth of 2 *J. lomatophyllus* ecotypes (MP & WC) were investigated (complete randomized design, 4 replicates). Plants were divided to have single sprouts and monitored for growth and development over a 12 month period. Data was analysed using ANOVA and treatments were compared using a t-test at p=0.05.

### **RESULTS AND DISCUSSION**

Seeds only germinated in constant light after 3 months of incubation. The best germination percentage (49%) was observed at 20°C under constant light conditions. Seeds are minute (377µm in length) and difficult to handle. Seed germination is also different and starts by the formation of a phaneromer which is followed by the development of roots. Due to the small size of the seed it was also difficult to surface sterilize and fungal diseases led to the death of germinated seedlings. Medium did not have an any significant effect on sprouting percentage, survival or rooting percentage after division although the medium containing sand:compost (2:1) produced significantly more sprouts compared to most of the other media. Differences in growth habit in the two ecotypes were also observed. During this investigation numerous challenges were encountered, varying from extreme weather (heavy rains, destroying the pond) to some scary encounters with nature.

### CONCLUSIONS

Seed production in *Juncus lomatyphyllus* is abundant, but germination is fairly low and vegetative propagation is easier. A medium of sand and compost (2:1) produced the highest number of sprouts, which is advantages for leaf collection and extract preparation. Differences in ecotypes should be explored further and linked to activity.

KEYWORDS: Division, ecotypes, seed histology, seed propagation

# DELAYING POTATO TUBER SPROUTING WITH ABSCISIC ACID CONTAINING SEAWEED EXTRACT KELPAK®: THE EFFECT ON SIFRA AND MONDIAL CULTIVARS

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# INTRODUCTION

Potato (Solanum tuberosum) is one of the food crops that has sustained the human diet for thousands of years. However, sprouting is one of the factors that leads to loss of quality during the storage of potatoes. Currently, synthetic chemicals are used as sprouts suppressants, however there are health and environmental concerns that are related to the use of some of these chemicals. Therefore, there is a need for an alternative ecofriendly, cost-effective methods of suppressing sprouting. The phytohormone abscisic acid (ABA) is used to delay physiological disorder sprouting in various geophytes produce. The present study investigated whether the ABA containing seaweed extract Kelpak® delays potato tuber sprouting and if its effect is cultivar dependent.

# MATERIALS AND METHODS

This experiment was conducted at the University of Limpopo in Plant production Laboratory. The study consisted of a total of 100 potato tubers of two cultivars (Mondial and Sifra). The potatoes were immersed in 0.2% Kelpak® for 5 minutes. Untreated potatoes served as control. The potatoes were then stored at ambient temperature ( $\pm$  25 °C) for 20 days. Mass loss, sprouting and length, starch and dry matter were measured at 10-day intervals.

# **RESULTS AND DISCUSSIONS**

The application of Kelpak® significantly delayed sprouting incidence on both Sifra and Mondial during ambient storage (P<0.05). This was attributed to phytohormones such as ABA present in Kelpak®, which is known dormancy hormone. Tuber dry matter and starch content were lower in Kelpak® treated Mondial tubers compared Sifra. The initial dry matter and starch content were high in Sifra compared to Mondial cultivar, suggesting that the difference observed in Kelpak® treated tuber is due to genotype difference. The results demonstrated that Kelpak® has a potential to be used in the potato industry as eco-friendly and cost-effective technique for sprout suppressant.

# CONCLUSIONS

The study demonstrated that the seaweed-based biostimulant could be used an alternative ecofriendly and cost-effective sprout suppressant. Therefore, the method could be adopted as an alternative to synthetic chemicals that are currently used in the potato industry.

Keywords: biostimulants, dormancy, physiological disorder, potato cultivars, sprout suppressant

# ACKNOWLEDGEMENTS

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# ETHANOL PRODUCTIVITY OF SWEET SORGHUM (SORGHUM BICOLOR (L.) MOENCH) VARIETIES AS A SOURCE OF BIOFUEL UNDER DRYLAND CONDITIONS OF THE FREE STATE

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# INTRODUCTION

Sweet sorghum (*Sorghum bicolor* (L.) Moench) has been identified as an ideal energy crop for biofuel production due to its high biomass production, good stress tolerance and low input requirements. Ten sweet sorghum genotypes were evaluated for biomass, sugar yield and juice quality. The main objective was to determine the agronomic characteristics, juice and ethanol yields adaptable to marginal and dry land conditions, to contribute towards availing suitable sweet sorghum for industrial ethanol production.

### MATERIALS AND METHODS

Field experiments were conducted at Glen, Bothaville and Koppies for three growing seasons (2018/19, 2019/20 & 2020/21) to evaluate sweet sorghum genotypes. The varieties were evaluated for their stalk yield, quantity and quality attributes for ethanol production. Agronomic parameters measured and evaluated were days to 50% flowering, plant height, stalk yield, panicle fresh weight, leaf fresh weight, bagasse fresh weight, °Brix, stalk juice yield, Juice extraction%, and theoretical ethanol yields. Soil samples were also taken and analysed for pH (KCI) and clay content. Seasonal rainfall ranged from approximately 342 to 755 mm across various study areas.

### **RESULTS AND DISCUSSION**

All data gathered were analysed using analysis of variance (ANOVA), correlation and principal component analysis (PCA). Analysis of variance detected highly significant (P<0.001) differences among genotypes across seasons and locations for the traits investigated. A combined analysis revealed high performance for stalk juice yield, ethanol yield and Brix content by genotypes Hunnigreen (23 074 L/ha), followed by ARC-SS76 (18 185 L/ha) and ARC-SS27 (17 252L/ha). Positive correlations were observed between ethanol yield and plant height, stalk yield, stalk juice yield and biomass yields. A PCA biplot showed that °Brix, Juice extraction%, ethanol yield, Leaf fresh weight, days to 50% flowering and Bagasse fresh weight had the most significant contributions to genotypes variability.

#### CONCLUSIONS

There was a high degree of variability among the genotypes that can be exploited on sweet sorghum to improve ethanol production. Further studies on adaptability and stability in more diverse environments and seasons using more varieties are important to generate more reliable information on the effects of genotypes, environment, and their interaction on ethanol yield and related traits.

Keywords: Biofuels, Brix content, Ethanol, Genotypes, Sweet Sorghum

# PHYSIOLOGICAL RESPONSES AND LC-MS BASED METABOLOMICS OF BUSH TEA (ATHRIXIA PHYLICOIDES DC.) TO VARIOUS NUTRIENT SOURCES OF ORGANIC AND INORGANIC FERTILIZERS

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### INTRODUCTION

Herbal tea cultivation has become a thriving large business in many parts of the world with complex industry producing a wide range of teas. Bush tea (*Athrixia phylicoides* DC.) is an indigenous shrub in South Africa that is commonly used as an anti-depressant and aphrodisiac in southern African populations. However, bush tea is currently collected in the wild for its medicinal properties to treat chronic diseases such as cardiovascular disease and cancer. This implies that the plant has a high commercialization potential as a health benefit herb and a source of high-value products for beverage and pharmaceutical industries. Hence, previous studies have been conducted to determine the effect of environmental factors and management practices. However, information on how organic versus inorganic fertilizers may impact the quality of bush tea is not yet documented. Thus, the study aims to investigate the influences of organic and inorganic fertilizers on plant growth and molecular responses of bush tea.

#### MATERIAL AND METHODS

The study was conducted at University of Venda, Vhembe District, Limpopo Province, South Africa, under field conditions. The study treatments consisted of various organic and inorganic nutrient sources arranged in a randomized complete block design with 3 replicates per treatment. Treatments were control (0kg/ha) and 300kg/ha of lime ammonium nitrate, kraal manure, kelpak and multicote. Data for chlorophyll content, plant height, IR%, fresh and dry weight were collected as physiological parameters and were subjected to one-way ANOVA using IBM® SPSS® Statistics version 25 software at p < 0.05 as the significance threshold. Dried grounded of bush tea samples were subjected to Liquid Chromatography–Mass Spectrometry was used to analyze the samples and molecular networking was further used to unravel the molecular families within the metabolomes of bush tea.

#### **RESULTS AND DISCUSSION**

The study revealed that bush tea plants treated with kraal manure had a significant difference in fresh and dry weight. While the LC-MS preliminary results revealed that bush tea treated with lime ammonium nitrate and kraal manure results in higher concentrations of metabolites compared to the control. The quercetin, 3-o-demethyldigicitrin, 5,6,7,8,3',4'-hexamethoxyflavone, 5-hydroxy-6,7,8,3',4',5'-hexamethoxy-flavan-3-ol, and tannins annotated in bush tea exhibits biological activities associated with antioxidants effects, cardiovascular-protective properties, and anti-inflammatory effects.

#### CONCLUSIONS

Bush tea revealed to be phytochemically rich plants consisting of many biologically active metabolites that exhibits biological activities associated with antioxidants effects, cardiovascular-protective properties, and antiinflammatory effects.

**KEYWORDS**: Athrixia phylicoides, inorganic fertilizers, LC-MS, manure, molecular networking, organic fertilizers.

### ACKNOWLEDGEMENTS

University of South Africa and University of Mpumalanga for funding, and University of Venda for supplying agricultural land and LC-MS for metabolites analysis.

# PRE- AND POST-HARVEST LOSSES OF SWEET POTATO AND OUTLOOK ON THE PROCESSING POTENTIAL OF ORANGE-FLESHED SWEET POTATO

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# INTRODUCTION

Sweet potato, in particular due to its versatility as a crop and its multiple end-uses, is starting to attract growing attention from researchers and policymakers having potential to address Sustainable Development Goals and promote a sustainable society. The reduction of postharvest losses (PHL) is key for food and nutrition security in sub-Saharan Africa. The main objectives of the study were to quantify losses amongst producers, pack houses and processors, and to provide an outlook on the potential of processing of orange-fleshed sweet potato.

# MATERIALS AND METHODS

A literature review was conducted on pre-harvest losses, losses at harvesting and postharvest losses. A questionnaire was developed to obtain data on the magnitude of losses occurring through the value chain. Small holder farmers, commercial farmers, pack houses, distributors and processors of sweet potatoes were contacted via phone and/or email. Convenient sampling was used by contacting persons and companies with which the ARC had dealt with before. Forty persons were contacted of which 14 responses were received. This represented Limpopo, Mpumalanga, Gauteng and Western Cape.

### **RESULTS AND DISCUSSION**

During the growing season, losses of 0 to 30% are experienced. Some respondents indicated high % loss due to poor weed control and lack of irrigation. Generally, during harvesting, washing and sorting, losses can be 5 to 29%; with the exception of 70% for some due to high weevil infestation. During transport generally 0 to 9%, storage 0 to 9% and marketing 0 to 9% losses were experienced. A packing and distribution house indicated they are able to pack 76% as 1<sup>st</sup> grade (prepack). The total losses are 11%, of which, 2% are cutting waste and 9% are out spec (skin bruising/loose skin, rot, insect, size). During processing, 20-29% losses may be experienced due to off-bits, peels and insect-infested parts. The most prevalent type of products were puree-based and included a wide variety of baby foods and ready-to-eat soup. The second most prevalent type of product was ready-to-eat or convenience foods. These are most often pitched as vegetarian/vegan, gluten-free, organic, healthy foods or weight loss. Therefore, there is a strong marketing approach for such food items and mostly aimed at higher income groups. There are several processing options which are not yet explored. Although orange fleshed sweet potato is a nutritious crop, it is not widely cultivated and consumed in many regions.

#### CONCLUSIONS

Converting storage roots into processed products of high culinary value, nutritious foods, medicinal and industrial products are a definite means to reduce food losses and increase the economic potential.

KEYWORDS: food losses, food processing, irrigation, insect infestation, weed control

#### ACKNOWLEDGEMENTS

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# EFFECT OF SHORT-DURATION DROUGHT STRESS ON CYCLOPIA SUBTERNATA LEAF COMPOSITION AND HERBAL TEA QUALITY

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**Introduction:** Honeybush tea is made from the fynbos plant *Cyclopia subternata*, which is unique to South Africa. Cultivation takes place in its natural environment, which has a Mediterranean climate with dry summers and wet winters. During the summer, the plant is vulnerable to drought, an abiotic stress factor that is likely to affect its development and yield. This study investigated the effect of drought stress for a short duration on the leaf, as well as the quality of the herbal tea.

**Materials and method**: Fifteen-month-old *C. subternata* plants were subjected to three water treatments (control, moderately-stressed (MS), and severely-stressed (SS)) for ten days. Leaves were sampled at regular intervals throughout the treatment period to determine their relative water content (RWC). Leaves were also sampled on the 11th day for untargeted and targeted chemical composition. The remaining leaves and stems were processed to obtain the herbal tea. A descriptive sensory analysis of the herbal tea was performed to determine whether drought stress affected product quality. Data were analysed using the NIR-HIS and DI-IMS-MS for untargeted leaf analysis and ANOVA for targeted leaf analysis.

**Results and discussion**: RWC was substantially higher (p < 0.05) in the control plants (100%) than in the MS and SS treated plants (83 - 90% and 47%, respectively). Untargeted analysis revealed that drought stress considerably altered leaf chemical composition. However, the plant constituents responsible for these differences were not identified. According to targeted analysis, the proline content of SS-treated plants increased more than 40-fold in comparison to the control, implying that proline may act as an osmoprotectant, protecting the plants from cell damage and enhancing survival during drought stressed conditions. Contrary to expectations, drought stress treatments did not affect the individual phenolic compounds and total carbohydrate content of the leaves or the sensory profile of the herbal tea. These findings imply that *C. subternata* plants require more severe drought stress conditions to alter these characteristics. As a result, additional drought stress research addressing these issues is required.

**Conclusions and recommendations**: These findings lay the foundation for future research into the functions of drought response in *Cyclopia* species, and the identification of stress-tolerant honeybush genotypes. Future studies are required to better understand the stress responsive mechanism in *C. subternata* when subjected to prolonged drought stress under field conditions.

Keywords: Carbohydrates, Cyclopia, drought stress, polyphenols, proline, relative water content

# NUTRITIONAL COMPOSITION AND PHYTOCHEMICAL PROPERTIES OF SELECTED AMARANTH LANDRACES UNDER OPEN FIELD CULTIVATION

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# INTRODUCTION

There has been a progressive change during the last 50 years as far as the food security concept is concerned. Food security issues, pressure on the land, and increasing soil degradation have led to increasing research interest on the utilisation and inclusion of indigenous leafy vegetables such as Amaranth in having the potential to alleviate hunger and malnutrition. There have been new research findings revealing that Amaranth contains a certain peptide that has been identified in soybean and can ease inflammation in the body and even prevent the activity of free radicals that can cause healthy cells to mutate into cancerous cells. This lesser-known benefit of Amaranth is one of the most exciting new developments in recent Amaranth research.

# MATERIALS AND METHODS

Ten lines of Amaranth landraces from the breeding division were selected and tested for their agronomic performance. A randomized complete block design (RCBD) was conducted in an open filed to evaluate phytochemistry and selected nutritional composition of these various Amaranth landraces.

# **RESULTS AND DISCUSSION**

The ten lines of interest were *Anna, Arusha, VI061487, VI062433, VI063759, VI044371, VI044437, VI06472, VI061494 and VI050446*, which have exhibited varying profiles in terms of nutrition and phytochemicals. Although their vitamin contents did not differ significantly between landraces at P=0.001, their phytochemistry revealed that they are high in antioxidants, flavonoids and phenolic content that aids the body's defence mechanisms against disease. In this study, concentrations of the various nutritional compounds were found to be largely influenced by the plant part, as there was a positive interaction between the plant part (leaves, stems and flowers) to the Amaranth landrace. The landraces exhibited high total phenolic and flavonoid content, antioxidant, *beta*-Carotene and vitamin E content in *LandR1, LandR4* and *LandR9*, with the lowest vitamin E contents at LandR5 (mg/100 g DW) (Fig. 1). The ANOVA showed that the landraces have a high significant difference at (p < 0.05).

# CONCLUSIONS

Regardless of landraces, the ten Amaranth lines tested in this study exhibited high phytochemistry, though some of the species are bred for both leaves and grain production (*A. cruentus* and *A. hypochondriacus*). Their leaves are used mainly for nutrition hence the tests showed high variation of *beta*-Carotene, Vitamins C and E, respectively. A positive and significant interaction was observed for the plant part (leaves, stem and flowers) with total phenolic content (TPC), vitamin C contents, as well as in their antioxidant activities (DPPH), while for other nutritional and phytochemical content there was low significant interactions (Vitamin E, DPPH in *beta*-Carotene and *beta*-Carotene content). Leaf colour can therefore be used as a breeding trait to ensure improved nutritional attributes, and in addition, evaluation of landrace and Amaranth genotypes' performance in different locations is recommended as this could be a key factor for improvement programmes of these crops.

KEYWORDS: Amaranthus, underutilized crops, food security, phytochemicals

# ACKNOWLEDGEMENTS

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# WATER RETENTION POTENTIAL OF BIOCHAR MADE FROM STEMS OF MORINGA AND VARIOUS INVASIVE PLANTS

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# Introduction

Water scarcity in South Africa, where annual rainfall is below atmospheric evaporative demand, threatens food security (Araya et al., 2020). Biochar additives possess the potential to improve water holding capacity, reduce leaching and enhancing water availability in the crop root zone (Gondim et al., 2018). Thus, a study investigated water retention of different biochar feedstocks.

### **Material and Methods**

Lab experiment was conducted at the Agricultural Research Council- Vegetable, Industrial and Medicinal Plants in Roodeplaat, Gauteng Province, South Africa. A 45-minutes pyrolysis (>700 °C) prepared biochar of 5 grams across all the plant species. *Moringa oleifera, Lantana camara L., Azadirachta indica, Solanum mauritianum* stems and Charcoal as the control. The experiment included five beakers with 200 ml of water in a completely randomized design replicated five times. Biochar was immersed into a designated beaker, and the weights were recorded at five-minute intervals.

### **Results and Discussion**

Moringa absorbed more water (27.82 ml in 5 mins), followed by Bugweed (10.19 ml), charcoal showed minimal change (6.11–6.41 ml). Lantana and Neem displayed consistent absorption (6–9 ml). After 10 mins, there was a slight increase by 1 ml per 5 mins. Moringa displayed the highest water retention (95% of 150 ml in 5 mins), followed by Lantana, Neem, and Bugweed (87–90%), and while charcoal retained 69%. Water retention remained constant after 25 mins. There's a direct relationship between biochar water absorption/retention and the pore sizes.

# Conclusions

Moringa showed excellent water absorption and retention, followed by Lantana. Therefore, incorporating these products into low-water-holding soils benefits moisture and nutrient retention.

# References

Araya HT, Araya NA, Amoo SO, Mofokeng MM, Makgato MJ, Laurie SM, du Plooy CP. 2020. Participatory school-based vegetable gardens to enhance school feeding schemes and well-being of children in Mamelodi, Gauteng Province. WRC Report No TT 818/20, 1-156.

Gondim, R.S., Muniz, C.R., Lima, C.E.P. and the results A.D., 2018. Explaining the water-holding capacity of biochar by scanning electron microscope images. *Revista Caatinga*, *31*, pp.972-979. *Keywords: pyrolysis, soil water retention.* 

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# PHYTOCHEMICAL AND MINERAL COMPOSITION OF SELECTED AROMATIC HERBS

# **GROWN IN DIFFERENT PRODUCTION SYSTEMS**

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# INTRODUCTION

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Increased market demand for herbs has prompted growers to ensure a continuous and assured supply of superior nutritional quality over the years. The nutritional quality properties of aromatic herbs are reported to vary with growing environmental conditions. This study aimed to evaluate the phytochemical composition in selected aromatic herbs grown under varied production systems at harvest.

# MATERIALS AND METHODS

Five selected aromatic herbs (coriander, rocket, fennel, basil and moss-curled parsley) were evaluated at harvest when grown under three production systems, in a gravel-film technique (GFT) hydroponic system and in soil under the 40% white shade-net structure, and in a soilless medium under a non-temperature-controlled plastic tunnel (NTC). The phytonutritional quality properties (total phenolic, flavonoids,  $\beta$ -carotene,  $\beta$ -carotene-linoleic acid, vitamin C and condensed tannins contents), 1,1-diphenyl-2-picrylhydrazyl (DPPH), and leaf mineral content were evaluated.

# **RESULTS AND DISCUSSION**

The highest levels of vitamin C were found in basil leaves grown in GFT and in-soil, under shade-net compared to soilless production under NTC. The amount of total phenolic and flavonoid compounds,  $\beta$ -carotene,  $\beta$ -carotene-linoleic acid and DPPH was considerably high in-soil cultivation under shade-net environment, except on condensed tannins compared to the GFT and NTC which could be as a result of photosynthetic active radiation (PAR) values (683 µmol/m<sup>2</sup>/s) and t not favouring accumulation of tannins. At the same time. Furthermore, all the environmental conditions evaluated showed no effect on the antioxidant activity of the aromatic herbs. Overall, mineral content was greatly influenced by the environment. Leaf Ca and Mg content were highly accumulated in rocket grown in soilless system and GFT under NTC and shade-net, respectively, which could be due to cation competition in the nutrient solution.

# CONCLUSION

Results have as highlighted the growing environmental conditions to have a significant nutritional impact on the biosynthesis of health-promoting phytochemicals in aromatic herbs. Some have positive ramifications, while others have negative ramifications. As a result, growers should prioritise in-soil production system under the shade-net over GFT and NTC for the production of aromatic herbs in order to improve customer health and promote the increasing economic value of herbs in a commercial setting.

Keywords: aromatic herbs, nutritional quality, growing environments

# ACKNOWLEDGEMENTS

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# POSTHARVEST APPLICATION OF PLANT-BASED EDIBLE WAX FOR DELAYING POTATO TUBER SPROUTING

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# INTRODUCTION

Postharvest sprouting of potato tubers reduces quality, shelf-life and consumer acceptability of the produce. Important quality attributes including starch, colour and taste are reduced due to tuber sprouting. Thus, several methods and treatments have been introduced to delay potato tuber sprouting. However, these are eco-unfriendly and some are cost ineffective. Therefore, due to the growing consumer demand to preserve food in a natural way, with fewer additives and synthetic agents, the study aimed at delaying potato tuber sprouting on two commonly consumed cultivars using the eco-friendly plant-based edible wax.

### **METHODS AND MATERIAL**

Tubers of two potato cultivars (Mondial and Sifra) were dipped in plant-based wax ® for 5 seconds. Control tubers were dipped in distilled water. Both unwaxed and wax treated tubers were allowed to dry at ambient temperature thereafter stored in the dark at ambient temperature to induce sprouting for a period of 20 days. During ambient dark storage, sprouting, fresh and dry mass were evaluated at 5-day intervals.

### **RESULTS AND DISCUSSION**

During 20-day storage period, the wax significantly (*P*<0.05) reduced sprouting incidence compared to the control in both Mondial and Sifra cultivars, where treated tubers for Mondial and Sifra had lower sprouting percentage of 44% and 28%, respectively, compared to the control having 76% and 92%, respectively. Control tubers lost significantly higher mass compared to the wax-treated tubers in both cultivars. Furthermore, dry matter and starch content were significantly lower in wax-treated tubers compared to the control. Decay incidence was significantly higher in tubers treated with wax compared to the control in both cultivars. The findings indicate that sprouting could be reduced by the plant-based wax ®, however; it induced decay. This was attributed to wax acting as a barrier for oxygen intake by the tuber, limiting sprout development; however, with increased anaerobic respiration, making tubers susceptible to microbial attacks.

#### CONCLUSION

The study showed that coating potato tubers with plant-based wax ® at room temperature could be an environmentally acceptable method for controlling potato tuber sprouting. However, proper protocol should be developed to reduce decay incidence, without compromising sprout control efficacy.

Keywords: Edible coating, lipid-based coating, natural waxes, Solanum tuberosum, tuber sprout

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# CHANGES IN CAROTENOID AND METABOLITE PROFILES FROM LEAVES OF SIX CULTIVARS OF SWEET POTATO (*IPOMOEA BATATAS* L.) DURING LACTIC ACID FERMENTATION

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# INTRODUCTION

Sweet potato leaves (SPL) are extremely perishable and they contain health promoting composites which facilitates their choice as food. Consumption of sweet potato leaves as a vegetable could significantly increase food availability in countries with recurring food shortages. The aim of this study was to investigate the effect of fermentation by *Lactiplantibacillus plantarum* 75 (L75) on carotenoids, organic and amino acids and organic sugars of smoothies produced from leaves of six sweet potato cultivars.

# MATERIALS AND METHODS

Tender leaves were harvested from six cultivars ('Bophelo', 'Beauregard', 'Blesbok', 'Ndou', '08.21P' and 'Purple-purple') at Agricultural Research Council-VIMP in Roodeplaat (25, 56°S; 28, 35°E). The leaves were then blended and fermented by L75 for 48 h to produce a smoothie. Thereafter, the total carotenoid content (TCC) was determined using a spectrophotometric method, whereby carotenoid profiles were quantified using UHPLC system (Dionex Ultimate 3000, Thermo FisherScientific, Waltham, MA, USA). The derivatised sugars and acids were analysed using a gas chromatograph instrument (GC/MS).

# **RESULTS AND DISCUSSION**

The total carotenoid content of the smoothies was 0.50 mg/100 g before fermentation and increased to 13.93 mg/100 g after fermentation. Hence, lactic acid fermentation aids the release of carotenoids from the blended leaves. For the quantified carotenoid compounds, the lutein content ranged from 10.35 to 38.24 mg/100 g, while alpha and cis-beta carotene ranged from 0.49 to 37.23 mg/100 g. The increase in carotenoid profiles could be due to the enzymatic breakdown of the cell walls causing an improved extractability. The amino acid contents also increased after fermentation, where valine was highest (10.12 mg/100 g) in fermented and lowest in the unfermented smoothies (1.04 mg/100 g). Organic acids quantified after fermentation were tartaric acid (3.39 mg/100 g), malic acid (3.35 mg/100 g) and lactic acid (3.91 mg/100 g). These acids help to create an unfavourable environment for the evolution of food pathogens in the unfermented smoothies.

# CONCLUSIONS

The results showed that fermentation can release the carotenoids, organic and amino acids from the SPL leaves used in the smoothies. Therefore, fermentation can be recommended as a desirable processing method for SPL smoothies.

**Keywords:** Antioxidants, Carotenoids, Lactic acid fermentation, Lactiplantibacillus plantarum 75, Smoothies, Sweet potato cultivars

# ACKNOWLEDGEMENTS

National Research foundation and the Agricultural Research Council (ARC-VIMP) for funding this research study.

# EFFECT OF SUCROSE AND CALCIUM CHLORIDE PULSING ON EARLY SEASON 'HASS' AVOCADO FRUIT EXOCARP CHILLING INJURY AND COLOUR CHANGE DURING STORAGE AND RIPENING

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# INTRODUCTION

'Hass' avocado fruit exocarp changes colour from green to purple and black during ripening (Cox *et al.*, 2004). However, uniform purple or black exocarp colour is not achieved during ripening, leading to consumers' rejection of fruit for not meeting quality standards. 'Hass' avocado fruit harvested early remain green or develop a multicoloured appearance, making them unattractive to consumers and consequently devaluing their commercial value (Mathaba *et al.*, 2015). This study aimed to investigate the role of sucrose and calcium postharvest pulsing on exocarp colour change during ripening of early matured 'Hass' avocado.

# MATERIALS AND METHODS

In this study, early matured 'Hass' avocado fruit were harvested from Halls and Sons, Mataffin farm  $(25^{\circ}25'39.13" \text{ S}, 30^{\circ}55'52.84" \text{ E})$ , Nelspruit, South Africa at commercial dry matter content (22%), with 10 cm pedicel. Thereafter, the fruit were transported to the University of Mpumalanga laboratory. In the laboratory, 'Hass' fruit were continuously infused through the pedicel with different sucrose and calcium chloride solutions; no solution (control), distilled water, sucrose at 0.2 and 0.5 mM, and calcium chloride at 2 and 3 mM. Thereafter, treated and untreated fruit were stored at 5.5°C for 28 days. After removal from cold storage, fruit were ripened at ambient temperature ( $\pm 25^{\circ}$ C) and evaluated every other day for firmness, subjective colour (visual colour), objective colour parameters (lightness-*L*\*, chroma-*C*\* and hue angle- *h*°), external chilling injury and ripening percentage.

# **RESULTS AND DISCUSSION**

The results showed that sucrose (0.2 mM) pulsing, and calcium chloride (2 and 3 mM) extended the ripening period by one day, corresponding with maintained fruit firmness. Furthermore, sucrose (0.2 mM) and calcium chloride (2 and 3 mM) treated fruit reduced the 'Hass' avocado fruit chilling injury index (CII), concomitant with improved 'Hass' avocado fruit exocarp colour change during cold storage, when compared with the control.

# CONCLUSIONS

In conclusion, the results of this study indicated that sucrose and CaCl<sub>2</sub> applied as postharvest treatments may contribute to avocado colour development by increasing anthocyanin synthesis and accumulation.

# REFERENCES

Cox, KA, McGhie TK, White A, Woolf AB. 2004. Skin colour and pigment changes during ripening of 'Hass' avocado fruit. *Postharvest Biology and Technology* 31:287-294.

Mathaba N, Mafeo TP, Kruger FJ. 2015. The skin colouring problem of 'Hass' avocado fruit during ripening. *South African Avocado Growers Association Yearbook* 38:51-57.

Keywords: Calcium chloride, chilling injury, exocarp colour, sucrose

# EVALUATING GRAIN YIELD AND NUTRITIONAL COMPOSITION OF TWO LEGUME

# SPECIES IN FARMERS' FIELDS IN FOUR MUNICIPALITIES OF VHEMBE DISTRICT

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### INTRODUCTION

Grain legumes such as Bambara groundnuts (*Vigna subterranean*) and Cowpea (*Vigna unguiculata*) are rich in protein and mineral elements and a nutrient-dense source for most smallholder subsistence and resource-poor farmers in South Africa. This study aimed to evaluate grain yield and nutritional composition of two legume species that have not been extensively studied in smallholder farmer's participatory research in the specific geographic area of the Vhembe district.

### MATERIALS AND METHODS

The experimental design consisted of four treatments (Thulamela, Makhado, Musina and Collin chabane). The experiment was laid out with five replicate (farmers' fields) per treatment. Bambara groundnut and cowpea were grown during the 2021/2022 summer cropping season in South Africa. Ten plants were randomly sampled at 50% flowering from each farmer's field following the zigzag manner across the fields used to determine growth, grain and yield components. Soil samples were randomly sampled from each experimental field (0 - 30 cm depths and analyzed for chemical (such as s pH (H 2 O), P using Bray-2 (Bray, 1945), K, Na, Ca, Mg, Na, B, Mo, Fe and Z and physical (Sand, Silt, and Clay) properties of the soil. For nutritional composition analysis, a sample of 0.1-0.5 g flour was taken from the milled pods. The mineral content was determined at the (ARC-ISCW) analytical laboratory in Pretoria, South Africa. Ca, K, Mg, Na, B, Cu, Fe,Zn, and protein levels were determined in ground pods and leaves.

# **RESULTS AND DISCUSSION**

Pearson's correlation analysis revealed the associations between most of the soil physio-chemical properties and the correlation between soil Physio-chemical properties were consistent across the farmer's fields. The collected data showed significant ( $p \le 0.05$ ) differences in plant dry matter (DM) yield, number of pods, pods dry weight and number of nodules from different farmer's fields. The correlation analysis in Makhado indicated that shoot + pods was positively and significantly correlated with soil pH, for Bambara groundnut (r = 0.83) and cowpea (r = 0.82). In Makhado municipality, the data showed increased dry matter (144.3 g/plant) with the lowest dry matter in Musina (68.3 g/plant), irrespective of the farmer's field.

# CONCLUSIONS

The data on the plant growth and grain yield of Bambara groundnut and Cowpea from this study has confirmed that the Bambara groundnut and Cowpea can contribute to high grain yields. The production location of Bambara groundnut and cowpea species were significant, and Musina was more suitable for Bambara groundnut production. Cowpea plant parts had a higher nutritional content than Bambara groundnut. These legumes can help you create a well-balanced diet. It can also be beneficial in areas where these minerals and nutrients are deficient in the diet.

Key words: Minerals, Protein, Pods, nodulation, municipalities, food security, Limpopo province.

# ACKNOWLEDGEMENTS

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# RHIZOSPHERIC MICROORGANISMS OF TWO-LEGUME SPECIES GROWN IN FARMERS' FIELDS IN LIMPOPO PROVINCE

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### INTRODUCTION

Plant-beneficial microorganisms are determinants of plant health and productivity. However, the effects and functional diversity of rhizosphere soil microbes associated with two different legume species grown in farmers' fields are unclear. The study was conducted to understand the functional diversity of rhizosphere soil microbes for two legume species, variations in the total microbial count, carbon source utilization profile, andsoil–plant interactions in the rhizosphere. Therefore, the study hypothesizes that the rhizosphere soil microbes of two-legume species will host distinct microbial communities with composition and functional diversity variations under different farmer's fields.

### MATERIALS AND METHODS

The experimental design consisted of four treatments (Thulamela, Makhado, Musina Collin chabane). The experiment was laid out with five replicate (farmers fields) per treatment. The rhizosphere soil was sampled during the 50% flowering stage per plot. Soil microbial Carbon Source Utilization Profiles (CSUP) using BIOLOG<sup>TM</sup> GN2 plates determined microbial diversity, and the carbon source utilization pattern of the soil microbial communities was determined from the BIOLOG microplate's average well-colour development (AWCD). Rhizosphere samples were sampled 15 cm deep from two different legume species. The abundance and richness of the soil microbes were determined using the Shannon-Weaver and Evenness diversity indices, respectively. Principal component analysis showed differences in carbon source utilisation profiles between the two different legume species samples and farmers fields. Soil microbial enzymatic activities were assessed by measuring  $\beta$ -glucosidase and alkaline phosphatase in the soil microbes at farmer's fields.

#### **RESULTS AND DISCUSSION**

The microbial abundance (richness index) in this study ranged from 18 to 31, with cowpea at Collin chabane farm fields being the highest while rhizosphere soil microbes (Bambara groundnut) while in Thulamela and Collin chabane farmer's fields ranged from 11 to 28 being the lowest. The Shannon-Weaver index varied between 2.49 and 3.41 across all the farmer's fields, respectively. Carbon sources utilized by bacterial communities spread across the 31 carbon sources. The highest utilization of carboxylic acids, amino acids, amines, polymers, and carbohydrates was found in the bacterial communities of sample Makhado (cowpea)-C15, Makhado (cowpea)-C16, Collin Chabane (cowpea) – C6, Makhado (Bambara groundnut)-B9 and Makhado (Bambara groundnut)-B7.

### CONCLUSION

The study showed that the variations observed in rhizosphere soil microbe parameters of two legume species at farmer fields highlight the complexity of soil microbiota and their potential implications for soil health and agricultural productivity. This soil diversity and richness is an indicator of the quality of the soil to increase crop yields and agricultural production.

Keywords: Enzyme and Soil microbial activity, Shannon Weaver Diversity Index.

# ACKNOWLEDGEMENTS

Agricultural Research Council and Water Research Commission for funding, DALRRD.

# LEAF ANATOMICAL TRAITS OF MACADAMIA CULTIVARS WITH POTENTIAL LINKS TO DROUGHT TOLERANCE

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# INTRODUCTION

Leaves play a critical role in plant water use, thus evaluating leaf and petiole anatomy may reveal variations linked to drought tolerance. In South Africa, *Macadamia integrifolia*, *Macadamia tetraphylla*, and their hybrids are commonly grown for their edible nuts and consequent nutritional benefits. To improve yields, irrigation is used to grow these trees in regions where rainfall is often inadequate. Selecting cultivars with desirable leaf anatomies, capable of withstanding drought, is one strategy to increase water use efficiency. To test the potential efficacy of this strategy in macadamia, we tested differences in multiple traits related to water use efficiency in common South African macadamia cultivars.

### MATERIALS AND METHODS

After the vegetative flush in spring 2021 and summer 2022, we collected leaves of various macadamia cultivars ('695', 'A4', '814', '816', and '842') from the northern (Levubu, Nelspruit, and Komatipoort) and southern (KwaZulu Natal) regions of South Africa. Using standard microscopy techniques, we determined leaf area, stomatal density, the thickness of the palisade and spongy parenchyma tissues, xylem cross-sectional area of the petiole, and vein density, as these are of direct functional relevance to water use.

# **RESULTS AND DISCUSSION**

Leaf anatomical traits showed significant differences between *Macadamia integrifolia* and macadamia hybrids, as well as across farms. The variation in leaf anatomy was significantly influenced by the timing of vegetative growth and type of leaves (sun and shade), while the influence of specific farm and cultivar were minor. Climate played a role in these differences, although no clear patterns emerged. It is highly likely that genetic factors significantly contributed to the observed differences in leaf anatomy among various macadamia cultivars.

# CONCLUSIONS

Leaf anatomical characteristics related to water use vary substantially and in ways that are flush, leaf type, farm, and cultivar dependent. This means that any effects on water use efficiency and potential drought tolerance may be difficult to predict and will require direct experimentation under various irrigation schemes and in different crop-growing regions. Results will be made available to macadamia growers, and it is hoped that a better understanding of leaf anatomical proxies of water use will lead to better management practices, such as the selection of drought-tolerant cultivars and enhanced irrigation management, in the South African macadamia industry.

**KEYWORDS:** drought tolerance, macadamia, stomatal density, vein density, water use, xylem cross-sectional area

# INFLUENCE OF EXOGENOUSLY APPLIED PLANT EXTRACTS ON GROWTH, PHYSIOLOGICAL AND YIELD PARAMETERS OF SUMMER SQUASH (*CUCURBITA PEPO* L.)

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#### INTRODUCTION

The world's population is anticipated to rise enormously to reach 9.7 billion by 2050. Consequently, the global food demand is also expected to increase by 59-102%. Agricultural industries, therefore, face a major challenge of increasing crop productivity and food production under unpredictable weather conditions due to climate change and its aligned factors (*viz.*, drought, salinity, as well as weed, pest and disease infestations). In the 21<sup>st</sup> century, inorganic fertilizers and synthetic pesticides have been vital; however, their usage negatively impacts human health and the environment. Plant extract utilization is the promising, safer, eco-friendly and financially feasible option that could potentially reduce the usage of hazardous chemicals. Given the importance of safe and high-nutritious food, this study aims to evaluate the growth and yield response of summer squash following the exogenous application of plant extracts.

#### MATERIAL AND METHODS

The experiment was conducted inside a glasshouse with environmental condition maintained at 25±2°C, 68 % RH during the day and 10±2°C, 75 % RH during the night. Summer squash plants were established from direct seeding. Two weeks after planting, five healthy, similar-sized summer squash (*Cucurbita pepo* L.) seedlings were then randomly selected and assigned to each of the six treatments, hence, resulting in 30 experimental units. The treatments were: *Ascophyllum nodosum* extract (ANE), aloe vera leaf extract (AVE), garlic bulb extract (GBE), ginger rhizome extract (GRE) and moringa leaf extract (MLE), as well as a control. Data on vegetative growth parameters were initially recorded (two weeks after emergence) before treatment application, then further collected in 14-day (bi-weekly) intervals until fruiting. Immediately after harvesting, leaf chlorophyll concentration was determined following the destructive procedure described by Lichtenthaler (1987). Lastly, all yield parameters were recorded immediately after harvesting.

### **RESULTS AND DISCUSSION**

The soil drench application of plant extracts, as pre-harvest treatments, had a significantly ( $p \le 0.05$ ) influence on growth and development, as well as physiological and yield attributes of summer squash plants. ANE, GBE and MLE application significantly enhanced vegetative growth of summer squash plants, hence, produced higher number of leaves and brances, as well as greatest leaf area compared to AVE, GRE and the control. ANE-treated plants also yielded higher leaf chlorophyll concentration than other treatments AVE, GBE, GRE and MLE, as well as a control. Lastly, soil drench applications of plant extracts considerably increased yield parameters of summer squash, with ANE- and MLE-treated plants producing highest number of fruits/plant, largest fruit size and heavier fruit mass than other treatments.

#### CONCLUSIONS

Based on these results, use of natural plant extracts, as an alternative to hazardous chemicals is highly advisable and recommended for the sustainable production of summer squash, without compromising consumers' health.

Keywords: Cucurbitaceae, natural biostimulant, growth parameters, soil drench, yield

#### ACKNOWLEDGEMENTS

National research Foundation for funding and University of KwaZulu-Natal, School of Agriculture, Earth and Environmental Sciences, Department of Horticultural Sciences for technical support.

# DO PROTECTIVE NETS REDUCE WATER USE AND IMPROVE WATER PRODUCTIVITY IN APPLE ORCHARDS UNDER MEDITERRANEAN-TYPE CLIMATE CONDITIONS?

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#### INTRODUCTION

Protective nets are increasingly used in warm production areas (Bosco et al., 2018). Apple production in Mediterranean-type climates is frequently limited by water scarcity and water saving technologies are needed. Water use of irrigated trees and orchards was quantified under fixed and draped nets. We found that water savings and improvements in crop water productivity (WP) can be achieved under both net types (Girona et al., 2012).

#### MATERIAL AND METHODS

Trials were conducted over two seasons in a 'Rosy Glow' orchard under 20% fixed white netting (Koue Bokkeveld, KBV), and in 'Golden Delicious Reinders' and 'Golden Delicious' orchards in KBV and Villiersdorp, respectively, under 24% black draped netting. Open tree rows in the same orchard served as the control. Tree transpiration (T) was estimated using the heat ratio sap flow method, and orchard evapotranspiration (ET) was estimated using the soil water balance approach (Dzikiti et al., 2018). Data were interpreted in conjunction with data for microclimate, plant water status, soil water content, and irrigation. The basal crop coefficient (K<sub>cb</sub>) was calculated. WP (marketable yield per unit of water used) was calculated based on tree (T) and orchard (ET) water use.

#### **RESULTS AND DISCUSSION**

The fixed net reduced solar radiation, wind speed and reference evapotranspiration (ET<sub>o</sub>, 12% lower). Seasonal T and ET were 11% and 4% lower under the net, respectively, compared to the control. Mid-season K<sub>cb</sub> was 0.54 (net) and 0.59 (control). Transpiration-based WP was higher under the net (20.7 kg m<sup>-3</sup>) than in the control (18.2 kg m<sup>-3</sup>). ET-based WP did not differ. The black draped net reduced solar radiation, wind speed and air temperature, while relative humidity was higher than in the control. In the netted period, T was 3% lower (KBV) and 15% lower (Villiersdorp) under the net. The ET response was inconsistent, declining by 19% in KBV under the net while increasing by 16% in Villiersdorp, due to soil water differences. Mid-season K<sub>cb</sub> in KBV was 0.42 (net) and 0.51 (control), and in Villiersdorp it was 0.79 (net) and 0.70 (control). Transpiration-based WP was increased in KBV (net: 25.5 kg m<sup>-3</sup>, control: 23.2 kg m<sup>-3</sup>), as was ET-based WP (net: 19.0 kg m<sup>-3</sup>, control: 14.5 kg m<sup>-3</sup>). In Villiersdorp, T-based WP was 16.8 kg m<sup>-3</sup> (net) and 12.6 kg m<sup>-3</sup> (control), with no treatment difference in ET-based WP.

#### CONCLUSIONS AND RECOMMENDATIONS

Fixed nets reduced tree water use, but the water saving benefits were smaller at orchard level (ET) because of a more active ground cover. Careful management of the orchard floor is essential to maximize the water saving benefits. Water saving benefits are potentially high under black draped nets. For both net types, care must be taken not to over-irrigate under the nets.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

Bosco, LC, Bergamaschi, H, Cardoso, LS, de Paula, VA, Marodin, GAB, Brauner, PC, 2018. Microclimate alterations caused by agricultural hail net coverage and effects on apple tree yield in subtropical climate of southern Brazil. Bragantia 77, 181–192.

Dzikiti, S, Volschenk, T, Midgley, SJE, Lötze, E, Taylor, NJ, Gush, MB, et al., 2018. Estimating the water requirements of high yielding and young apple orchards in the winter rainfall areas of South Africa using a dual source evapotranspiration model. Agric. Water Manag. 208, 152–162.

Girona, J, Behboudian, MH, Mata, M, Del Campo, J, Marsal, J, 2012. Effect of hail nets on the microclimate, irrigation requirements, tree growth, and fruit yield of peach orchards in Catalonia (Spain). J. Hortic. Sci. Biotechnol. 87, 545–550.

Keywords: Basal crop coefficient, Crop water productivity, Evapotranspiration, Netting, Soil water balance, Transpiration

# DETERMINATION OF THE OPTIMAL DOSES OF MUTAGENS FOR INDUCING MUTATIONS IN POTATO THROUGH *IN VITRO* SENSITIVITY TESTS Mota, M.M., Kempen, E., and Van der Vyver, C.

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# INTRODUCTION

Potato is recognised as the most important non-grain crop, constituting the fourth most important crop after rice, wheat and maize in global food crop production. Potato production is severely affected by drought, which has recently been identified as the most limiting factor worldwide. Water stress can drastically reduce cell division and expansion rate and root growth resulting in low yield. The use of genetic improvement through selection and breeding offers a long-term, widely available and sustainable mechanism to mitigate the negative effects of drought. Induced mutation could improve potato production by increasing genetic variability in new germplasm followed by the selection of desirable mutants while maintaining the genetic potential of the proven germplasm. This study aimed to determine the effects of different doses of gamma irradiation and concentrations of Ethyl methane sulfonate (EMS) on potato.

# MATERIAL AND METHODS

*In vitro*, sensitivity tests using gamma irradiation and EMS were conducted to determine LD<sub>50</sub> values to induce mutations on BP1 and Up-to-date potato varieties. Nodal cuttings from each variety were subjected to different dosages of gamma irradiation (0, 5, 10, 15, 20 and 30 Gy) from a <sup>60</sup>Co source and EMS (0, 2.5 mM, 5 mM, 10 mM and 20 mM). Nodes were cultured in magentas containing 100 mI of MS-medium supplemented with 20% sucrose, 2.22g gelrite and the pH of the media was adjusted to 5.8. The cultures were kept in the growth room for four weeks at 26°C under 16-hour continuous light and 8-hour darkness. Data was collected after 4 weeks, the parameters measured were plant height, number of leaves and nodes, root length and fresh weight.

# **RESULTS AND DISCUSSION**

Potato growth parameters increased (P<0.05) with the decrease in the different gamma irradiation doses and EMS concentrations. This showed that the highest dose and concentration have the highest negative effect on plant growth. A huge decline in all measured parameters was observed at 30% and 20 mM compared to the control. This is due to harmful effects of the mutagens that reduce the stability of the plant genome, such as chromosomal damages.

# CONCLUSION

Lower doses of gamma irradiation and lower concentrations of EMS induce positive morphological changes in potato growth, while higher doses and EMS concentrations negatively affect plant growth.

Keywords: Ethyl methane sulfonate, in vitro sensitivity test, gamma irradiation, potato germplasm

# ACKNOWLEDGEMENTS

We thank the Government of Lesotho, World Bank, APPSA and IAEA for funding the project.

# BIO-SYNTHESIZED CALCIUM CARBONATE (CACO3) NANOPARTICLES: THEIR ANTI-FUNGAL PROPERTIES AND APPLICATION AS NANOFERTILIZER ON LYCOPERSICON ESCULENTUM GROWTH AND GAS EXCHANGE MEASUREMENTS.

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# INTRODUCTION

Bio-synthesized calcium carbonate nanoparticles (CaCO<sub>3</sub> NPs) have gained attention due to their costeffectiveness, minimal toxicity, biological compatibility, cytocompatibility, pH sensitivity, sedate biodegradability and environmental friendliness. As current agricultural practices have demonstrated weaknesses in providing enough food for the ever-growing world population, the incorporation of nanotechnology to improve crop production could provide a sustainable solution to the food shortage challenges. Thus, this study assessed the use of bioinspired CaCO<sub>3</sub> NPs as nanofertilizers on the growth, gas exchange, and yield parameters of tomatoes (*Lycopersicon esculentum*) and their antifungal activity.

### MATERIAL AND METHODS

The study was conducted at the University of South Africa, at its Florida campus at latitude S26°9.501 and longitude E27°54.113. The experiment was laid out in a 2x4 completely randomized design (CRD) with four replicates. The treatments consisted of four different CaCO<sub>3</sub> NPs concentrations (Control = 0 mg. L<sup>-1</sup>, 50 mg. L<sup>-1</sup>, 150 mg. L<sup>-1</sup> and 250 mg. L<sup>-1</sup>) on two tomato cultivars (Money-maker and Heinz-1370). The antifungal activity of the CaCO<sub>3</sub> nanoparticles was tested against *Cladosporium cladosporioides*, *Fusarium oxysporum* and *Penicillium halotolerans* which cause diseases in tomato plants.

#### **RESULTS AND DISCUSSION**

The tested CaCO<sub>3</sub> NPs exhibited moderate antifungal activity against *C. cladosporioides*, *F. oxysporum* and *P. halotolerans* at minimum inhibitory concentration (MIC) values of 125, 250 and 500  $\mu$ g. mL<sup>1</sup>. The effects of nanoparticles as nanofertilizers were assessed on growth and yield and gas exchange measurements of the two tomato cultivars. The findings show that 250 mg. L<sup>-1</sup> exhibited the highest number of leaves on Money-maker, while 150 mg. L<sup>-1</sup> resulted in the highest number of leaves in week 8 for Heinz-1370. The application of 150 mg. L<sup>-1</sup> yielded the highest number of flowers in both cultivars when compared to other treatments. The gas exchange parameters varied significantly across the different CaCO<sub>3</sub> NP concentrations, however at concentrations higher than 150 mg. L<sup>-1</sup> the efficiency in water use was lowered during the vegetative and fruiting stages. Significant differences were observed among the different treatments on the fruit weight. The highest fruit weight of the Money-maker was observed at 50 mg. L<sup>-1</sup>, while Heinz-1370's fruit weight was higher at 250 mg. L<sup>-1</sup>, indicating that the two cultivars respond differently to the foliar application of CaCO<sub>3</sub> NPs. However, the incorporation of CaCO<sub>3</sub> NPs in cropping systems for Ca fertilization is ideal for sustainable tomato production.

#### CONCLUSIONS

Therefore, the findings of this study suggest that the inclusion of an eco-friendly preparation of CaCO<sub>3</sub> NPs as a nano-fertilizer has the potential to promote tomato growth and yield. Further, their anti-fungal properties could play a role in crop protection by suppressing fungal diseases in tomato plants.

Keywords: antifungal activity, calcite nanoparticles, foliar application, nanofertilizers, tomato.

# EFFECT OF NPK RATES ON SHOOT YIELD AND ESSENTIAL OIL YIELD OF AFRICAN WORMWOOD (ARTEMISIA AFRA) GROWN UNDER CONTROLLED ENVIRONMENT CONDITIONS

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### Introduction

Nutrition plays a key role in the growth and development of all crop plants, but little is known about the interactive effects of various chemical fertilizers on growth and essential oil composition in medicinal plants. Research on essential oil-producing plants, revealed that nutrients can effectively increase thyme (Jabbari et al., 2011), sweet basil (Sharafzadeh et al., 2011) and lemongrass (Zheljazkov et al., 2011) oil yield and quality. However, little is known on the effect of NPK on growth, and essential oil yield of *A. afra*, and hence this study was initiated.

# **Materials and Methods**

The research was conducted at Döhne Agricultural Development Institute (DADI), in the Eastern Cape Province of South Africa. The trial was conducted under semi-controlled environment conditions in a plastic tunnel. Seedlings grown from seeds were transplanted into 10 liter pots, filled with a fine builder's sand. Different rates of N, P, and K were applied while the recommended rates of NPK were applied as a control, replicated 3 times. Plants were irrigated using a spaghetti drip irrigation system. Five months after transplanting, all plants were harvested to determine fresh and dry shoot biomass. From each experimental unit, sub-samples were harvested to extract essential oil using hydro-distillation techniques and to measure essential oil content. Data collected was subjected to analysis of variance (ANOVA) using the GenStat statistical package.

#### **Results and Discussions**

Average fresh weight was significantly higher (166,1g/plant) in plants that were fertilized with double rates of recommended nitrogen, while the lowest (92.4g/plant) was obtained when the plants were treated with half rates of nitrogen. The highest essential oil content of basil (105.3 mg/plant) was obtained at highest NPK rates (150 kg/ha N, 100 kg P/ha and 100 kg K/ha) (Sharafzadeh et al., 2011). Generally, low essential oil yield was obtained in *A. afra* in all treatments but there were no significant differences.

# Conclusions

Preliminary results indicate that the addition of nitrogen increases herbage yield, however, no effect could be established on essential oil yield.

### References

Sharafzadeh S, Esmaeilli M and Mohammadi AH, 2011. Interaction effects of nitrogen, phosphorus and potassium on growth, essential oil and total phenolic content in sweet basil. Advances in Environmental Biology, 5 (6): 1285-1289.

Zheljazkov, V.D.J., Cantrel, C. L., Astatkie, T. and Cannon, J. B., 2011. Lemongrass Productivity, Oil Content, and Composition as a Function of Nitrogen, Sulfur, and Harvest Time. Agronomy Journal 103(3):805-812

Keywords: Artemisia afra, Essential oil yield, Growth

# SAFEGUARDING FOOD SECURITY THROUGH THE ADOPTION OF INDIGENOUS VEGETABLES IN THE EASTERN CAPE PROVINCE: A REVIEW

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# INTRODUCTION

Indigenous vegetables are characterised as plants that are indigenous to a particular location. They have an ability to physiologically withstand the conditions of the area and in most cases they grow in the wild. They have been found to have significant nutritional qualities, such as macro and micro nutrients. With the estimated increase in the population in the coming years, the demand for food is also on the rise. Therefore, there is a need to ensure food security despite challenges of climate variation and increase in population which pose a threat to food security. In most African rural areas, malnutrition, particularly micronutrient malnutrition, is common. There is limited literature on the role played by indigenous vegetables in household food security, especially in the Eastern Cape Province, hence this study was initiated.

# MATERIALS AND METHODS

The objective of the study was to review the benefits and value of indigenous vegetables in the African context and to outline how utilisation of these can contribute to food security and also bring to light the research gaps regarding the matter. The study was conducted using secondary data in the form of published literature sources from Google Scholar, PubMed, Research Gate, and Frontiers, as well as theses, dissertations, books, reports, and other relevant websites.

# **RESULTS AND DISCUSSIONS**

The results showed that indigenous vegetables have a significant role in promoting and maintaining food security. The findings showed that there is an under-utilisation of indigenous vegetables in the Eastern Cape. Factors that caused non-adoption of indigenous vegetables were identified and included perception, non-cultivation and post-harvest challenges of these vegetables.

### CONCLUSIONS

Indigenous vegetables are an alternative nutritious food to address food security in Africa. In the light of this review, it is recommended that there is a need for further investigation into the role of indigenous vegetables in promoting food security and other aspects of agronomic practices of indigenous vegetables. Since most indigenous vegetables offer both nutritional and medicinal benefits, awareness should be made to bring back their cultivation, consumption and conservation at household level.

Keywords: Food security, indigenous vegetables, nutrients

# REFERENCES

-Bvenura, C. and Afoloyan A.J.2014. Ethnobotanical survey of wild vegetables in Mbashe and Nkonkobe municipalities, Eastern Cape Province, South Africa. *Société botanique de France, Vol. 161, No. 2, 189–199* 

-Mavhengana, S. 2013. The contribution of indigenous vegetables to food security and nutrition within selected sites in South Africa. Thesis Stellenbosch University, South Africa.

# EFFECTS OF PRE- PLUS POST-HARVEST APPLICATION OF PLANT EXTRACTS ON THE POST-HARVEST QUALITY OF POTATOES (SOLANUM TUBEROSUM L.) KEPT UNDER AMBIENT STORAGE CONDITIONS

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#### INTRODUCTION

Potato is an economically important non-grain, semi-perishable agricultural commodity. After harvesting, potatoes become highly prone to moisture losses and quality deterioration, all contributing to post-harvest losses during storage. To combat these issues, synthetic pesticides has been vital; however, their usage can endanger human and environmental health. Plant extract utilization is a promising, safer, eco-friendly and financially feasible approach that could potentially reduce the usage of hazardous chemicals.

### MATERIAL AND METHODS

The present study, therefore, investigated the efficacy of various plant extracts on retention of postharvest quality of harvested potato tubers. Freshly harvested tubers, cv. 'Sifra' were dipped in plant extracts (10 g/L concentration), allowed to dry and stored at ambient conditions (day:  $25 \pm 2$  °C & 45% RH; night:  $18 \pm 2$  °C and 65% RH) for 28 days. The treatments were: *Ascophyllum nodosum* extract (ANE), aloe vera leaf extract (AVE), garlic bulb extract (GBE) and moringa leaf extract (MLE), as well as a control (water only).

# **RESULTS AND DISCUSSION**

Plant extract applications, as post-harvest treatments, significantly ( $p \le 0.05$ ) influenced post-harvest quality of potato tubers. AVE application remarkably reduced physiological mass loss during storage. Moreover, ANE and MLE treatment application considerably increased mineral composition and total soluble solids. These treatments also gave the most promising results as showed the highest retention potential of tuber vitamin C, total carbohydrate, protein, phenolic and flavonoid concentration, as well as antioxidant activity during storage.

#### CONCLUSIONS

Based on these results, the use of natural plant extract, as an alternative for hazardous chemicals, is highly advisable and recommended for preserving post-harvest quality of potato tubers, without compromising consumers' health.

KEYWORDS: Nutritional status, plant extracts, post-harvest quality, shelf-life, storage.

### ACKNOWLEDGEMENTS

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# HISTOLOGY OF POTATO TUBERS DURING INFESTATION BY SOFT ROT BACTERIA

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# INTRODUCTION

Potato cultivars have different tissue and cell arrangements. Tubers of the same plant can have varying cell numbers and sizes, which determine the level of accessibility and penetration of tuber flesh by soft rot pathogens. Histological studies of potato tubers of different cultivars are required to understand the nature of tuber penetration by soft rot bacteria.

# MATERIALS AND METHODS

Histological experiments were conducted *in vitro* using small-size (40-60g) tubers of two cultivars: 'Mondial' and 'Sifra'. Tubers were injured by making a v-shaped longitudinal incision of 2mm deep and 2mm wide using a microtome blade. *Pectobacterium carotovorum* strains were subcultured on nutrient agar 24h before inoculation. Bacterial colonies were dissolved in sterile distilled water and diluted to a concentration of  $2x10^8$  CFU.ml<sup>-1</sup>. Tubers were inoculated individually by applying six drops (±250µL) of the liquid inoculum on the incision. Tubers were then incubated at 25°C in an airtight container with a cushion of paper towel inside to prevent rolling of tubers. Samples were taken daily by cutting ±0.5mm thin transverse section slices. Slices were subjected to tissue staining with Toluidine blue, Safranin, and Fast green to allow examination of tissue maceration and cell deterioration at different magnifications under a stereo microscope.

# **RESULTS AND DISCUSSION**

The results showed a steady increase in the severity of soft rot as the bacteria penetrated deeper into the inner tissues with time. As soon as the cell wall is broken into, the bacteria macerate the tissue, the cell walls start collapsing as the contents leak out of the individual cells. 'Sifra' proved to be more susceptible to soft rot, exhibiting more severe rotting symptoms than 'Mondial'. About 20% of the tissue on a given 'Sifra' tuber, as compared to  $\pm 10\%$  on 'Mondial', was macerated within 48 hours of inoculation. The three selected stains showed varying rotting patterns on the tuber tissues. Toluidine blue proved to be the best stain for examination of fresh tuber tissues, showing clearly defined borders between cells, from a low magnification. The stains turned into different colours on the tissue at different stages of rotting, from healthy tissues to newly infected and, finally, completely macerated.

# CONCLUSIONS

The parenchyma tissue on the outer medulla is the most susceptible tissue of the tuber, since it contains bigger cells. Tissues with bigger cells break and collapse easier than tissues with smaller cells. The study recommends Toluidine blue stain for better histological investigation of potato tuber tissue.

KEYWORDS: Histology, Soft rot, stains, tuber tissue.

### ACKNOWLEDGEMENTS

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# OLEOCELLOSIS: WHY HAS THE CONTROL THEREOF NOT BEEN RESOLVED?

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### INTRODUCTION

Oleocellosis is a common post-harvest blemish on citrus fruit due to rough handling. Commercial farms reported certain orchards to be highly sensitive, irrespective of a long wilting (drying soil out) period. The aim was to investigate the effect of shade netting and/or rootstock choice on oleocellosis incidence of Lemons and Navel, and to develop updated guidelines to minimize oleocellosis incidence.

### MATERIAL AND METHODS

The trial was conducted over three seasons in the Sundays River Valley on 'Eureka' lemon and 'Washington', 'Cara Cara' and 'Palmer' navel fruit. Fruit were sampled, and oleocellosis inducing test were performed by dropping fruit from a standard height whereafter fruit were scored based on severity. A penetrometer was used to apply a force and the lesion size was measured. The force required for oil release, Rind Oil Release Pressure (RORP) was also recorded. From harvested trees, the soil water content (SWC) was determined.

# **RESULTS AND DISCUSSION**

For lemons, there was a slight trend during the first season for shade net fruit to be more sensitive, but no effect during the last two seasons. No distinct shade net effect was seen for 'Cara Cara' and 'Washingtons' grafted on 'Swingle' and 'Palmers' on rough lemon. Differences in sensitivity was seen for 'Palmers'/swingle, but might be due to lower temperature at harvest. A rootstock effect on 'Palmer' were seen, with a high sensitivity for rough lemon compared to 'Carrizo' and 'Swingle', but in 2022, both 'Carizzo' and rough lemon showed high sensitivity due to SWC being high. Trends were seen for 'Cara Cara' where 'Swingle' showed a lower oleocellosis incidence than 'Carrizo' but was inconsistent between seasons. RORP did differ between time of day for each treatment (shade net and open). Further results also showed that differences were evident for navels, but not always the expected trend of an increase in RORP, irrespective of fruit surface temperature increase. Outside canopy fruit had a higher RORP than inside canopy fruit.

# CONCLUSIONS

The data emphasizes the different role players, i.e. SWC and time of harvest (air and pulp temperature, RH and VPD), responsible for fruit sensitivity and especially certain cultivars that are more sensitive to developing oleocellosis symptoms. Fruit position influences the RORP of the fruit. An orchard's sensitivity needs to be determined through the RORP test and extra careful harvesting practices should be implemented for sensitive fruit.

Keywords: citrus, rind disorder, rootstock, shade net, Washington, water.

### ACKNOWLEDGEMENTS

CRI for funding and growers in the Sundays River Valley.

# INVESTIGATING EFFECT OF WATER STRESS ON GROWTH AND BIOCHEMICAL RESPONSE OF PELARGONIUM SIDOIDES

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# INTRODUCTION

Pelargonium sidoides, is an evergreen perennial plant, also known as the black geranium or Cape pelargonium. The crop is indigenous to South Africa and Lesotho regions. This herb is widely used as a South African traditional medicine for the treatment of respiratory infections. Although the plant dies during droughts and inhewinter season, its survival under harsh environmental conditions, is linked to its well-developed tubers. Owing to its high demand, *P. sidoides* has suffered extensive wild harvesting, leading to the diminishing of its natural population. Thus, commercial cultivation of this crop is necessary. In addition to water stress, successful commercialization is hindered by drought stress, especially in South Africa. Therefore, investigate effect of different traits of *P. sidoides* is an important factor for its sustainability. This project aimsto investigate effect of different irrigation regimes on the growth and biochemical response of *P. sidoides*.

#### METHOD AND MATERIALS

The trial was conducted in the tunnel at the Agricultural Research Council (ARC) Infruitec-Nietvoorbij, Stellenbosch, South Africa. Granite-derived soil (13% clay, 17% silt and 70% sand) was collected from an uncultivated land at the ARC Infruitec-Nietvoorbij campus in Stellenbosch. Composite soil samples were taken from the 0–300 mm layer and sieved using a 6 mm mesh sieve to remove large fragments. Triplicate samples were collected from the composited soil to determine the baseline physical and chemical properties of the soil. Thereafter, the soil was used to fill up 40 cm plastic pots in which Pelargonium sidoides sprouted root cuttings were grown. The soil in each pot was irrigated to pot capacity (PC), then was designed in a randomized block with four replications to investigate three irrigation depletion levels (75%, 50%, and 25% PAW) and harvesting age (6 and 12 months). *P. sidoides* response to different water depletion levels was determined by assaying physiological (plant biomass, stomatal conductance, photosynthetic pigments, relative water content) and biochemical traits malondialdehyde (MDA), proline, and reactive oxygen species (ROS).

#### **RESULTS AND DISCUSSION**

Different depletion levels showed that a 75% depletion level significantly reduced stomatal conductance (393.50 mmol m<sup>-2</sup> s<sup>-1</sup>), while a 25% depletion level was significantly higher (523.52 mmol m<sup>-2</sup> s<sup>-1</sup>) than the 50% and 75% depletion levels, respectively. Similarly, relative water content was significantly higher at a 25% depletion level (68.95%) with a 25% depletion level significantly lower (59.02%) than all other depletion levels. Malondialdehyde was significantly higher at a 75% depletion level (43.72 nmol g<sup>-1</sup>FW) while a 25% depletion was significantly lower (16.92 nmol g<sup>-1</sup>FW) than all other depletion levels.

#### CONCLUSIONS

Our findings suggest that severe water stress significantly lowers leaf water status, and gas exchange and exacerbates oxidative stress.

KEYWORDS: Pelargonium sidoides, Depletion level, Biochemical, Physiological

### ACKNOWLEDGEMENTS

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# THE EFFECT OF ORCHARD-APPLIED ETHEPHON ON POST-HARVEST MACADAMIA KERNEL QUALITY

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# INTRODUCTION

Ethephon is used in various crops to promote the onset of fruit maturity. In South Africa, ethephon was registered in 2010 as a nut abscission agent in the 'Beaumont' macadamia cultivar, which exhibits low levels of nut drop in the desired harvest period. To date, no attention has been paid to whether this acceleration of senescence affects macadamia kernel quality and shelf life, an aspect this current work aims to address.

### MATERIAL AND METHODS

This trial was conducted at two sites on the 'Beaumont' cultivar. There were two application dates (late May, early July). Site 1 had three application rates (unsprayed control, 750 ppm and 1000 ppm ethephon, n=12), while site 2 had two (unsprayed control and 1250 ppm ethephon, n=6). Applications were made via a mist-blower, ensuring nuts were wetted to run-off. Nuts from control trees were picked from the tree. For treated trees, once the onset of nut abscission was observed trees were shaken to release the crop for harvesting. After dehusking nuts were cured, moisture loss ceased, first at 35°C and then at 50°C. Nuts were cracked and premium kernels were selected. These kernels were divided into two batches per replicate for pre- and post-storage analysis. The stored portion was vacuum packed and held for 1 year at 21°C. Analyses included peroxide value (Pv) and Rancimat induction time pre-storage, and Pv and free fatty acids (FFA) post-storage.

# **RESULTS AND DISCUSSION**

Before storage, average Pv for site 1 kernels varied from 0.22 to 0.58 meq/kg  $O_2$ , while site 2 values ranged from 0.026 to 0.085 meq/kg  $O_2$ . Despite the noticeable differences between sites, these values were well below the 3 meq/kg  $O_2$  required by industry for export. Neither site showed significant differences between treatments. Despite the differences between the two sites in terms of Pv, all treatments yielded kernel with a Rancimat induction time of between 15.2 and 16.6 hours, again with no significant differences between treatments. These induction times indicate good oxidative stability and predict a shelf life of at least a year. Post-storage quality analysis will be discussed in the context of pre-storage quality.

# CONCLUSIONS

There is no indication of adverse post-harvest effects due to use of ethephon. The apparent quality differences between sites and the role of microclimate in post-harvest quality warrants further attention.

Keywords: ethephon, kernel, macadamia, peroxide value, quality, Rancimat

#### ACKNOWLEDGEMENTS

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# HOST-STATUS OF 16 CROPS USED IN POTATO ROTATION

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# INTRODUCTION

In South Africa, all commercially produced potato (*Solanum tuberosum* L.) cultivars are hosts of rootknot (*Meloidogyne* species) nematodes. In most production systems, *M. incognita* and *M. javanica* occur as mixed populations with *M. javanica* considered to be more aggressive than *M. incognita*. The host status and host sensitivity of most crops used in crop rotations intend to manage nematode population densities in potato producing regions had not been established.

# MATERIAL AND METHODS

The two-fold objective of the study was to determine whether the reproduction potential (RP) values of *M. enterolobii*, *M. incognita* and *M. javanica* on 16 crops used in potato crop rotation systems, along with their associated relative susceptibilities to tomato would separately be below unity. Separate trials, for *M. enterolobii* (Trail 1), *M. incognita* (Trial 2) and *M. javanica* (Trial 3) were conducted under greenhouse conditions. In each trial, treatments, 16 crops and susceptible tomato cv. 'Floradade' were laid out in a randomised complete block design, with six replications. The crops were inoculated with 250 eggs and second-stage juveniles (J2).

# **RESULTS AND DISCUSSION**

At 56 days after inoculation, nematodes variables were collected demonstrating that there were similarities and differences in terms of host-status and relative susceptibility status of the 16 crops to the three test nematode species in both Experiment 1 and 2. The findings of this study showed that non-host crops for *M. enterolobii* trial were common vetch, velvet bean and *E. curvula* whereas in *M. incognita* trial were white maluti oats, common vetch, rye, Rhodes grass and *E. curvula*. On the other hand, white maluti oats, tillage radish, forage sorghum and Jap radish were non-hosts to *M. javanica*. In relative susceptibility study, the results showed that for both Experiment 1 and 2 in *M. enterolobii* and *M. javanica* trials, all the test crops had rsa values below unity, but for *M. incognita* white maluti oats, dolichos beans, forage sorghum, rye, sunflower and *E. curvula*, were the only crops which had rsa values above unity for *M. incognita*.

# CONCLUSIONS

The observation demonstrated the need to identify the *Meloidogyne* species on the farm in order to ensure that the crop rotation would succeed in reducing population densities of the target nematode species.

# REFERENCES

Chiuta NE, Pofu KM, Mashela PW 2021. Nematode resistance technologies for managing thermophilic *Meloidogyne* species on potato (*Solanum tuberosum*): A review. Research on Crops. 22 (2): 369-379. DOI: 10.31830/2348-7542.2021.081.

**KEYWORDS:** Meloidogyne enterolobii, Meloidogyne incognita, Meloidogyne javanica, potatoes, rotation

# RELATIVE SUSCEPTIBILITY OF NINETEEN SWEET POTATO LINES TO MELOIDOGYNE INCOGNITA AND MELOIDOGYNE JAVANICA

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#### INTRODUCTION

Most crop-producing regions are replete with root-knot *(Meloidogyne* species) nematodes, especially *M. incognita* and *M. javanica. Meloidogyne* species are a threat on sweet potato production. Internationally, *M. incognita* is viewed as the more aggressive *Meloidogyne* specie than *M. javanica*. However, in South Africa is vice versa. Previously widely used, fumigant nematicides, were withdrawn from the agro-chemical markets due to their negative impact on the environment and toxicity to humans and animals. Following their withdrawal, the use of resistant plant genotypes serves as alternative nematode strategy in managing high nematode population densities. Therefore, the objective of this study was to determine whether the relative susceptibility (rs<sub>a</sub>) values of *M. incognita* and *M. javanica* on 19 ARC sweet potato lines would be below unity.

# MATERIALS AND METHODS

Cuttings of 18 sweet potato lines and the susceptible control cv. 'Beauregard' were laid out in a randomised complete block design with 6 replicates. Plants were each inoculated with (250 eggs + J2) in two separate trials each for *M. incognita* and *M. javanica*.

### **RESULTS AND DISCUSSION**

Fifty-six days after inoculation, For *M. incognita*, four sweet potato lines 2015-1-6, FS5-2-1, FS1-1 and 'Khumo' were categorized as non-hosts based on reproductive potential values below one. However, all other lines were resistant since the rs<sub>a</sub> values were below unity. *Meloidogyne javanica* only failed to reproduce on two sweet potato lines namely, 2013-26-5 and 2014-17-6, four sweet potato lines (FS10-21, FS10-25, 2014-13-1 and 2015-9-2) were categorized as susceptible hosts since rs<sub>a</sub> values were above one, whereas all other lines were resistant since the values were below unity.

### CONCLUSIONS

Due to the existence of non-host status and resistance of the tested sweet potato lines to *M. incognita* and *M. javanica* based on the RP and rs<sub>a</sub> values below unity, sweet potato lines with resistance to the tested *Meloidogyne* species should be subjected to mechanism of resistance test to determine whether they have pre-infectional or post-infectional nematode resistance, those with post-infectional nematode resistance could therefore be used in plant breeding for plant-introgression.

**KEYWORDS:** Host status, host-sensitivity, Meloidogyne species, reproductive potential, relative susceptibility

#### ACKNOWLEDGEMENTS

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# EVALUATION OF THE USEFULNESS OF EARLY LEAF ANALYSIS TO IMPROVE NUTRITION MANAGEMENT OF CITRUS

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### INTRODUCTION

Citrus fruit quality is a determining factor in the export value of a carton and determines market access. Nutrition management affects fruit quality in several ways (Obreza *et al.*, 2020). Leaf analysis is therefore widely used within the citrus industry to establish tree nutritional status, with well-established norms for leaves behind fruit bearing terminals sampled during autumn (Menino, 2012). This, however, is too late for in-season fertilisation adjustments. Furthermore, over-fertilisation is common, and there are mounting pressures on producers from environmentally aware parties to reduce fertiliser inputs (Snyder *et al.*, 2009). This study investigated the extent to which excessive fertilisation is expressed by early season leaf analysis, and whether early season leaf analysis can be used to make in-season adjustments to the fertilisation rates.

#### MATERIAL AND METHODS

The study was conducted for two seasons in two commercial orchards (Midknight Valencia & Orri mandarin). Treatments at both sites entailed double the prescribed fertilisation rate of nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg) respectively. Mature leaves were sampled monthly for mineral nutrient analysis from non-fruiting, purely vegetative shoots at the third to fifth position of the latest applicable flush. An additional sample from fruit bearing shoots was collected in autumn.

#### **RESULTS AND DISCUSSION**

A response in the leaf N concentration of the trees that were fertilised at a 200% rate of the standard practices could be observed from 30 days after full bloom in the first season of the conservatively fertilized mandarin orchard. This indicates the ability of citrus trees to respond quickly to additional N fertilisation. The same rapid response to the excessive fertilisation did not occur for P, K or Mg – only in the second season was significantly higher leaf K obtained in the K-fertilised trees. There was a total lack of responsiveness of the Valencia trees to the excessive rates of mineral nutrition during the first season, but here too the leaf K concentration was higher than the control in the second season. Consequently, it was concluded that in-season regular short-term changes in fertilisation rates of orchards that have previously been amply fertilised is of no value.

A consistent pattern of differences in mineral nutrients was obtained between fruit-bearing and non-fruit bearing leaves.

#### CONCLUSIONS

The limited usefulness of foliar analysis in conditions of ample to over-supply of nutrients was emphasised. Leaves from non-fruit bearing and fruit-bearing shoots can be sampled for analysis, but the proposed adjustments from the norms for fruit-bearing shoots should be made if leaves are sampled from non-fruit bearing shoots.

### REFERENCES

Obreza TA, Zekri M, Futch H. 2020. General soil fertility and citrus tree nutrition. In: Morgan KT, Kadyampakeni DM (eds), *Nutrition of Florida Citrus Trees*. Florida: University of Florida Institute of Food and Agricultural Sciences Extension. pp.13–21.

Menino, R. 2012. Leaf analysis in citrus: Interpretation tools. In: Srivastava AK (ed), *Advances in Citrus Nutrition*. Nagpur: Springer. pp. 59–80.

Snyder CS, Bruulsema TW, Jensen TL, Fixen PE. 2009. Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agriculture, Ecosystems and Environment* 133:247–266.

Keywords: citrus, leaf analysis, nitrogen, nutrition, phosphorus, potassium.

# E EFFECTS OF N-(2-CHLORO-4-PYRID

# THE EFFECTS OF N-(2-CHLORO-4-PYRIDYL)-N'-PHENYLUREA (CPPU), AND THE COMBINATION OF CALCIUM AND BORON ON FRUIT CRACKING DISORDER OF 'EARLY DELIGHT' LITCHI FRUIT

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# INTRODUCTION

Fruit cracking is a major disorder of litchi fruit. Though fruit cracking is mainly as a result of stress, certain cultivars are genetically more prone to fruit cracking, such as 'Early Delight'. Fruit cracking will therefore still occur even under non-stressful conditions. Application of calcium and synthetic cytokinins was shown to improve cellular integrity and strength, thereby reducing physiological fruit disorders in several crops. The objective of this study was to determine if the application of CPPU or calcium in combination with boron will reduce fruit cracking of 'Early Delight' litchi fruit.

# MATERIALS AND METHODS

CPPU and calcium in combination with boron were applied during full female bloom on bearing 'Early Delight' litchi trees. The treatments consisted of an untreated control, 20 mg.L<sup>-1</sup> CPPU, 40 mg.L<sup>-1</sup> CPPU, and 5mL.L<sup>-1</sup> 40% Ca(NO<sub>3</sub>)<sub>2</sub> in combination with 0.3% boron treatments. Each treatment was replicated seven times. Fruit cracking was assessed prior to harvest. After harvest, fruit mass, aril, pericarp and seed mass and pericarp thickness were assessed. In addition, one carton of fruit was harvested per replicate, cold stored for 30 days at 1°C and evaluated for pericarp colour retention and fruit weight loss after the cold storage period.

# **RESULTS AND DISCUSSION**

Both CPPU treatments reduced fruit cracking significantly. The percentage of cracked fruit for the untreated control was 15.4%, while 7.6 and 7.4% for the 20 and 40 mg.L<sup>-1</sup> CPPU treatments, respectively. The percentage of cracked fruit for the calcium and boron combination treatment was 11.7%. Lower fruit cracking for the CPPU treatments was, as a result of increased pericarp thickness. In this instance the pericarps of fruit for the 20 and 40 mg.L<sup>-1</sup> CPPU treatments were 1.02 and 1.09 mm, respectively, compared with 0.87 mm for the untreated control. Fruit size and seed mass were not significantly affected by any of the treatments. For fruit that were cold stored for 30 days, pericarp colour retention was significantly improved by the 40 mg.L<sup>-1</sup> CPPU treatment, while none of the treatments had any effect on fruit weight loss.

# CONCLUSIONS AND RECOMMENDATIONS

Results of this study showed that CPPU reduced fruit cracking of 'Early Delight' fruit as a result of increased pericarp thickness. Calcium and boron also had some effect on fruit cracking, but further investigation into the use of calcium and boron needs to carried out. CPPU can only be recommended once registered for use on litchi.

Keywords: litchi, pericarp, fruit size, seed mass, pericarp colour

# COMPARATIVE STUDY ON THE YIELD PERFORMANCE AND ACCEPTABILITY OF IMPROVED SWEET POTATO VARIETIES IN MPUMALANGA

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### INTRODUCTION

Sweet potato (*Ipomoea batatas L.*) is one of the most versatile staple root crops in South Africa. Its cultivation is predominantly done by resource-poor farmers on marginal soils with low inputs, for both consumption and selling to generate income. Smallholder and subsistence farmers include sweet potatoes in their cropping programmes because of its versatility, ease of cultivation and hardiness. The ARC-VIMP has released high yielding varieties with improved taste and quality, aimed at income generation, addressing food security and vitamin A deficiency. However, the adaptability, yield performance and acceptance of these varieties have not been extensively investigated in Mpumalanga province.

# MATERIALS AND METHODS

The field experiments were conducted in four locations (Nooitgedacht farm in Ermelo, Greylingstad, Saul Mkhizeville and Thulamahashe) in Mpumalanga Province. Eight varieties were evaluated during the 2021/22 cropping season. The experiments were laid out in a Latinised row-column design with four replications. Varieties were planted in a 6m row with inter- and intra-row spacing of 1m and 30cm respectively. Yield (t/ha) and physiological traits were recorded. Two medium storage roots were sampled for dry mass determination. Acceptability of cooked sweet potatoes was tested by 20 participants per location indicating acceptability as Yes/Unsure/No. Data was analysed using the Statistical Analytical System (SAS) version 9.4.

# **RESULTS AND DISCUSSION**

The results indicated that there was a wide variation in the mean marketable storage root yield per variety ranging from 18 to 31 t/ha (mean 25 t/ha) across the locations. The mean total yield ranged from 38 to 54 t/ha (mean 43 t/ha). The highest marketable yield recorded was from varieties 199062.1 (51 t/ha) and Monate (48 t/ha) at Driefontein. Whereas Blesbok (41 t/ha) and Monate (36 t/ha) produced the highest marketable yield at Nooitgedacht respectively. A similar trend was observed at Thulamahashe with Blesbok (31 t/ha) and Monate (17 t/ha) placed at the highest, while 199062.1 (31 t/ha) and Ndou (25 t/ha) recorded the highest yield at Greylingstad. Varieties Ndou (23%), 199062.1 (22%) and Monate (21%) were shown to be high in dry mass across all locations. The highest percentage of dry mass was obtained at Thulamahashe. Taste evaluation results indicated that the most preferred varieties were Bearegard (83% yes), Bophelo (73% yes), and Monate (70% yes); which can be an indication of potential adoption by consumers.

# CONCLUSIONS AND RECOMMENDATIONS

The study indicated that a mean marketable yield of 25 t/ha was achieved in on-farm trials. Monate, 199062.1, and Blesbok marketable yields were significantly higher than that of all the other varieties. Ndou followed by 199062.1 and Monate had the highest dry mass percentage. However, Bearegard, Bophelo, and Monate were the most preferred varieties based on taste, texture and appearance. The improved varieties produced sustainable yields, which indicates the good yield and production potential of these varieties in these areas.

KEYWORDS: acceptability, sweet potato varieties, taste, yield

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# INTRODUCTION

Small-scale citrus growers often struggle with sufficient cash flow and resources to successfully employ typical commercial farming practices (i.e., regular mineral nutrition, chemical weed, pest and disease control, mulching, etc.). For successful production of export quality fruit, however, their orchards require the same level of nutrition, weed control and soil water availability as that of commercial orchards. This study is an attempt to alleviate some of the direct input costs, as well as to reduce the management requirements of both small-scale and commercial citrus growers. The benefits of cover crops have been demonstrated in various fruit production systems, with special reference to reduced weed pressure, improved organic carbon content and long-term reduction in overall production input costs. In addition, it is regarded as one of the basic elements of environmentally friendly production systems and improvement of soil health.

# MATERIAL AND METHODS

The study was carried out from May to September 2022 and 2023 in the citrus grove orchard near Franschhoek, South Africa. The seedbed was prepared between the lemon tree rows. Three cover crop species (Oats, medics and vetch) were planted and rows with weeds were used as control. Soil samples were taken from each experimental plot using soil auger before cover crop sowing and one year after cover crop termination following mulch decomposition. The soil samples were sent to the laboratory to determine the soil carbon. Soil water content was monitored at depths of 10, 20, 30, 40, 60 and 80 cm during the growing seasons with DFM probes. Soil carbon, soil water content, weeds and cover crop dry matter were measured and calculated using standard procedures.

# **RÉSULTS AND DISCUSSION**

Preliminary results had shown that cover crops increased soil carbon after one year of planting. Oats gave the highest cover crop dry weight ranging between 200-240g m<sup>-2</sup>, followed by vetch and medics ranging 45-52g m<sup>-2</sup>. Moreover, oats suppressed weeds successfully compared to other treatments. Weed's dry weight under oats treatment ranged below 100g m<sup>-2</sup> while under vetch, medics and control treatments ranged above 140 g m<sup>-2</sup>. The highest weed dry weight was obtained from control treatment, followed by vetch, medics and oats.

# CONCLUSIONS

Preliminary results showed that the use of cover crops increased soil carbon in the citrus orchard and oats gave the highest dry matter for mulch. In addition, the oats cover crop was more effective at controlling weeds and conserving soil water content than other cover crops.

KEYWORDS: Soil carbon, cover crops, soil water content, soil health, citrus

# ACKNOWLEDGEMENTS

Citrus Research International (CRI) for co-funding the research and for supplying agricultural land. Agricultural Research Council for co-funding the research Soil & Water Science Division for technical assistance and the University of the Western Cape for administration.
# EFFECTS OF DIFFERENT SOIL SUBSTRATES ON GROWTH AND MINERAL COMPOSITION OF LESSERTIA FRUTESCENS L. (GOLDBLATT & J.C. MANNING) SEEDLINGS CULTIVATED UNDER GLASSHOUSE CONDITIONS

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#### INTRODUCTION

Lessertia frutescens (syn. Sutherlandia frutescens R. Br., Fabaceae) is an important medicinal plant in southern Africa. Apart from being used as an immune booster, in cancer therapy, and to treat diabetes, stomach and liver problems, it is an ingredient of many healthcare products such as teas and tinctures, leading to an increased demand and harvesting pressure on wild populations. The use of efficient propagation techniques as part of good agronomic practices is a tool for plant species conservation. Therefore, this study aimed to determine the most suitable type of soil or growth substrate for the seedling growth of *L. frutescens*.

#### MATERIAL AND METHODS

The study was carried out under glasshouse conditions at the Agricultural Research Council-Vegetable, Industrial and Medicinal Plants (ARC-VIMP) (25°59"S28°35"E). Seeds collected from the Free State Province were soaked in hot water for 1 min before germination in Hygromix-T. Three-week-old seedlings were transplanted into two different soil substrates: (i) river sand and (ii) organic potting medium. The experiment was replicated six times with eight data plants. Once per week, irrigation was substituted with the application of 2 g of 2:1:2 (43) Multifeed- Nulandis fertilizer. At sixty days after transplanting, the leaves were collected, dried, ground and submitted to the ARC-VIMP Analytical Biotesting Facility for mineral composition and phytochemical analysis, while plant height and number of leaves were recorded twice over a 30-day interval. Data collected were subjected to statistical analyses following standard procedures.

#### **RESULTS AND DISCUSSION**

In comparison with organic potting soil as a substrate, plants grown in river sand demonstrated greater plant height (157%) and number of leaves (241%) during the first observation and an increase of 230% (plant height) and 427% (number of leaves), respectively, during the second observation. The proximate analysis revealed that leaves of plants grown in river sand were richer in total phenolic content (91%), K (12%), P (107%), and Zn (259%), but lower in Ca (34%), Fe (90%), Na (14%) and Mg (44%) when compared with the use of organic potting soil. However, there were no significant differences in their total flavonoid, condensed tannins and Cu content of the dried leaves. Growing seedlings in river sand enhances accumulation of nutrient elements that play a significant role in plant development, pigmentation, and reproduction in addition to resistance to insects and diseases. This could be due to *L. frutescens*' adaption to sandy soils, which have high porosity, aeration, and water drainage capability. These soil properties might have promoted a robust root system, which subsequently enhanced the plant's ability to absorb the nutrients present in the multifeed fertilizer supplement.

#### CONCLUSIONS

Growing *L. frutescens* seedlings in river sand stimulated growth and the accumulation of total phenolic content, K, P and Zn. The use of river sand is relatively inexpensive compared with the use of potting medium, reducing seedling production cost.

KEYWORDS: Cancer bush, Cultivation, Growth media, Propagation, Traditional medicine

# BIOSTIMULANT BR4 MAINTAINS QUALITY OF SLICING TOMATO (SOLANUM LYCOPERSICUM L.) CULTIVATED UNDER MILD HEAT STRESS IN UNDER COVER PRODUCTION SYSTEMS

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#### Introduction

Tomato is an intensively cultivated crop, with global production of 189.13 million tons in 2021. Globally, particularly in the warming climate, tomatoes are widely produced in protected systems. However, heat stress negatively impacts fruit development by impeding nutrient uptake and altering the vegetative and reproductive growth response in tomatoes. This, in turn, leads to reduction in the quality and yield. In recent years, biostimulants have been found to mitigate abiotic stresses. The biostimulant BR4, an organic, non-toxic, plant extract biostimulant, was found to improve above and below ground biosmass in tomato. The aim of this study was to evaluate if BR4 would have an impact on the quality of slicing tomatoes grown under heat stress in intensive agronomic systems.

#### Materials and methods

Seedlings of two respective tomato cultivars, *Cultivar 1*, and *Cultivar 2*, received BR4 two weeks after sowing. Control seedlings received no product. Seedlings were transplanted into a temperature-controlled glasshouse (night/day temperature of 16 / 30 °C). For each cultivar treatment, plants were divided into two groups. Group one received a soil drench application, and the second received a foliar application of BR4 (50ml / 100L). For each cultivar there was a respective control, soil drench and foliar application treatment of BR4 (n=14). The product was applied at week 6, 10, and 14 after sowing. The trial was laid out in a completely randomized design. Fruit firmness measurements were taken with a handheld penetrometer at two intervals. The first interval was directly after harvest and the second was seven days after harvest. The total soluble solid (°Brix) content per fruit was also measured in triplicate with a refractometer. Average values were calculated for parameters and data were submitted to an Analyses of Variance.

#### **Results and discussion**

Results indicated that all fruit of both cultivars that received treatment with BR4, either as drench or as spray application, had higher firmness and brix values than control fruit. The firmness of the first cultivar that respectively received a drench and foliar application, as well as the second cultivar that received a drench, differed significantly from the control treatments. Similarly, the postharvest firmness of the first cultivar that respectively received a foliar and drench application differed significantly from the control treatments.

#### Conclusion

BR4 can be a valuable tool for mitigating the impact of heat stress on the quality of tomatoes. The adoption of sustainable methods that can increase quality while enhancing the resilience of cropping systems is therefore possible. Future investigations into the efficacy of BR4 under heat stress will be done to make recommendations to the commercial tomato industry.

Keywords: Bio-stimulant, Brix, firmness, foliar application, heat stress, soil drench

# A DEMONSTRATION ON HOW PLANT WATER POTENTIAL-BASED DEFICIT IRRIGATION ALTERS PHYSIOLOGICAL, REPRODUCTIVE AND WINE QUALITY RESPONSES OF GRAPEVINE IN THREE DIFFERENT CLIMATIC REGIONS

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#### INTRODUCTION

Plant-based irrigation scheduling techniques such as midday stem water potential ( $\Psi_{SWP}$ ) has been used in the South African wine industry, but not to a great extent. The study was set out to demonstrate the effect of irrigating at different  $\Psi_{SWP}$  thresholds, in three important wine grape growing regions in the Western Cape (Olifants River Valley, Breedekloof Valley, Coastal region). The study investigated how irrigating at different  $\Psi_{SWP}$  affect water use, yield and wine grape quality.

#### MATERIAL AND METHODS

Threshold treatments were applied in above mentioned regions between pea berry stage and harvesting during four growing seasons *i.e.* from 2019/20 until 2022/23. The following  $\Psi_{SWP}$  thresholds were applied: -1.1 MPa (T1); -1.5 MPa (T2) and -1.8 MPa (T3). The first threshold of -1.1 MPa (control) was found to be the  $\Psi_{SWP}$  at which the producer irrigated the Treatment block. Bunches were harvested at a total titratable solid reading of 24° Brix, after which experimental wine was made and sensorially analysed.

#### **RESULTS AND DISCUSSION**

The Olifants River Valley had a saving in irrigation water of 36% for T2 and 52% for T3 compared to T1 while these savings were 63% and 78% in the Breedekloof Valley. A similar trend occurred in the Coastal region with a reduction of 39% for T2 and 86% for T3 compared to T1. The study concluded that with the reduction in irrigation water, there was a decrease in vegetative growth in each of the three regions. This however was not the case with the yield produced, as only the Olifants River Valley showed a significant loss in yield with the Coastal region and Breedekloof Valley producing similar yields across all three Treatments. Preliminary data showed that Treatment 2 produced the best quality wine grapes across each of the regions (full sensorial results will be presented at Congress).

#### CONCLUSIONS

The study concluded that there is a correlation between  $\Psi_{SWP}$  and yield, as well as with wine grape quality. The research can greatly help the wine industry with water saving through the use of  $\Psi_{SWP}$ , especially in drought conditions, by aiding in irrigation scheduling.

KEYWORDS: Midday stem water potential, wine grapes, yield

# EFFECTS OF DIFFERENT PLANT GROWTH REGULATORS ON ESTABLISHMENT OF A MICRO-PROPAGATION PROTOCOL OF GREEN PEPPER (CAPSICUM ANNUUM L.)

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# INTRODUCTION

Bell peppers are important vegetables of the Solanaceae family. The limited availability of high quality seedlings and increased seed cost hinders the adoption and commercialisation of bell pepper (*Capsicum annuum* L.) as a profitable vegetable in Eswatini. Plant micro-propagation is an alternative technique to produce clonal plants on a large scale. However, no developed protocol is available for bell pepper production in vitro. The study was conducted to develop a micro-propagation protocol of bell pepper. Plant growth regulators have significant and varying effects in the morphogenesis of plants. The effect of different concentrations of plant growth regulators in the establishment of a micro-propagation protocol for bell pepper was investigated.

#### MATERIALS AND METHODS

The experiment was laid in a Randomised Complete Block Design (RCBD) with five different concentrations per plant growth regulator used which were: 6-Benzyladinine (BA), Indole-3 butyric acid (IBA), Indole-3 Acetic acid (IAA), and Kinetin, the concentrations were 0.5 mg/L, 1 mg/L, 1.5 mg/L, 2 mg/L and the control (0.0 mg/L). The experiment was conducted in the Biotechnology teaching laboratory of the University of Eswatini from January 2020 to October 2020. Agronomic and vegetative parameters were collected every two weeks.

#### **RESULTS AND DISCUSSION**

The results obtained varied with the different concentrations of the different plant growth regulators and the measured parameters. The cytokinin induced shoot initiation showed that the bell pepper with the highest shoot length (4.3 cm) was obtained from the control at 6 weeks after subculture (WAS) and the lowest (3.1 cm) from BA applied at 2 mg/L. The highest shoot length was obtained from cultures treated with Kinetin at 1.5 mg/L (2.3 cm) and the lowest (1.5 cm) from Kinetin at 1 mg/L at 6 WAS. The highest root length (4.7 cm) at 4 WAS was observed from pepper cultures treated with IBA at 0.5 mg/L, and the lowest was (1.8 cm) from IBA 2 mg/L.

# CONCLUSIONS

For bell pepper morphogenesis the optimum auxin for root formation is at 0.0 mg/L followed by 2.0 mg/L of IAA.

**KEYWORDS:** Bell pepper, Plant Growth Regulators, 6-Benzyladenine, Kinetin, Indole-3-Acetic acid, Indole-3-butyric acid.

# **CROPS ABSTRACTS**

# EFFECT OF ZINC FERTILIZER RATES ON GROWTH AND PANICLE YIELD OF GRAIN SORGHUM CULTIVARS

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#### INTRODUCTION

Sorghum is highly susceptible to zinc deficiencies. Researchers revealed that more than 30% of the agricultural soil in the world is prone to zinc deficiencies. The addition of zinc is an important agricultural strategy to ensure optimal sorghum production. Different cultivars of the same crop respond to zinc fertilizer differently. However, the literature on the influence of different zinc fertilizer rates on the performance of grain sorghum cultivars is scanty. Hence, this study aimed to investigate the response of grain sorghum cultivars to different zinc fertilizer rates.

#### MATERIAL AND METHODS

A greenhouse experiment was carried out at North-West University Research Farm. The experiment was set as a 4 x 3 factorial fitted in a randomized complete block design. Soil samples were collected from 0-15 cm depth from the North-West University Campus and analyzed for physical and chemical properties. The soil was sandy clay loam with a pH of 6.79, total nitrogen of 0.38%, available phosphorus of 2 mg/kg, potassium of 270 mg/kg and zinc of 57. 2 mg/kg. Each experimental pot (475 mm x 270.70 mm x 339.65 mm dimensions) was filled with 14 kg of soil, and four seeds were planted per pot). The treatment factors comprised three zinc rates (0, 5.6 and 10.6 kg Zn/ha) and four grain sorghum cultivars (Avenger, Enforcer, NS5511 and PAN 8816). Each pot was irrigated with 3 litres of water weekly based on field capacity followed standard procedure. The measured parameters were plant height, number of leaves, chlorophyll content index, stem dry matter, leaf area, total dry matter, and panicle mass. Data were analyzed using Analysis of Variance (ANOVA) with GenStat. Differences in treatment means were tested using the Duncan Multiple Range Test (DMRT) measured at a 5% probability level..

#### **RESULTS AND DISCUSSION**

The sorghum cultivar Enforcer and NSS 511 fertilized with 0 Zn kg/ha produced significantly tallest plant height (103.90 and 129.30cm) compared to PAN 816 at 49 and 77 days after planting. Enforcer and Avenger treated with 0 and 5.6 Zn kg/ha had the highest number of leaves (10.25 and 12.25). The highest and most significant panicle mass (142 g) was obtained from PAN 816, supplied with 10.6 Zn kg/ha than all other cultivars. This showed that the reproductive parameters of sorghum required higher zinc fertilizer applications than growth traits.

#### CONCLUSIONS

It is concluded that grain sorghum cultivars required a low rate of zinc fertilizer (5.6 Zn kg/ha) close to 0 Zn kg/ha for growth. However, the cultivars needed more zinc fertilizer of 10.6 Zn kg/ha for grain production. Enforcer are best for growth purposes such as fodder. PAN 8816 is best for grain purposes.

**KEYWORDS:** Zinc deficiency, plant height, panicle mass, grain sorghum.

# DRY MATTER ACCUMULATION, TRANSLOCATION AND YIELD OF WATER EFFICIENT MAIZE (WEMA) IN RESPONSE TO NITROGEN FERTILIZER AND PLANT DENSITY

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#### INTRODUCTION

Maize plays an important role in food security in the world. The dry matter production mainly depends on the potential of the different maize varieties and agronomic practices. Research showed that among agronomy practices, plant density and nitrogen fertilizer application significantly affect dry matter accumulation and yield. Nonetheless, more still need to be learnt on effect of different nitrogen fertilizer rates and plant density on dry matter translocation, accumulation and yield of maize. Therefore, this study investigates dry matter accumulation, translocation and yield response of Water Efficient Maize (WEMA) to different nitrogen fertilizer rates and plant density. We hypothesize that WEMA dry matter translocation and yield will respond differently to different nitrogen fertilizer rates and plant densities.

#### MATERIAL AND METHODS

A field study was conducted over two planting seasons (2015/16 and 2016/17) at North -West University Research Farm Mafikeng Campus in North-West Province. The trial comprised three plant densities: 33 333, 44 444 and 55 555 plants ha<sup>-1</sup> and five nitrogen rates: 0, 60, 120, 180 and 240 kg N ha<sup>-1</sup> as main and subplots, respectively. The experiment was laid out in split-plot, fitted into a randomized complete block design with four replicates in each site. The parameters measured were dry matter accumulation, dry matter translocation efficiency, contribution of pre – anthesis to grain, dry matter yield and nitrogen removal. Data were analyzed using Analysis of Variance (ANOVA) with GenStat. Differences in treatment mean values were evaluated using Duncans Multiple Range Test (DMRT) at probability level of 5%.

#### **RESULTS AND DISCUSSION**

Maize planted at 55 555 plants ha<sup>-1</sup> and fertilized with 120 kg N ha<sup>-1</sup> had significantly highest dry matter translocation (445 kg ha<sup>-1</sup>) than maize sown at 33 333 plants ha<sup>-1</sup> and treated with 240 kg N ha<sup>-1</sup>. Maize sown at 55 555 plants ha<sup>-1</sup> and treated with 120 kg N ha<sup>-1</sup> showed highest dry matter translocation efficiency (19.5%). During vegetative stage, highest and significant dry matter yield (10.13 t ha<sup>-1</sup>) was recorded in the plot with 55 555 plants ha<sup>-1</sup> and supplied with 120 kg N ha<sup>-1</sup>. Similarly, the plant density of 44 444 plants ha<sup>-1</sup> and application of 120 kg N ha<sup>-1</sup> produced highest dry matter yield (22.78 t ha<sup>-1</sup>) during physiological maturity. There is a positive and significant relationship between nitrogen removal and grain and dry matter yields (R<sup>2</sup> = 0.89 and 0.88). This indicated that dry matter translocation and yield of WEMA maize required highest plant density and optimal nitrogen fertilizer.

#### CONCLUSIONS

It is concluded that WEMA produced maximum dry matter yield at 55 555 plants ha<sup>-1</sup> when fertilized with 120 kg N ha<sup>-1</sup>. This combination is recommended for increasing dry matter maize production.

KEYWORDS: Dry matter yield, grain yield, nitrogen fertilizer rates, Water Efficient Maize.

## PRODUCING VEGETABLES IN A CONSERVATION AGRICULTURE SYSTEM: EFFECTS ON SOIL HEALTH AND CROP PRODUCTIVITY

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#### INTRODUCTION

Maintaining soil health is crucial for optimal crop production. Conservation Agriculture (CA) stands out as a sustainable approach with far-reaching benefits for field crops on a global scale. However, little is known about CA in vegetable production systems. To assess the prospects of CA for sustainable field vegetable production, this study investigated the impact of CA on soil health and vegetable productivity.

#### MATERIALS AND METHODS

The study was conducted at three sites near Lutzville, in a semi-arid region of South Africa. The conventional farming method (i.e., control), cover crops and wheat mulch addition in a crop rotation were compared. The experiment was conducted over a two-year period (2022 to 2023), with one summer and two winter cropping seasons. In the middle of the winter seasons, data were collected on soil compaction as one of the soil's physical properties. Soil samples were collected on three dates: at the beginning, middle and end of each season for soil chemical and biological analyses. In addition, crop performance in the field was evaluated, and crop yield and quality parameters were assessed.

# **RESULTS AND DISCUSSION**

Cover crop treatment reduced (p<0.05) soil compaction, followed by mulch, compared to the control. Mulching affected extractable soil phosphorus and soil organic carbon (p<0.05), but not sodium, cation exchange capacity, sulphur, and calcium contents (p>0.05). Soil pH was lower in cover crops (p<0.05), which can be attributed to decomposition of cover crop residues. The control showed higher (p<0.05) cauliflower productivity (crop yield and curd size uniformity), and cauliflower leaf analyses showed higher (p<0.05) ammonium content compared to cover crops and mulch, but with no effect on other nutrients. High weed biomass (p<0.05) was associated to a greater extent with the mulch treatment than with the control and cover crops, possibly due to the wheat straw. Effects on microbial communities and enzymatic activities (urease and  $\beta$ -glucosidase) varied greatly among sites, treatments, and sampling dates, which could be due to microbial changes over time and inherent soil properties.

#### CONCLUSIONS

Cover crops are the superior solution for reducing soil compaction, and mulch for improving soil chemical properties. However, wheat seeds in mulch can invade crops as weeds the next season. Site differences mean that different sites and soil properties respond differently to different management practices. Cauliflower crops performed best in the control treatment. However, longer studies are recommended to investigate the effects on soil health and crop productivity over time. The benefits of CA usually take time to materialise, as it takes time for soil health to improve and for farmers to gain experience with implementing CA.

KEYWORDS: CA, Cover crops, Mulch, Soil health, Vegetable productivity

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# CONSERVATION AGRICULTURE IN VEGETABLE SYSTEMS: A NEW HORIZON FOR SOIL HEALTH?

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#### INTRODUCTION

Conservation agriculture (CA) – the implementation of three management principles – permanent soil cover, diverse crop rotations, and reduced soil disturbance – has increased steadily over the years and now accounts for 12.5% of global croplands. While the adoption of CA is common in grain production systems in South Africa, its implementation into vegetable production systems remains low. As vegetable production is constrained by its high nutrient and water requirements, and crops are vulnerable to pest and disease attacks, the implementation of sustainable farming practices in these intensive systems is essential for sustained food production.

#### MATERIAL AND METHODS

The study aimed to determine the effects of three soil cover treatments – control, mulch, and cover crop – on various soil health indicators in the first year of adopting CA in an irrigated vegetable production system located in Vredendal, South Africa. Soil health indicators included soil  $pH_{KCI}$ , Olsen-P, organic and active C, available N, microbial activity, acid phosphatase,  $\beta$ -glucosidase, and urease activity.

#### **RESULTS AND DISCUSSION**

The effects of treatments were only significant on organic C, while other soil indicators were not influenced by treatment. A short-term study investigating the effects of transitioning from conventional to organic vegetable production emphasised that at least 2 years were required to notice significant changes in soil health. Both soil chemical and biological properties were strongly influenced by farms. Several studies in similar vegetable production systems (organic no-tillage systems) have found improvements in organic C, microbial diversity, activity, and macronutrients. These studies, however, all focused on longer-term trials ranging from 2 to 10 years.

#### CONCLUSIONS

Despite including indicators that respond quickly to management change, the results presented in this study do not align with those found in longer-term studies with multiple cropping years, suggesting that implications of introducing conservation agriculture to production systems may not be noticeable immediately after its adoption. Strong site differences in soil parameters were evident. The CA strategies used by farmers may, therefore, differ across sites. While the sites were managed similarly in this study, the historical management of each site and its location in the larger landscape likely differed. This should be considered in future research.

# FACILITATING SUSTAINABLE MINE WATER IRRIGATION

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#### INTRODUCTION

There is much interest in the use of mine water for irrigation as a means to reduce mine affected water treatment costs and to create sustainable livelihoods, especially as mines reach closure and communities need to diversify away from mining as part of the "Just Energy Transition". Large volumes of mine waters are affected, and many mine waters are suitable for irrigation. However, guidance is required to assess mine water fitness-for-irrigation and the steps that need to be taken to set up a successful mine water irrigation scheme need to be clearly set out.

# MATERIAL AND METHODS

Modelling and past experience has shown that irrigation with gypsiferous mine waters can be successfully and sustainably undertaken, but regulators are understandably concerned about the productivity and environmental impacts of a large-scale roll out of mine water irrigation. To overcome their concerns, and to facilitate informed decision making around the establishment and regulation of mine water irrigation schemes, support is needed. To this end, a commercial scale Demonstration Site (19 ha irrigation pivot), which has irrigated crops with untreated circum-neutral mine water since September 2017 on previously un-mined land in Middelburg, Mpumalanga, South Africa, was established and has been carefully monitored for the last five years. In addition, Technical Guidelines for Mine Water Irrigation were developed to assist potential irrigators and regulators.

#### **RESULTS AND DISCUSSION**

Maize (*Zea mays*) has been grown very successfully for five consecutive seasons, with no observable impact on soil and water resources. Crops have been profitably produced, and grain and fodder have been shown to be safe to consume. The Technical Guidelines that were developed make use of a logical decision tree structure, with a source-pathway-receptor approach to determining monitoring requirements and thresholds for action.

#### CONCLUSIONS

The Technical Guidelines and successfully established Demonstration Site are assisting those interested in developing mine water irrigation schemes, as well as the regulators who need to approve such developments. Importantly, the Irrigation Water Quality Decision Support System that forms an integral part of the guidelines, is able to flag constituents of potential concern and identify mine waters that should rather not be used for irrigation without at least some level of treatment.

Keywords: Adaptive management, Irrigation site selection, Monitoring, Irrigation water quality guidelines, Mine water irrigation

# THE NITROGEN AVAILABILITY IN SOIL FOLLOWING LEGUME CROPS AND THEIR EFFECT ON THE SUBSEQUENT CROP.

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#### INTRODUCTION

Nitrogen has an important role in crop production. Nitrogen fertilisers have become expensive in terms of both financial and environmental cost. Legumes have the ability to fix nitrogen and can therefor start to mitigate these problems. The full potential of legumes are not fully understood in the Western Cape crop

rotation systems. The aim of the study is to determine the amount of nitrogen fixed by different legumes and the effect on the following year's crop in the Western Cape.

#### MATERIAL AND METHODS

The study was done at Riversdale and Langgewens. In 2021, legumes were planted and followed by wheat in 2022. The treatments included 11 legumes cultivars consisting of four peas (*Pisum sativum*), six lupins (four *Lupinus angustifolius* and two *Lupinus albus*) and one faba bean (*Vicia faba*). A bare plot was the control. The legumes and cash crops were established with only 5 kg ha<sup>-1</sup> of nitrogen fertiliser. Soil samples were taken at the beginning and end of the growing season of 2021 and 2022 for nitrogen content. Wheat yield in 2022 following the legumes of 2021 was also determined.

#### **RESULTS AND DISCUSSION**

The results from the soil samples after the legumes were harvested, indicated that nitrogen was highest at two of the pea treatments, three lupin treatments, the faba bean as well as the control treatment at Langgewens in the 0 - 150 mm soil depth. At Riversdale, the highest nitrogen was found at one pea and one lupin treatment in the topsoil depth. The yield of the wheat following these treatments had no significant differences at Riversdale or Langgewens. The average wheat yield at Riversdale was 3677 kg ha<sup>-1</sup> and Langgewens was 2969 kg ha<sup>-1</sup>. The small differences could be because the effect of the legumes will be more prominent in a few years following the legumes. Even though the soil showed significant differences in nitrogen concentrations averaging 19 mg kg<sup>-1</sup> at Langgewens and 20 mg kg<sup>-1</sup> at Riversdale, there were still sufficient nitrogen in the soil to maintain the wheat yields.

#### CONCLUSIONS

The legumes fixed enough nitrogen to have industry comparable wheat yield, with almost no additional inorganic nitrogen input. With these results, the Western Cape grain producers will benefit by optimising their fertiliser programs accordingly.

#### Keywords:

Fertiliser, Legume, Nitrogen, Wheat

# EFFECTS OF DIFFERENT NPK FERTILIZER RATES ON MICROBIAL DIVERSITY OF JATROPHA ZEYHERI TEA LEAVES UNDER GREENHOUSE CONDITIONS

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#### INTRODUCTION

Nitrogen (N), phosphorus (P) and potassium (P) fertilization is an effective strategy for improving tea yield and quality. Subsequently, deficiencies of N, P and K in the soil have a direct effect on growth of tea resulting in poor performance (Tang *et al.*, 2023). Fertilization also employs unintended effects on tea yield and quality by influencing the microbial community in the soil which is critical for regulating nutrient cycling. Therefore, the objective of this study was to assess the effect of different NPK fertilizer application rates on microbial composition of *J. zeyheri* tea under greenhouse conditions.

#### MATERIALS AND METHODS

Six treatments constituting NPK 2:3:2 (22) fertilizer rates namely, 0, 2, 4, 8, 16 and 32 g were arranged in a randomized complete block design, with five replications. Seedling trays were used and after emergence to 5 cm, after 20 days *J. zeyheri* seedlings were hardened off for a week through intermittent withholding of irrigation water outside the greenhouse. Uniform four-week-old *J. zeyheri* seedlings were transplanted into 25 cm diameter plastic pots. 130 days after initiating treatments, leaves were harvested and oven-dried for 72 h at a temperature of 60°C. The dried leaves were ground through a 1 mm sieve using a grinder before analysis. Tempo reader (BioMerieux, Rodolphe, Durham, United States) instrument was used to determine the microorganism on tea leaf tissues. Data were subjected to ANOVA using the Statistix 10.0 software.

#### **RESULTS AND DISCUSSION**

Treatments had a highly significant effect ( $P \le 0.01$ ) on *Bacillus cereus* contributing 39% in total treatment variation (TTV), whereas increasing NPK fertilizer rates had significant effects ( $P \le 0.05$ ) on Enterobacteriaceae contributing 58% in TTV. Increasing rates of NPK fertilizer did not influence total coliforms contained in *J. zeyheri* tea leaf tissues. *Bacillus cereus* and Enterobacteriaceae over increasing NPK fertilizer rates exhibited positive quadratic relations, with density dependent growth pattern.

## CONCLUSIONS

In the current study, at low NPK fertilizer rates microbial composition was stimulated. However, this could have a great impact on tea beverage consumption since products intended for consumption in their raw form should contain less than 100 CFU/gram. At highest NPK fertilizer rates, microbial composition in tea leaf tissues adhered to the permissible limit which is less than 100 CFU/gram.

#### REFERENCES

Tang, S., Zhou, Z., Pan, W., Sun, T., Liu, M., Tang, R., Li, Z., Ma, Q. and L. Wu. 2023. Effects of combined application of nitrogen, phosphorus, and potassium fertilizers on tea (*Camellia sinensis*) growth and fungal community. *Applied Soil Ecology* 181: 104661.

Key words: Fertilizer, indigenous tea, microbial, secondary metabolites, tea quality

# INFLUENCE OF PRIMARY NUTRIENTS ON THE ESSENTIAL AND NON-ESSENTIAL MINERAL ELEMENTS OF JATROPHA ZEYHERI TEA UNDER GREENHOUSE CONDITIONS

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#### INTRODUCTION

Fertilization of N, P, and K is one of the key factors influencing tea's physiological, physical and chemical qualities (Ma *et al.*, 2021). However, the influence of N, P, and K on essential and non-essential mineral elements of *J. zeyheri* indigenous tea has not been documented. Therefore, this study aimed to evaluate N, P, and K fertilizer's effect on essential and non-essential mineral elements in *J. zeyheri* leaf tissues.

#### MATERIALS AND METHODS

At two-leaf stage, *J. zeyheri* seedlings were transplanted into 25 cm diameter plastic pots. Each pot was filled with heated-pasteurised sandy soil and Hygromix at a 3:1 (v/v) ratio and placed in a spacing of 0.30 m  $\times$  0.30 m inter-and intra-row spacing. Six treatments constituting N, P, and K fertilizer rates (0, 2, 4, 8, 16 and 32 g) were arranged in a randomized complete block design, with 5 replications. The sample was prepared using a microwave digestion system and essential minerals and on-essential mineral elements were determined using an ICPE-9000.

#### **RESULTS AND DISCUSSION**

N, P, and K fertilizer rates significantly affected essential mineral elements Ca, Fe, K, Mg, Zn and Mn contributing 62, 44, 58, 70, 56 and 45% in TTV, respectively. However, Cu and P were not significantly affected. Significant effects were observed on non-essential mineral elements, AI, Na and Cd contributing 72, 42 and 62% in TTV, respectively. N, P, and K fertilizer rates did not affect Co, Cr, As, Pb and Ni in *J. zeyheri* leaf tissues. Fertilizer requirements for *J. zeyheri* tea leaf tissues were optimized at 2.77 g fertilizer mixture/plant, translating to 28 kg NPK fertilizer/ha for 10 000 plants of *J. zeyheri*.

#### CONCLUSIONS

This study found that moderate NPK application was sufficient for enhanced accumulation of *J. zeyheri* tea leaf mineral elements. The results suggested that NPK fertilizer should be applied at low rates to enhance the accumulation of mineral elements in leaf tissues.

#### REFERENCES

Ma, L., Yang, X., Shi, Y., Yi, X., Ji, L., Cheng, Y., Ni, K. and Ruan, J. 2021. Response of tea yield, quality and soil bacterial characteristics to long-term nitrogen fertilization in an eleven-year field experiment. *Appl. Soil Ecol.* 166: 103976.

Keywords: Fertilizer, indigenous tea, Jatropha zeyheri, mineral elements, tea quality

## MONITORING GROWTH AND DEVELOPMENT OF OATS UNDER THE PHENOSPEX PHENOTYPING PLATFORM

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#### INTRODUCTION

Crop growth and development can be quickly and non-destructively monitored through spectral monitoring techniques. These techniques help to understand how phenotypic variation in crops is linked to environmental conditions most especially in fluctuating climate environments. Oats is a very important grain crop in South Africa, and it is one of the mandate crops of the Agricultural Research Council. The objective of this study was to evaluate and test the efficiency of Phenospex, a high-throughput plant phenotyping (HTPP) platform using oat.

#### MATERIALS AND METHODS

The study was conducted during the 2021/2022 season under the Phenospex phenotyping platform of the Agricultural Research Council – Grain Crops, Potchefstroom. Oat was used as the test crop for the study. The crop was planted under the platform during the winter season, and plant height, stomatal conductance and chlorophyll content were measured manually from two weeks after emergence until the flowering stage was reached. The crop plots under the machine were scanned (automated growth measurements) from planting till the end of the study. Regression analysis was used to construct the model for plant height, stomatal conductance and chlorophyll content using the Excel 2016 software (Microsoft Inc., Redmond, WA, USA). The coefficient of determination (R<sup>2</sup>) and relative root mean square error (RRMSE) were used to comprehensively evaluate the model's performance of the model. The range of R<sup>2</sup> is between 0 and 1; the larger the value, the higher the prediction accuracy of the model; the smaller the RRMSE value, the smaller the data difference and the higher the prediction accuracy of the model.

#### **RESULTS AND DISCUSSION**

For this study, the linear method was used for estimating the measured parameters. Hyperspectral image analysis was able to identify a new vegetation index for the estimation of chlorophyll content. The coefficient of determination (R<sup>2</sup>) revealed a moderate correlation between measured and calculated plant height traits, stomatal conductance, and chlorophyll content. However, out of the three parameters, plant height traits were better computed than the other two.

#### CONCLUSIONS

The results suggested that Phenospex was better computed effectively phenotyped oats at optimum growing conditions. As we advance, the present season (2022/2023) data should be used for validating the first season's automatic phenotype data. It is recommended that the machine should be engaged to phenotype oats' abiotic stresses for effective growth and development monitoring.

KEYWORDS: Chlorophyll, oat, phenotyping, plant height

#### ACKNOWLEDGEMENTS

National Research Foundation (NRF) and ARC Grain Crops, Potchefstroom are appreciated.

# INVESTIGATING HERBICIDE RESISTANCE IN LOLIUM SPP.

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#### INTRODUCTION

Herbicide resistance is a growing problem in commercial agriculture. Farmers are reliant on chemical herbicides in high-intensity cropping systems to control unwanted plants i.e., ryegrass (*Lolium* spp.). Successful weeds and crops share similar lifecycles i.e., germination, establishment. Herbicide resistant ryegrass has been observed in South Africa for decades and with focus on glyphosate, glufosinate-ammonium and paraquat resistance. Germination, spray-deposition and dose-response experiments were conducted to investigate the differences in ryegrass resistance from various locations.

#### METHODS AND MATERIALS

Ryegrass seeds were collected from Welgevallen Experimental Farm (WS) in Stellenbosch, consistently sprayed for 30 years, separating seeds from the centre of the field and perimeter (SS). Seeds from Langgewens Research Farm (LS) near Moorreesburg were sprayed sporadically, and commercially available ryegrass (*Lolium multiflorum*) for pasture production (control - BC) were used totaling four-populations. Germination experiments followed International Rules for Seed Testing (ISTA) determining mean germination time (mgt), mean germination percentage (mgp), thousand-seed weight (TSW) calculated using Data Count S 25+. Spray deposition was determined using Dropsight® fluorescent solution - representing active ingredient remaining after spray application at increasing doses and dose-response experiments were conducted on ryegrass under varying temperature regimes (shaded netting at 25°C, heated glasshouse at 35°C and moderate glasshouse at 23 °C), using glyphosate, glufosinate-ammonium and paraquat with 8 applied doses ranging from 0.25X to 4000X. Fluorescent Particle Cover (FPC%), mortality and biomass was recorded and analysed in R.

#### **RESULTS AND DISUCSSION**

Significant results ( $p \le 0.05$ ) were seen across all experiments. Differences in mgp and mgt were seen across all seeds, with BC have the shortest mgt with the highest mgp of 3.1 days and 96% respectively, while LS had the longest mgt of 10 days yet the lowest mgp was SS at 42%. Negative relationship ( $p \le 0.05$ ) between seed characteristics and resistance was found with WS and SS having ED50's 10 to 1000 fold - in cooler temperature regimes - greater than quick germinating BC. Spray-deposition results ranged from 5% to 15% FPC%, albeit not directly correlated to herbicide active ingredient up-take, highlights the futility of needlessly increasing doses.

## CONCLUSION

Resistant ryegrass has adapted to regimes delaying germination, emerging as to either avoiding postemergence herbicide applications or surviving through age-induced resistance. Increasing doses to accommodate for spraying delays saturates the leaf surface, yet spray deposition was not greater than 15% and ED50's were too extreme to justify the expense.

**Keywords:** Herbicide resistance, spray deposition, ryegrass

# THE EFFECT OF NITROGEN APPLICATION CONCENTRATION ON THE YIELD AND QUALITY OF BABY SPINACH CULTIVARS GROWN IN A SOILLESS MEDIUM

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#### INTRODUCTION

Baby spinach (*Spinacia oleracea* L.) is a green leafy vegetable that is high in nutritional value and is rich in phytochemicals and core nutrients. Soilless culture is a modern way of growing crops without soil and is rapidly gaining momentum. Nitrogen (N) plays a significant role in crop yield and quality. Limited studies have been conducted on the effect of N on bioactive compounds in soilless-grown baby spinach cultivars. This study aims to investigate the yield and selected bioactive compounds at harvest of three soilless-grown baby spinach cultivars subjected to different N concentrations.

#### MATERIALS AND METHODS

The trial was conducted in the Tshwane University of Technology greenhouse from October to December 2022 using a soilless culture system. Seeds of baby spinach cultivars 'Acadia', 'Crosstrek' and 'Traverse' were sown in 200 cavity seedling trays filled with peat moss (Mikskaar) as a growing media. The treatment design was a randomised complete block design with six N concentrations (0, 30, 60, 90, 120 and 150 mg/L) combined with three baby spinach cultivars and replicated four times. Ammonium nitrate was used as a source of N. The following fertilisers were used to prepare nutrient solutions: hygroplex, MKP, CaCl2, MgSO4, K2SO4, and KCI. Genstat® was used to analyse data.

#### **RESULTS AND DISCUSSION**

A nitrogen concentration of 90 mg/L was sufficient to increase the yield of 'Acadia' and 'Traverse', while 120 mg/L N showed the most significant yield for 'Crosstrek'. In contrast, at 60 mg/L N, total phenols were higher in all three baby spinach cultivars. Under N deficiency, carbon molecules produced during photosynthesis may be used more for the biosynthesis of phenolic compounds (Becker *et al.*, 2015; Mampholo *et al.*, 2018). The total carotenoid content increased with an increase in N concentration, and all three cultivars showed the highest concentration at 150 mg/L N. At 90 mg/L N, all three cultivars showed the highest DPPH. A linear regression model's relationship of yield and total phenols showed a weak correlation ( $R^2$ =0.11), while yield and carotenoids showed a moderate correlation ( $R^2$ =0.64).

#### CONCLUSIONS

This study has shown that less N-sensitive varieties can effectively use N and accumulate higher total phenols and antioxidant activity without compromising yields. To achieve the desired yield, moderate concentrations of total phenols and carotenoids, antioxidant activity, and an N concentration of 90 mg/L in the soilless medium are recommended for cultivars 'Acadia' and 'Traverse'.

KEYWORDS: Antioxidant activity, bioactive compounds, leafy vegetable, peat moss.

#### ACKNOWLEDGEMENTS

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# PREDICTING THE N<sub>2</sub>O EMISSIONS IN DIFFERENT TILLAGE AND CROP ROTATION SYSTEMS IN THE SWARTLAND REGION, WESTERN CAPE

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#### INTRODUCTION

Nitrous oxide (N<sub>2</sub>O), a greenhouse gas (GHG) approximately 300 times more potent than carbon dioxide, must be managed to reach our global climate change target. N<sub>2</sub>O emissions are the largest source of GHGs in cropland agriculture. Improving the accuracy of N<sub>2</sub>O measurement allows for better-informed decisions to manage N<sub>2</sub>O. Nitrogen availability in the soil is typically used as the determinant for estimating N<sub>2</sub>O emissions in agriculture, as described by the 2019 Refinement and 2006 IPCC Guidelines. These estimations have a high uncertainty level. Studies have shown that N<sub>2</sub>O emissions are impacted by multiple factors and the combined effect of additional factors is necessary to better assess N<sub>2</sub>O emissions. The factors include carbon availability, nitrogen availability, soil moisture, soil texture, soil temperature, soil pH and salinity, fertiliser types, timing of fertiliser application, tillage type, harvest and crop residues and irrigation. The aim of this study is to develop a framework for estimating N<sub>2</sub>O emissions with increased accuracy, considering this set of factors.

#### MATERIAL AND METHODS

An investigation is being conducted to predict the relative N<sub>2</sub>O emissions of three different crop rotation systems (wheat monoculture, wheat-medic alternating, wheat-canola-wheat-lupin rotation) managed through conventional tillage versus zero tillage. The crop systems under zero tillage have previously been quantified through direct measurements of N<sub>2</sub>O. A framework for analysis was developed based on the N<sub>2</sub>O impact factors described by Wang et al. (2021) to predict the N<sub>2</sub>O emissions that extend beyond nitrogen availability.

#### **RESULTS AND DISCUSSION**

Compared to zero tillage, the preliminary analysis shows the treatments under conventional tillage exhibit a net decrease in  $N_2O$  emissions. This assumes the crop rotation systems, temperature, nitrogen inputs, precipitation and soil conditions are similar. The main causes of the decrease in  $N_2O$  emissions is less soil moisture and lower soil organic carbon in the treatments under conventional tillage. Higher soil temperatures from less soil cover, and less soil aggregates result in reduced soil moisture under conventional tillage. Lower soil organic carbon is due to higher oxidation rates under conventional tillage. Additional work is ongoing to quantify these impacts and to test the framework using direct measurements.

#### CONCLUSIONS

Estimating emissions more accurately using minimal resources will assist farmers in their own GHG analysis and inform government policy. This study is developing a simple and efficient framework for predicting N<sub>2</sub>O emissions of crop-based systems of different rotation and tillage types with increased accuracy in the Swartland region of the Western Cape.

#### REFERENCES

Wang, C., Amon, B., Schulz, K., & Mehdi, B. (2021). Factors that influence nitrous oxide emissions from agricultural soils and their representation in simulation models: A review. In *Agronomy* (Vol. 11, Issue 4). MDPI AG. https://doi.org/10.3390/agronomy11040770

Keywords: Conservation agriculture, Conventional Tillage, Greenhouse Gas, Nitrous oxide, Zero Tillage,

#### ACKNOWLEDGEMENTS

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# EFFECT OF TEMPERATURE STRESS ON GROWTH AND YIELD OF SUNFLOWER (HELIANTHUS ANNUUS L.)

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# INTRODUCTION

The ever-increasing human population necessitates the need to maximise global food production. However, temperature stress is a significant factor affecting agricultural production. Moreover, in the changing climate, heat waves and frost are expected to become more frequent, erratic, and last longer. The study aimed to investigate the effect of temperature stress on the growth and yield of sunflowers.

# MATERIALS AND METHODS

A glasshouse pot trial was conducted at the University of Pretoria, Hatfield, South Africa (**S25° 45' 21'' E28° 13' 51''**). Sunflower genotype AGSUN8251 was planted in pots at three temperature regimes, namely, 22°C, 28°C and 35°C (25 plants each), maintained throughout the growth period. The plants were grown in 25 cm plastic pots and were given 250 ml of water every second day. The experiment was randomised entirely and comprised of two trials. Sunflower growth was monitored by measuring plant height and yield components (number of seeds and seed weight per head, thousand seed weight, head diameter, number of leaves and empty husk, stem and root fresh and dry mass) were measured at harvest.

# **RESULTS AND DISCUSSION**

The results from both trials demonstrated that increasing the temperature reduces plant height, with the reduction being most significant at 35°C. With increasing temperature, the number of seeds, seed weight, and biomass accumulation decreased significantly in Trial 1, whereas in Trial 2, there was only a significant decrease in biomass accumulation. In Trial 2, a temperature rise decreased the number of seeds, seed weight, and head diameter only at 35°C. The non-significant reduction between 22°C and 28°C could be due to the similar head diameters. The considerable decline at 35°C could be attributed to a lower number of filled seeds reflected by a higher number of empty husks. At 28°C, the thousand seed weight was higher in both trials. This is most likely due to the decreased number of seeds produced at 28°C, thus allowing the amount of assimilates available in plants to be divided between the smaller number of seeds.

# CONCLUSION

Heat stress will reduce sunflower growth and yield. With the projected increase in the human population, temperature stress could challenge food security.

KEYWORDS: Biomass, plant height, temperature, thousand seed weight, sunflower, yield

# EVALUATION OF THE AGRONOMIC PRACTICES OF BAMBARA GROUNDNUT PRODUCED BY SMALLHOLDER FARMERS IN MPUMALANGA PROVINCE, SOUTH AFRICA

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#### INTRODUCTION

Bambara groundnut (*Vigna subterranea*) is an indigenous, climate-smart legume mainly cultivated in South Africa for subsistence purposes. Despite Bambara groundnut's potential as a nutritious, environmentally resilient crop and its economic benefits, it remains underutilised. Improved and sustainable production can lead to commercialisation of the crop. The aim of this study was to investigate the current agronomic and socio-economic barriers that limit production and investigate practices that can increase production.

# MATERIAL AND METHODS

Qualitative and quantitative research was conducted in the Ehlanzeni district of Mpumalanga with smallholder farmers from Makoko and Mzinti villages. A survey comprising of questionnaires, focus group discussions and key informant interviews was done to understand the farmers' agronomic practices. Farmer participatory field trials were done with nineteen farmers over two seasons. The trials were carried out in two parts: i) a comparison of the effects of five treatments, namely control, fungicide treated-seed, fertiliser, Rhizobium inoculation, and earthing-up practice on yield, implemented in a complete randomised design. ii) a comparison between recommended practices, which combined the use of fertiliser, fungicide-treated seed and narrower row spacing, and farmers' practice where wider row spacing was used without any fertiliser or fungicide. The seed used was sourced from the informal market and local retailers. Pod number, mass, and fresh stem mass were measured and recorded at the end of each season.

#### **RESULTS AND DISCUSSION**

The survey revealed that Bambara groundnut production is done mainly by women over 40. More than 90% of respondents indicated that they produce Bambara groundnut only for home consumption. They also do not apply any fertiliser or control pests and diseases, suggesting that Bambara is not obtaining its full yield potential. Field experiment results showed that fertiliser treatment significantly increased pod yield. Without earthing-up number of pods was significantly less. Seed sources and practice had a significant effect on number of pods, pod mass, and fresh stem mass. The recommended practices significantly increased the number of pods and mass compared to the farmer practices. The informal market seed had a better yield than the retailer-sourced seed.

#### CONCLUSION

Increased productivity in Bambara groundnut is attainable if improved agronomic practices are applied. Food security can be enhanced at household level and commercialization possible if marketing and promotion of the crop are explored.

**KEYWORDS:** agronomic practices, Bambara groundnut, climate-smart, farmer participatory research, smallholder farmer

# MORPHOMETRIC RESPONSE OF *CRICONEMA MUTABILE* EXPOSED TO INCREASING CONCENTRATION OF CUCURBITACIN PHYTONEMATICIDES AND PURE CUCURBITACINS UNDER *IN VITRO* CONDITIONS

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## INTRODUCTION

The ring nematode (*Criconema mutabile*), is one of the large ectoparasitic nematodes, with large annules, which may accord it the capability to adapt to environmental responses. Thus, the objective of this study was to investigate *in vitro* morphometric responses *C. mutabile* to two cucurbitacin phytonematicides and their purified active ingredients.

#### MATERIALS AND METHODS

Nematodes were exposed to seven increasing concentrations (0, 2, 4, 8, 16, 32 and 64%) of Nemarioc-AL and Nemafric-BL phytonematicides and eleven increasing concentrations (0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 µg of dilutions) of pure cucurbitacin A and pure cucurbitacin B. Thereafter morphometrics of heat-fixed nematodes were measured using the AMScope compound stereomicroscope equipped with a digital camera and digital measuring software. Prior to data analysis, treatment values were expressed as exponent of 2<sup>×</sup> and then log-transformed using log<sub>2</sub>2<sup>×</sup> variables subjected to analysis of variance. Variables were subjected to ANOVA using Statistix 10.0 computer software. Significant treatment means were subjected to lines of the best fit in Microsoft Excel 2016.

## **RESULTS AND DISCUSSION**

Results demonstrated that the measured morphometrics versus either phytonematicide or purified active ingredients exhibited both positive and negative quadratic relationships, suggesting the existence of density-dependent growth (DDG) pattern responses with three phases, namely, stimulation, neutral and inhibition phases, possibly providing an empirically-based explanation on the existence of observed variability among nematode species within a given genus. Additionally, non-significant effects on other variables, suggested that affected organs were saturated by cucurbitacins at sampling. Meanwhile, positive relations demonstrated an increase in body length whereas negative relations demonstrated a decrease in body diameters. Increases in length of certain morphometric characters and decreases in diameters of characters was indicative of *C. mutabile* having some degree to exhibit tolerance to the test phytonematicides and its active ingredients.

# CONCLUSIONS

In conclusion, the study provided the first incident of the high adaptability of the genus *C. mutabile* to phytonematicides and its active ingredients.

**KEYWORDS:** Annules, Criconema mutabile, density-dependent growth pattern, stimulation phase, neutral phase, inhibition phase.

# ACKNOWLEDGEMENTS

University of Limpopo for all consumables and experimental infrastructure.

# SCREENING SUNFLOWER CULTIVARS IN THE NORTH-WEST PROVINCE FOR RESISTANCE AGAINST SCLEROTINIA SCLEROTIORUM

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#### INTRODUCTION

Sclerotinia is caused by the necrotrophic fungus *Sclerotinia sclerotiorum*, which has up to 408 host species. *S. sclerotiorum* is a soil-borne plant pathogen that can stay in the soil for up to seven years through sclerotia, making it extremely difficult to control. The most prevalent host crops in South Africa are soybean, sunflower and canola. Due to the large variety of host species of Sclerotinia and its wide distribution, cultivar selection is crucial for disease control. Thus far, no cultivars with complete resistance have been identified in South Africa. This study aims to screen commercially available cultivars in the North-West Province for sources of resistance.

#### MATERIALS AND METHODS

Commercial hybrids (21) were planted over three years (2020/21 - 2022/23) in a randomized block design at the Agricultural Research Council, Potchefstroom. The two planting dates used were in December and January. The milled grain mycelium method was used to prepare inoculum. Sunflower heads were inoculated at flowering. Lesion sizes of all heads (from individual plots) were calculated and divided by the number of heads assessed to get an average disease score measured as cm<sup>2</sup>. Twelve cultivars that were consistent inclusions over the three-year period were analysed, and the *S. sclerotiorum* sunflower head rot potential of all the plantings at Potchefstroom was determined as the mean disease severity over all common cultivars and was assumed to be an integration of all environmental and inoculum effects on disease severity in the test population. Spearman rank correlations were used to evaluate the repeatability of cultivar reactions from each planting and locality. Regression analysis using the model Y = AX<sup>b</sup> was applied using NCSS, where X = sclerotinia head rot potential, Y = mean observed disease incidence within the test cultivar associated with a specific planting date and locality, and a and b are parameters. Nonlinear regression analysis quantified cultivars into three categories, i.e., those linearly related to disease potential, those highly susceptible even at low disease potentials and those with various degrees of resistance despite increasing disease potentials.

#### **RESULTS AND DISCUSSION**

Cultivars AGSUN5103CL, AGSUN5106CLP, AGSUN5108CLP and PAN7100 showed resistance, while cultivars PAN7160CLP, P65LP54, P65LP65 and AGUARA6 were susceptible to Sclerotinia based on the regression analyses used. The Spearman ranking correlation method is a good indicator of cultivar behaviour under different changing conditions (two planting dates, repeated over a three-year period).

#### CONCLUSIONS

Commercial sunflowers vary in susceptibility, and with this study, we could identify cultivars with resistance, which can aid farmers and seed companies in making informed Sclerotinia management decisions. The producer and the industry can utilise information to improve the sunflower seed quality and increase the profitability of the sunflower.

KEYWORDS: Resistance, Sunflower, Spearman ranking correlations, Sclerotinia

#### ACKNOWLEDGEMENTS

Agricultural Research Council-Grain Crops for facilities and the Oil and Protein Seed Trust for funding.

# EFFICACY EVALUATION OF SPRAY PROGRAMMES FOR THE CONTROL OF GLYPHOSATE RESISTANT CONYZA SPECIES UNDER CONSERVATION AGRICULTURE

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# INTRODUCTION

The objective was to evaluate the efficacy of post-emergence herbicides, applied solo or in tank mixtures suitable for soybean production, during autumn and spring on *Conyza* resistant populations in conservation agricultural fields.

# MATERIALS AND METHODS

Two field trials were conducted during 2022/23 on CA farms with glyphosate-resistant *Conyza* populations. Autumn applications were done during 17 May 2022 (Clocolan) and spring applications during 9 September 2022 (Nigel). Nineteen treatments suitable for soybean production and an untreated control were included at both sites (randomized complete block design, three replicates). Active ingredients were applied solo, in tank mixture or as a follow-up application three or seven days after treatment (DAT), respectively (Clocolan – 133 L ha<sup>-1</sup>, Nigel - 187 L ha<sup>-1</sup>). Plot sizes were 0.9 m x 5 m at Clocolan and 2 m x 4 m at Nigel. Percentage stubble cover, % area covered by weeds and % area covered by *Conyza* plants were determined at 0 DAT. Percentage control achieved were determined at 21DAT and 14WAT (weeks after treatment) (Clocolan) and 21DAT and 9WAT (Nigel). The average number and weight of *Conyza* plants per 0.25m<sup>2</sup> were determined at 37WAT (Clocolan) and 26WAT(Nigel), and expressed as a percentage of the control plots (%C). Analyses of variance (P=0.05) were conducted on the parameters calculated.

# **RESULTS AND DISCUSSION**

Seventy three percent of the treatments applied during autumn at Clocolan achieved > 90% reduction in *Conyza* dry plant weight compared to that of the untreated control. The *Conyza* population at Nigel was more difficult to control (later plant growth stage and more resistant to glyphosate). Spring applications at Nigel consisting of Glyphosate+2,4D in tank mixture, followed by a paraquat application 7DAT, as well as glyphosate+saflufenacil followed up by dicamba-2,4D (Di-plus) three days later achieved between 80 and 90% *Conyza* control for up to 9 weeks after treatment (WAT).

# CONCLUSIONS

A higher number of autumn treatments were effective at Clocolan. Two spring treatments achieved 80-90% control of the more resistant and older *Conyza* population at Nigel.

KEYWORDS: Application time, fleabane, glyphosate resistance

#### ACKNOWLEDGEMENTS

Agricultural Research Council and Maize Trust for funding

# GLYPHOSATE RESISTANCE SURVEY OF CONYZA SPECIES AND HERBICIDE EFFICACY EVALUATION

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#### INTRODUCTION

*Conyza* spp. (fleabane), a well-known weed in South Africa, is most problematic under Conservation Agriculture (CA). A glyphosate resistance survey was conducted to establish the resistance status of difficult to control populations from identified farms and to evaluate alternative herbicides for their efficacy.

#### MATERIALS AND METHODS

Glasshouse trials were conducted at ARC-Grain Crops (Potchefstroom) and ARC-Small Grain (Bethlehem). Five replicates from a specific locality x treatment trial were planted at various times throughout the season and across seasons (2020 till 2023 - staggered approach) with three plants per pot. With trial 1 glyphosate was applied to 27 populations at bolt stage at 0X,  $\frac{1}{4}X$ ,  $\frac{1}{2}X$ , 1X, 2X and 4X label rate. With trial 2, one susceptible and two resistant *Conyza* populations were subjected at bolt stage to eight treatments consisting of glyphosate, paraquat, 2,4D, atrazine, saflufenacil and chlorimuron-ethyl applied solo or in tank mixture at 1X, 2X and 3X label rate. Dry mass was determined after 21 days of treatment (DAT). Dose-response curves were created for trial 1 (programme R<sup>®</sup>) and Relative Potency (PR) determined. ANOVA was conducted on dry mass expressed as a percentage of the control of trial 2 (P=0.05).

#### **RESULTS AND DISCUSSION**

In trial 1, 48% of *Conyza* populations demonstrated PR values between (10 and 100) and 48% values greater than 100. Close to half of the populations accordingly were highly resistant, whilst the other half was very highly resistant (Beckie 2012). In trial 2, 2,4D (0.75  $\ell$  ha<sup>-1</sup>) + atrazine (2  $\ell$  ha<sup>-1</sup>) in tank mixture provided the best consistent control across all three *Conyza* populations evaluated at bolt stage.

#### CONCLUSIONS

Varying degrees of glyphosate resistance were confirmed in all populations collected from farms where *Conyza* spp. could not be effectively controlled. Alternative herbicides and tank mixtures were however identified that were effective to control these glyphosate resistant populations.

KEYWORDS: conservation agriculture, fleabane, glyphosate

# ACKNOWLEDGEMENTS

Agricultural Research Council and Maize Trust for funding.

#### **REFERENCE LIST**

Beckie HJ, Tardif FJ. 2012. Herbicide cross resistance in weeds. Crop Protection 35:15-28.

# SEASONAL FORECAST INFORMATION, AWARENESS, ACCESS AND LOCAL UPTAKE: THE CASE OF COMMERCIAL AND SMALLHOLDER FARMING SYSTEMS IN THE WESTERN AND EASTERN CAPE PROVINCES

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#### INTRODUCTION

Climate change is affecting crop production on large scales through long-term changes (e.g. temperature, precipitation) as well, as it contributes to increased uncertainty in short-term climate variability. Climate services at large, specifically seasonal forecasts (SF) in our case, offer information which can help better prepare for the coming seasonal variability. While several studies have examined the skill or accuracy of SF, this study is concerned with the uptake of SF. We explored the current awareness, access and use of such information in Western Cape commercial and Eastern Cape smallholder farming system settings.

The aim of this study was to assess SF uptake in those different contexts, understand barriers and enablers of their use, and suggest priority directions to improve their understanding and use.

#### MATERIALS AND METHODS

A mixed-methods approach was used to collect and analyse the data. Interviews with open-ended and closedended questions were conducted with seasonal forecast providers, farmers, agricultural extension officers and agricultural support institutions. The interviews were tailored according to various interviewees' roles, designed to gain external (i.e. provider), collective (both extension and support), and individual (i.e. farmers) insight into the awareness, access and use of SF in farming decisions. The interviews were performed over the years 2021, 2022 and analysed in 2023.

#### **RESULTS AND DISCUSSION**

Farmer-researcher engagement and extension support is currently poor. This is demonstrated by the low response rate of commercial and smallholder farmers who reported using extension services, as well as a lack of awareness and understanding of seasonal climate forecasts. While access to climate services varies measurably from commercial to smallholder farmers, the use of seasonal climate forecasts remains rare/sporadic in both groups. Barriers expressed range from information-related (e.g. scale, timing, poor understanding) to social-related (e.g. trust, cultural), while networks' existence/reliability have been identified in both groups as enablers (e.g. farmer groups, co-ops). We will discuss the development of stronger connections into the local community (e.g. in EC schools), envisioned both as strengthening access to and awareness of SF but also including community members not only as recipients of the climate information but as active participants in the identification of locally relevant information.

#### CONCLUSIONS

This study recommends improving farmers' knowledge of seasonal climate forecasts through training and developing accessible, context-specific climate services. Moreover, the dissemination and interpretation of seasonal climate forecasts by local agricultural advisors and extension officers is recommended, which information of local relevance can be amplified through deeper local community engagements. This will contribute in the improved uptake of climate information and more active engagement among seasonal climate forecast producers, agricultural advisors, agricultural extension officers.

KEYWORDS: Seasonal climate forecasts, Farming uptake in WC and EC, South Africa

#### ACKNOWLEDGEMENTS

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# SOYBEAN RESPONSE TO CULTIVAR AND ROW SPACING IN SOUTH AFRICA

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#### INTRODUCTION

Soybean producers in South Africa use row widths that vary from 45 to 110 cm spacing. The selection of row width is driven by rainfall and irrigation available and is often largely determined by the equipment available. In research studies done in the US, narrow rows out-yielded wider rows 69% of the time due to earlier canopy closure that enables more light interception to drive photosynthesis. Beyond yield advantages, faster canopy development with narrow rows also enhances soybean competitiveness with weeds (Andrade et al., 2018).

#### MATERIALS AND METHODS

The data of nine (9) experimental sites from the National Soybean cultivar trials representative of the soybean production area in South Africa were used in the analysis. Only sites where the row width was either 76 cm or 90 cm, as well as the 15 cultivars included in the trials over a 3-year period, were selected for the analysis. The experiments were conducted over a period of three growing seasons, namely 2020/21, 2021/22 and 2022/23. The trials were conducted under dryland conditions, either on-station or on-farm, following farmers' practices. A randomised Latinised row/column design with three replicates was used for all field trials. Due to the shattering nature of soybeans, each cultivar was harvested when the cultivar reached the maturity stage.

## **RESULTS AND DISCUSSION**

The 76 cm row width produced significantly higher grain yields compared to the 90 cm at an average of 3.49 t/ha compared to 2.42 t/ha over the 3 planting seasons. However, narrower rows increased the risk of the appearance of Sclerotinia since it thrives in a cool and moist environment. Thus, the formation of an overly dense soybean canopy should be avoided in Sclerotinia high-risk areas. Due to the growth habit and format of the different cultivars, certain cultivars are expected to yield higher at specific row widths. PAN 1251R was the best performer at the 76 cm row width plantings and yielded significantly higher than NS 5909R, PAN 1555R and LS 6860R. However, at the 90 cm row width plantings, PAN 1555R was the best performer and yielded significantly higher than NS 5909R, DM 5351RSF, P71T74R, DM 59R03, RA 4918R, NS 5258R, DM 6.8iRR and LS 6860R.

#### CONCLUSIONS

Soybeans yielded significantly higher under narrow row width conditions, 76 cm vs 90 cm. However, narrower row width increases the risk for Sclerotinia and should carefully be considered in high-risk areas.

KEYWORDS: Row width, soybean cultivars, yield

#### ACKNOWLEDGEMENTS

The financial support of the Agricultural Research Council, Oil and Protein Seed Development Trust, Seed Companies, and other collaborators on-farm.

# ASSESSMENT OF GROWTH AND YIELD ATTRIBUTES OF 17 COWPEA GENOTYPES GROWN UNDER FIELD CONDITIONS IN SUB-TROPICAL ENVIRONMENT, SOUTH AFRICA

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#### Introduction

Cowpea (*Vigna unguiculata L.Walp*), is a multi-purpose and nitrogen-fixing crop whose protein content is comparable to that of animal meat. However, its growth and yield vary across different production zones depending on the genotype and farmers' management practices. In South Africa, cowpea production is mainly produced by smallholder farmers who mostly rely on unimproved varieties resulting in poor growth and low yields. The aim was to assess adaptability, growth and yield performance.

#### **Materials and Methods**

Agronomic field evaluation study was conducted during the 2023 summer planting season at the University of Mpumalanga, experimental farm. The experiment consisted of 17 cowpea genotypes as treatment each planted on a 5-meter row plot replicated 3 times. Growth parameters were measured which includes plant height, number of trifoliate leaves, number of branches, chlorophyll content, and leaf area. Yield parameters collected at crop harvest included pod length, number of seeds per pod, number of cavities per pod, actual yield, and grain yield. Data collected were subjected to analysis of variance (ANOVA) using Statistix version 10.0, while mean separation was done using Tukey Honesty at 5% probability level.

#### **Results and Discussion**

During reproductive stage, significant (p<0.01) variation existed among the various genotypes for the measured parameters namely, plant height, number of branches, number of trifoliate leaves, chlorophyll content, and leaf area parameters. The recorded highest plant height (27.1cm), number of trifoliate leaves (31.3), number of branches (4.7), chlorophyll content (74.4  $\mu$ mol m<sup>2</sup>), and leaf area (769.1cm<sup>2</sup>) were obtained from genotype CV18-1A, KT3, KT3, CV17E and CV17K, respectively. Furthermore, significant (p<0.01) variations in grain and related yield parameters were observed among the various genotypes with the highest pod length (15.7 cm), number of seeds per pod (13.3), number of cavities per pod (14.0), and seed yield (821 g/plot) were obtained from CV23A, KT-1A-19, KT3 and CV17H respectively.

# Conclusion

CV17H and KT3 was adapted and performed well compared to other genotypes based on grain yield and number of trifoliate leaves. Both genotypes can be recommended for smallholder farmers in Mpumalanga for human consumption and livestock feed.

Key words: Genotype, Growth, Yield, Yield attributes

# UNDERSTANDING CUCURBITACIN CONTROL OF ROOT-KNOT NEMATODES

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#### INTRODUCTION

Curcubitacins are a natural group of triterpenoid compounds that have received extensive research attention in the management of various pest types, including nematodes. These molecules were reported to inhibit juvenile hatch, mobility and juvenile mortality *in vitro* and reduce root-knot nematode population densities *in vivo*. However, how these molecules affect nematodes at molecular level has not been extensively studied. Hence, the objective of the study was to determine the binding affinity and structure-reactivity of cucurbitacin A and B on eight *Meloidogyne incognita* molecules critical for key life processes, such as movement, chemo-sensation, energy production, and digestion.

#### MATERIAL AND METHODS

Molecular docking analysis of pure cucurbitacin A and B were performed on eight *M. incognita* molecules namely: acetylcholinesterase, odorant response gene-1 (ODR1), cytochrome-c oxidase subunit 1, heat shock protein 90 (Hsp90), neuropeptide G-protein coupled receptor (nGPCR), aspartyl aminopeptidase, chitin synthase, triacylglycerol lipase, using a modified procedure by Omar *et al.* (2021).

#### **RESULTS AND DISCUSSION**

There were significant docking affinity scores on all investigated *M. incognita* molecules ranging from –188.3 to –15.2 kcal/mol. The sites of ligand cucurbitacin A and B and nematode proteins interactions varied with cucurbitacin molecule, with the best observed interaction formed with Hsp90.

#### CONCLUSIONS

The understanding of the disruption of key molecular processes in nematodes observed in this study could provide innovative ways of combating this destructive pest and protect global agricultural systems.

#### REFERENCES

Omar HS, Abd El-Rahman SN, AlGhannam SM, Reyad NEHA. and Sedeek MS. 2021. Antifungal evaluation and molecular docking studies of *Olea europaea* leaf extract, *Thymus vulgaris* and *Boswellia carteri* essential oil as prospective fungal inhibitor candidates. *Molecules* 26(20): 6118.

Keywords: Meloidogyne incognita, plant extracts, protein inhibition, triterpenoids.

#### ACKNOWLEDGEMENTS

University of Mpumalanga for funding and University of South Africa, Chemistry Department for molecular analysis.

# **BIOLOGICAL CONTROL OF AFLATOXINS IN GROUNDNUT**

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#### INTRODUCTION

Groundnuts are susceptible to aflatoxin contamination, and dependence on groundnuts as a food source may result in significant aflatoxin-associated hazards such as cirrhosis, liver cancer, stunting, reduced immunity, reduced weight gain and/or rapid death. Enforcement of regulatory limits on aflatoxin concentrations in foods and feeds causes a loss of markets for agricultural products and reduced income. Aflatoxin contamination is caused by crop infection *Aspergillus flavus* (which produces only B aflatoxins) and A. parasiticus (which produces both B and G aflatoxins) in South Africa. The aim of this study is to develop a biological control product using non-aflatoxigenic strains.

#### MATERIALS AND METHODS

Collect approximately 3500 *Aspergillus flavus* isolates from groundnut samples from different production regions of South Africa. In the lab, these isolates will be tested for their ability to produce aflatoxins or not, within which mating groups they fall, and Microsatellites or Single Sequence Repeats (SSRs) will be used to confirm which isolates fall in the same vegetative compatibility group (VCGs). The aim is to identify a VCG comprising only non-aflatoxigenic strains that will not cross with aflatoxigenic strains. The survival ability of the non-aflatoxigenic VCG for their ability to survive in the field will be determined. Select several non-aflatoxigenic strains from this VCG and start with initial field testing. Develop these into a prototype product for producers to apply in groundnut fields to reduce aflatoxin levels through competitive exclusion of aflatoxigenic strains and thus ensure food safety regarding groundnuts and their products.

#### DISCUSSION

This technology has been improved for use in sub-Saharan Africa, where efforts are under way to develop biocontrol products, under the trade name Aflasafe, for 11 African nations. The number of participating countries is expected to increase. In parallel, state-of-the-art technology has been developed for large-scale, inexpensive manufacturing of Aflasafe products under specific conditions in many African nations. Results to date indicate that all Aflasafe products registered and under experimental use reduce aflatoxin concentrations in treated crops by >80% compared to untreated crops in both field and storage conditions. This technology will be utilised to develop a biocontrol product for groundnut production in South Africa using local isolates.

#### CONCLUSIONS

The aim of this study is to develop a biocontrol product using non-aflatoxigenic strains to outcompete toxigenic strains in the field. It will prevent toxigenic strains from infecting groundnuts with aflatoxins, ensuring safer groundnuts and products for commercial and informal markets.

**KEYWORDS:** Biocontrol, groundnuts, aflatoxins

#### ACKNOWLEDGEMENTS

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# PHENOTYPIC VARIATION IN AMADUMBE (COLOCASIA ESCULENTA (L.) SCHOTT) GENOTYPES IN SOUTH AFRICA

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#### INTRODUCTION

Amadumbe is one of the most important staple food crops in the world. In South Africa, it is especially popular among farmers with limited resources. Amadumbe is used as a staple food and is rich in carbohydrates, protein, minerals and vitamins. Information on the genetic variability among the existing Amadumbe genotypes will increase the efficiency of the Amadumbe improvement production program.

#### MATERIAL AND METHODS

The field experiments were conducted at two sites (Roodeplaat research farm, and Umbumbulu in the farmer's field) in South Africa in 2013, 2014 and 2015 cropping seasons to estimate the level of genetic variability and yield stability among a collection of 29 Amadumbe genotypes. The experiment was laid out in a randomised complete block design, with three replications. Data was analysed using Agrobase Generation II computer software (2008).

#### **RESULTS AND DISCUSSIONS**

Nine quantitative morphological traits were recorded. Analysis of variance for the traits revealed that differences among Amadumbe genotypes were highly significant for all traits. This indicated that there was a high level of genetic variability among the genotypes studied. Genetic and phenotypic coefficient of variation, and broad sense heritability were estimated for all phenotypic traits. The principal component analysis also showed the total variability among the genotypes. Cluster analysis of the phenotypic traits resulted in different distinct groups of genotypes.

#### CONCLUSSION

The quantitative traits provide a useful measure of genetic distances among the Amadumbe genotypes and will enable the identification of potential parental materials for future breeding efforts for increased production, which will contribute towards a direct economic benefit for the community and an increase in the status of the crop. The Amadumbe genotypes AM-43, UM-3, Amzam3053/5118, UM-1, and Um-2 provided the highest yield per plant compared to the rest of the genotypes and are recommended as suitable parental lines for crop improvement in South Africa.

Key words: Amadumbe, genotypes, heritability, phenotype, principal component analysis

#### References

Agronomix. 2008. Agrobase Generation II. Agronomix Software, Inc. 71 Waterloo St. Winnipeg, Manitoba, R3N054, Canada.

# THE EFFECT OF PLANT DENSITY AND ZINC ADDED TO PHOSPHORUS FERTILIZER SOURCE ON SOYBEAN GROWTH PERFORMANCE UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

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# INTRODUCTION

Phosphorus supply and planting density regulate plant development by altering root morphological traits. The use of micronutrients such as zinc is an agronomic practice that has been neglected by most farmers. Lack of information on the use of other phosphorus fertilizer sources results in farmers relying on only one phosphorus source, and this limits soybean production The study's objective was to determine the effects of plant density and zinc added to phosphorus fertilizer sources on the growth performance of soybean under different environmental conditions.

# MATERIALS AND METHODS

The experiment was conducted during the 2018/19 and 2019/20 planting seasons in two locations, namely Mafikeng and Taung. The experimental design was a 2 x 2 x 5 factorial fitted into a randomized complete block design (RCBD) with four replications. The two plant densities were a lower plant density of 66 666 plants/ha and a higher plant density of 111 111 plants/ha. The five fertilizers investigated were single superphosphate, monoammonium phosphate, zinc added to single superphosphate, zinc added to monoammonium phosphate, and control. Soybean parameters measured include plant height, number of leaves, chlorophyll content, root length and mass.

# **RESULTS AND DISCUSSION**

Plant density significantly affected soybean plant height, number of leaves, chlorophyll content and root mass. Soybean planted under lower plant density conditions produced more leaves, higher chlorophyll content and greater root mass. These results could be attributed to lower competition for resources between plants. Applying phosphorus fertilizer sources/zinc significantly affected soybean plant height, number of leaves and root mass. Soybean plants treated with SSP were taller and had a greater number of leaves and greater root mass. These results could be attributed to the high solubility of SSP. Soybean plants treated with Zn + SSP produced longer roots during the 2018/19 and 2019/20 planting seasons. The findings could be attributed to the addition of zinc to SSP,

# CONCLUSIONS

Farmers interested in legume green manure and animal feeds are advised to plant soybean at low plant densities. Applications of zinc added to phosphorus fertilizer source are recommended as supplements to increase soybean growth.

KEY WORDS: Density, location, phosphorus, root length and zinc

# VIRULENCE DIVERSITY OF *PUCCINIA TRITICINA* COLLECTED FROM WHEAT AND TRITICALE IN SOUTH AFRICA FROM 2021 TO 2022

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#### INTRODUCTION

Leaf rust, caused by *Puccinia triticina* (*Pt*), is an important disease of wheat in the winter rainfall regions of South Africa (SA). Resistant cultivars provide environmentally safe and affordable leaf rust control. However, *Pt* exhibits significant pathogenic variability, challenging the durability of resistance. The objective of this study was to determine the frequency and distribution of *Pt* races in SA from 2021 and 2022.

#### MATERIALS AND METHODS

Wheat and triticale (*xTriticosecale*) infected with *Pt* were collected from various SA production regions. Twenty differential lines with single resistance genes were used for virulence analysis. Seedlings were grown, inoculated, and incubated in greenhouse cubicles (Terefe et al. 2022). Infection types (ITs) were determined using a 0 to 4 scale, with 0 to 2 indicating avirulence and 3 to 4 virulence (Roelfs et al. 1992). Races were named according to North American and ARC-race notations (Long and Kolmer 1989; Pretorius et al. 2007).

#### **RESULTS AND DISCUSSION**

A study identifying eight races of leaf rust in South Africa found that the most frequently found were 3SA170/MFPSJ (55% frequency),3SA115/CBPSG (13%), 3SA146/MCDSK (12%), and 3SA14/CNPSK (11%). The remaining races were found at frequencies varying from 1% to 6%. 3SA115 was found in the Western Cape, KwaZulu-Natal, and Free State, while 3SA14 and 3SA38 were only found in the Western Cape and 3SA127 in KwaZulu-Natal. The study also revealed variability in the composition of the Pt population in SA over seasons and wheat growing regions, which is crucial for effective and sustainable leaf rust control using resistant cultivars.

#### CONCLUSIONS AND RECOMMENDATIONS

The study revealed eight *Pt* races, including a new one, highlighting the ongoing variability of *Pt* in South Africa and the need for regular surveillance.

#### REFERENCES

Long and Kolmer. 1989. A North American system of nomenclature for *Puccinia recondita* f. sp. *tritici.* Phytopathology. 79: 525-529.

Pretorius et al. 2007. Challenges for sustainable cereal rust control in South Africa. Aust J Agric Res. 58: 593-601.

Roelfs, A.P., Singh, R.P. and Saari, E.E., 1992. Rust diseases of wheat: concepts and methods of disease management. Cimmyt.

Terefe et al. 2022. Physiologic races of *Puccinia triticina* detected on wheat in South Africa from 2017 to 2020. Eur J Plant Pathol. 165:1-15.

Keywords: Geographic distribution, Leaf rust, Pathotyping, Puccinia triticinia (Pt), Resistant cultivars, Triticale

# DEVELOPING PROCEDURES FOR IRRIGATION MANAGEMENT OF POTATOES FROM REMOTE SENSING-BASED CROP COEFFICIENTS AND WEATHER DATA

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# INTRODUCTION

Efficient irrigation management is essential for sustainable agriculture, especially in water scarce regions like the Sandveld in the Western Cape. Accurate estimation of crop coefficients (K<sub>c</sub>) and evapotranspiration (ET) is fundamental for optimizing irrigation. Normalised difference vegetation indices (NDVI), leaf area index (LAI) and green canopy cover (GCC) have previously been used in different crop types and were demonstrated to be successful in estimating basal crop coefficients (K<sub>cb</sub>) and ET. However, the potential of using these remote sensing techniques to improve water management in irrigated potatoes (*Solanum tuberosum L*.) has yet to be investigated. The aim of this study was to develop remote sensing-based K<sub>c</sub>'s for potatoes to facilitate irrigation water management.

# MATERIALS AND METHODS

The study was conducted during the 2023 summer growing season. Five trial sites were identified in the Sandveld region and planted with potato cultivars Mondial, FL2108 and Sifra. The study assessed the use of remote sensing techniques, canopy cover and K<sub>cb</sub> in combination with weather data and infield measurements as a viable method to estimate K<sub>c</sub>'s and ET, which were then compared with the FAO-56 approach. Drainage was measured using G3 Drain Gauges and soil water content (SWC) was monitored using capacitance sensors. Rain gauges recorded rainfall and pressure transducers monitored irrigation amounts. Two Eddy-Covariance (ECV) systems were installed to monitor H<sub>2</sub>O and CO<sub>2</sub> fluxes. In-field measurements were taken around four sampling points in each field. The measurements included fractional interception of photosynthetically active radiation (FI<sub>PAR</sub>) using an AccuPAR LP-80 ceptometer and canopy cover (GCC) measurements using the Canopeo® mobile application. Plant sampling was conducted through the growing season and destructive growth analyses were performed. Satellite images at 5-day intervals were derived from the Sentinel-2 satellite.

# **RESULTS AND DISCUSSION**

Substantial rainfall was recorded during the early stages of the growing season for most sites, as the Western Cape Province experienced a very wet winter and spring in 2023. This led to early drainage and variations in water inputs across the different fields, which was also reflected in differences in irrigation amounts applied. Early results suggest that remotely sensed phenology information offers a more dynamic and accurate approach in the real-time development of K<sub>c</sub> values and ET estimation, compared to the FAO-56 approach.

# CONCLUSIONS

Using remote sensing technology, combined with in-field measurements, proved to be a viable and promising method for estimating  $K_{cb}$  and ET values for potatoes in contrast to the more traditional FAO-56 approach.

KEYWORDS: Basal crop coefficients, drainage lysimeter, evapotranspiration, soil water balance, water use efficiency

# ACKNOLEDGEMENTS

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#### INTRODUCTION

Pre-harvest sprouting (PHS) of wheat is of global concern whereby seed in the spike germinates at or prior to harvest. This is due to a lack of genetic dormancy during conducive conditions of rainfall, temperature, and humidity. This results in the synthesis of the hydrolytic enzyme alpha-amylase which, in turn, decreases falling number, thereby reducing grain yields and quality with an associated decrease in grain price. The problem is that no single protocol for PHS exists and there is little research where correlations between the three assessments of visual score, falling number and alpha-amylase assay have been established.

#### MATERIALS AND METHODS

Two sites in the Eastern Cape province, South Africa, were used to establish 40 commercial South African cultivars with three replications. At anthesis 10 spikes per plot were labelled to ensure similar morphological maturity. During harvest the spikes were hand harvested before harvesting the grain. Hand harvested spikes were subjected to simulated conducive conditions for 72-hours and assessed for PHS using a scoring matrix of one to eight where one is no sprouting and eight is fully sprouted. Falling number and alpha-amylase activity were analysed on harvested grain according to the American Association of Cereal Chemistry Approved Method 56-81.04 and 22-02.01 respectively (AACC 2000). Statistical analyses were performed using R (R Core Team 4.1.3), assessing the assumptions of linearity and bivariate normal distribution. The results of these assumptions required the Spearman's non-parametric correlation coefficient to be used to evaluate the correlation between assessments and was plotted using the ggplot2 R package.

#### **RESULTS AND DISCUSSION**

When correlating alpha-amylase and falling number, a non-linear correlation resulted in a visibly negative correlation (P<0.05). In contrast, correlating visual score and falling number as well as visual score and alpha-amylase resulted in no significant relationship (P>0.05). This lack of correlation could potentially be due to the visual assessment and the other two assessments evaluating different phases of the germination. Two additional assessments should be included in the protocol to resolve the lack of correlation whereby falling number and alpha-amylase are performed on harvested seed which further undergo the conditions used for the visual assessment.

#### CONCLUSIONS

Two additional assessments to evaluate PHS susceptibility should be included in the protocol. This may allow for more accurate and consistent identification and quantification of how falling number is influenced as well as the change in alpha-amylase that occurs with the occurrence of PHS.

#### REFERENCES

American Association of Cereal Chemists. 2000. Approved Methods of the AACC, 10th ed. Methods 22-02.01 and 56-81.03. The Association: St. Paul, MN.

R Core Team (2023). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Keywords: alpha-amylase, dormancy, falling number, Triticum aestivum L.

# DRY BEAN GRAIN QUALITY INFLUENCED BY PHOSPHORUS FERTILIZER RATE, CULTIVAR AND ENVIRONMENTAL VARIATION Islam, M. and Sebetha, E.

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#### INTRODUCTION

Dry beans play an important role in food security (Beebe *et al.*, 2000). The problem experienced by dry bean farmers in SA is low soil fertility especially phosphorus rate under sandy soil. Selection of high-quality cultivars under different climatic and environmental conditions is still a challenge. The objective of this study was to determine the effect of cultivar, phosphorus fertilizer rate and location on dry bean grain quality.

#### MATERIALS AND METHODS

The research was carried out during the 2017-18 planting season at three locations in North West province namely, NWU Farm (Molelwane) at Mafikeng, Department of Agriculture experimental station at Taung, and a farmer's field at Ventersdorp. Three dry bean cultivars (PAN 148, PAN 123 and PAN 9292) were planted and five respective rates of phosphorus fertilizer were applied (0, 30, 45, 60 and 75 kg P/ha at Taung, 0, 45, 60, 75 and 90 kg P/ha at Ventersdorp and 0, 110, 114, 118 and 120 kg P/ha at Mafikeng). Variations in phosphorus fertilizer application rates were based on the soil analysis results of the three locations. Dry bean seeds were analyzed for crude fiber, ash, protein, starch and fat content using a NIR (Near Infrared Reflectance Grain) analyzer.

#### **RESULTS AND DISCUSSION**

Cultivar had a significant effect on dry bean crude fibre, ash, fat and starch content. The crude fiber and ash content of PAN 123 was significantly higher than other cultivars. PAN 9292 had a significantly higher fat content as compared to other cultivars. PAN 148 had significantly higher starch content. This observation could be attributed to the variation in the seed coats of the cultivars. Location had a significantly higher ash, fat and protein and fat content of dry bean grains. Dry beans planted in Taung had significantly higher ash, fat and protein content than those planted in other locations. The higher grain quality in Taung could be attributed to favourable environmental conditions, soil type and nutrient availability in the soil.

#### CONCLUSIONS

In this study, Taung responded positively on dry bean grain quality in terms of ash, fat and protein content. The grain quality differed among cultivars. The result of this study indicated higher starch content on cultivar PAN 148. Cultivar PAN 123 produced higher grain ash and crude fibre content. PAN 123 is highly recommended for dry bean producers due to its high grain quality. The phosphorus fertilizer rates in this study did not influence the grain quality of dry bean.

**KEYWORDS:** Cultivar, dry bean, location, phosphorus, quality.

#### ACKNOWLEDGEMENTS

The authors would like to thank Department of Crop Science and Food Security and Niche Areas for financial support.

# INCIDENCE OF MYCOTOXINS IN MAIZE GROWN UNDER CONSERVATION AGRICULTURE PRACTICES ON SMALL-SCALE FARMER FIELDS IN KWAZULU-NATAL

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#### INTRODUCTION

Conservation agriculture (CA) systems conserve and improve soil health by means of maintenance of a permanent soil surface cover (crop stubble), minimum soil disturbance and diversification of plant species. On the other hand, mycotoxin producing pathogens such as *F. verticillioides*, *F. graminearum* and *S. maydis* spores can survive on crop stubble, thereby infecting plants in the following season. The aim of this study was to investigate the effect of CA practices on maize ear rot incidence and mycotoxin contamination of grain from small scale farmers' fields.

#### MATERIALS AND METHODS

A total of 76 individual maize grain samples were collected from 13 small-scale farmers at on-farm experimental plots from KwaZulu-Natal (2019/20 – 2022/23). Samples sizes received were ±1kg due to smaller plot sizes (ranging from 100 - 1000m<sup>2</sup>). Farmers used differing CA practices (monoculture maize served as controls). *F. verticillioides, F. graminearum* and multiple mycotoxins were quantified (qPCR and LC-MS/MS).

#### **RESULTS AND DISCUSSION**

*F. graminearum* and *F. verticillioides* infections were greater in maize grain collected from maize – cowpea intercrop systems (685.70 pg/(20µl) and 99.80 pg/(20µl), respectively) compared to the maize monoculture systems (513. 78 pg/(20µl) and 26.56 pg/(20µl), respectively. Maize grain from the maize – dry bean intercrop system had the lowest *F. graminearum* and *F. verticillioides* infections. Maize grain from the monoculture maize systems had high mean levels of deoxynivalenol (2894 ppb) and diplodiatoxin (1401 ppb). This is expected because maize is the only host to *S. maydis*. Due to the paucity in research regarding the mycotoxins produced by *S. maydis*, there are no regulations for these mycotoxins. Maize grain from the maize - cowpea intercrop systems had slightly higher zearalenone levels (808.45 ppb) when compared to the monoculture maize systems (724.20 ppb).

#### CONCLUSIONS

With this study we wanted to elucidate the effect of conservation cropping systems on ear rot diseases and resultant mycotoxin production in maize grain. Maize grain intercropped with cowpea had unexpected higher levels of *F. graminearum* and *F. verticillioides* ear rot as well as zearalenone when compared with maize grain from monoculture plots from smallholder farmers in KwaZulu-Natal. It is speculated that cowpea and babala produce minimal crop residues and that elevated *F. gram* ear rot infections come from maize residues. Cowpea could be a possible host for this fungus, and this warrants further investigation. Grain from monoculture maize plots had higher levels of fumonsins, deoxynivalenol and diplodiatoxin. This study emphasises the importance of choosing the correct crop to be used in a rotation / intercrop system. Primary inoculum and weather conditions are suspected to play a critical role in the presence or absence of mycotoxins in this study.

**KEYWORDS:** Conservation agriculture, maize ear rots, mycotoxins

#### ACKNOWLEDGEMENTS

Agricultural Research Council-Grain Crops for facilities and Maize Trust for funding.

# IDENTIFICATION OF PLANT GROWTH PROMOTING RHIZOBACTERIA IN COWPEA CROP FROM SEMI-ARID REGION OF NORTH WEST PROVINCE, SOUTH AFRICA

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#### INTRODUCTION

The quest for suitable environment-friendly options to supplement chemical fertilizers remains a challenge, especially to underprivileged farmers. The progress in the development of molecular methods that facilitate the identification of rhizobacteria with respect to key functions enables the development of improved criteria by which molecular information can be tuned to increase plant yield.

#### MATERIALS AND METHODS

Soil samples from the cowpea rhizosphere were collected around Ngaka Modiri Molema and Dr. Ruth Segomotsi Mompati districts, in the North West province, South Africa. A total of twenty-five isolates were isolated from the rhizosphere of cowpea. Five isolates with plant growth-promoting (PGPR) traits were selected for further studies.

#### **RESULTS AND DISCUSSION**

These were positive for phosphate solubilization, produced ammonia while only three tested positive for antifungal activity. Only one isolate MM-II showed no biocontrol properties against fungal pathogens, but however was the only one that tested positive for siderophore production. The organisms were identified using 16S rDNA gene sequencing as *Burkholderia* sp, *Burkholderia cepacia, Serratia marcescenes, Bacterium* sp and *Sinorhizobium melitoti* respectively with 97 to 99 percentage similarities with organisms in the NCBI database.

#### CONCLUSIONS

This study suggests that these isolates are potential biocontrol agents with different degrees of efficacy and contribute to enhance food security without compromising or impacting population health or soil microbiome.

KEYWORDS: Agriculture, biocontrol agents, biotechnology, PGPR, soil microbiome

#### ACKNOWLEDGEMENTS

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### PHYSIOLOGY, GROWTH AND YIELD OF DIFFERENT MULTIPLE-PARENT ADVANCED GENERATION INTER-CROSS (MAGIC) AMARANTH GENOTYPES UNDER VARYING WATER REGIMES

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#### INTRODUCTION

Traditional vegetables are piloted as champion species for sub-Saharan Africa, a region experiencing high nutritional food insecurity and water scarcity. Amaranth is one of the traditional vegetables with excellent potential to commercialise in South Africa. The study's main objective was to assess the effect of different water regimes on six amaranth genotypes that were used to generate a MAGIC population and two reference genotypes.

#### MATERIALS AND METHODS

An experiment was conducted under rain shelters at ARC-VIMP, Roodeplaat Pretoria, Gauteng, during the 2020/2021 and 2021/2022 summer seasons. The experiment was laid out in a 3 x 4 factorial treatment in a completely randomized design with amaranth genotypes (VI060472, VI061494, VI044371, VI062433, VI061487, VI050446, Arusha and Anna) and water levels (20-25%, 60-65%, and 80-85%) of maximum allowable depletion, replicated three times using two rain shelters. Data collected included stomatal conductance, chlorophyll content, crop growth rate, total fresh and dry biomass, fresh and dry edible biomass, fresh and dry stem mass, harvesting index, leaf number, fresh and dry leaf mass in grams per plant and initial and final plant height.

#### **RESULTS AND DISCUSSION**

The study's findings showed a highly significant difference (P<0.0001) and an interaction effect for water levels and genotypes for the selected variables. There was a significant difference (P  $\leq$  0.05) for leaf number. In contrast, there was no significant difference for chlorophyll content and initial plant height. Stomatal conductance ranged from 308.56 to 378.97 mmolm<sup>-2</sup>s<sup>-1</sup>. Total dry biomass ranged from 32.93 to 61.36 t ha<sup>-1</sup>, dry stem mass ranged from 24.43 to 37.97 t ha<sup>-1</sup>, dry leaf per plant from 6.43 g to 18.35 g, and the HI ranged from 0.51 to 0.69 t ha<sup>-1</sup>.

#### CONCLUSION

The higher productivity was observed from the VI061494 genotype. Therefore, this genotype can be recommended to farmers who want to commercialize Amaranth; they will attain higher productivity, assuming that agronomic management is the same.

Keywords: Biomass, Crop productivity, Genotypes, Stomatal, Water regimes,

#### IDENTIFICATION OF QUANTITATIVE TRAIT LOCI (QTLS) REGULATING SEED VIGOUR AND COLEOPTILE LENGTH IN OLD SEED OF TUGELA-DN × ELANDS DOUBLED-HAPLOID (DH) POPULATION OF BREAD WHEAT

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#### INTRODUCTION

Seed vigour and coleoptile length are complex quantitative traits essential for successful and uniform seedling establishment and growth, and the ultimate grain yield in the field under altered environmental conditions (Rebetzke et al., 2007; Reed et al., 2022). Thus, the identification of associated genomic regions and responsible alleles is crucial to enable a speedy selection for these traits, which will enable the development of climate-resilient crops to improve grain yield (Reed et al., 2022; Zeng et al., 2022).

#### MATERIAL AND METHODS

Old seed of a doubled-haploid (DH; n=113) population derived from the Tugela-Dn × Elands cross was examined for seed physiological potential, coleoptile length, and seed longevity using both standard germination and accelerated ageing tests to identify genetic diversity and associated genomic regions. A Quantitative trait loci (QTL) analysis was conducted on Windows QTL Cartographer version 2.5 using a previously constructed genetic map (Khumalo et al., 2022) and the phenotypic scores of genotypes from the four replicates used to measure each trait.

#### **RESULTS AND DISCUSSION**

The Tugela-Dn × Elands DH population demonstrated great variation for seed % germination, coleoptile length, root number and root length. A set (25.66%) of genotypes with high seed physiological potential (% germination scores ≥80.00%, root number ≥3, root length: 11.3-13.3 cm) and longer coleoptiles (4.2-9.4 cm) was identified using the accelerated ageing treatment. In addition, six stable QTLs regulating seed % germination (two), coleoptile length (two) and root number (two) were identified on wheat chromosomes 1A, 4D, 6A, 6B.LG2, and 7B. These loci explained a phenotypic variance (PVE) ranging between 10.00 and 43.54% (LOD=2.50-6.57) under accelerated ageing experiments and 7.75-29.82 (LOD=2.50-8.67) under standard germination experiments. The results of the study prove the suitability of this wheat DH population for dryland production. Longer coleoptiles indicate drought tolerance at seedling stage (Wei et al., 2022), while high seed vigour is necessary to ensure and maintain high yields in the field under the changing climate (Reed et al., 2022).

#### CONCLUSIONS

The climate-resilient germplasm identified here is recommended for further selection in the improvement of grain yield. Moreover, the stable QTLs and respective molecular markers identified will enable speedy and early generation selection of the evaluated traits to improve germplasm, ultimately increasing wheat production. These results illuminate on the genetic basis of seed vigour and coleoptile length in wheat and are valuable to wheat producers and breeders seeking for high seed vigour and longer coleoptiles for their production environments.

**KEYWORDS:** accelerated aging, climate-resilient germplasm, genomic regions, seedling establishment, standard germination

#### EXPLORING THE RISK PROFILE OF SEASONAL FORECAST UPTAKE IN VITICULTURE <u>Miss Zwelihle Fidelity Khumalo</u><sup>1</sup>, Dr Olivier Crespo<sup>1</sup>, Miss Luleka Dlamini<sup>1</sup> <sup>1</sup>University Of Cape Town, Cape Town, South Africa Exploring the Risk Profile of Seasonal Forecast Uptake in Viticulture Fidelity Zwelihle Khumalo, Olivier Crespo and Luleka Dlamini University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa

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#### INTRODUCTION

Running a vineyard is inherently risky, and seasonal forecasts have the potential to reduce farmer's vulnerability to risks by offering advanced climate information. The scarcity of research that explores the nature and type of risks that exist in using seasonal forecasts in agriculture highlights the originality of this study. The aim of this study is to employ a risk management framework to identify and compare the level of risks that exist between the use and non-use of seasonal forecasting in viticulture.

#### MATERIALS AND METHODS

The study's primary data was collected through self-administered semi-structured interviews with viticulturists, agricultural consultants and farm managers at different wineries located throughout the Western Cape Province. The researcher interviewed farmers to learn their adaptation strategies in response to climate variability and their use of seasonal forecasting. The interviews also explored the nature and types of risks that exist in using seasonal forecasting in viticulture, and lastly, a risk framework was employed to compare the risk impact levels between using seasonal forecasts in viticulture and not using them.

#### **RESULTS AND DISCUSSION**

The results will be analysed thematically, and a risk management framework adapted for this study's context will be used as a reference point to achieve the study objectives. The framework categorized below and above-normal climate conditions and assessed how these conditions impact the grapevine at different growth stages. The assessment further determined whether or not the hazard impacts increased or decreased the risks related to grapevine yield and quality upon the use or non-use of seasonal forecasting in viticulture as a sustainability tool.

#### CONCLUSION

The study hopes to enhance the resilience of grape cultivation in the face of climatic variability by providing insights into risk mitigation strategies. The development of the risk framework can be adopted by farmers as an additional decision support tool that may enable them to make better-informed decisions about when and how to use seasonal forecasts in their management practices.

**KEYWORDS:** risks, risk management framework, seasonal forecasting, wine.

ACKNOWLEDGEMENTS: National Research Fund

#### REFERENCES

Naude, M.J. and Naude, R.T., 2022. A proposed risk framework as a tool for sustainability for the South African wine industry. *South African Journal of Economic and Management Sciences*, *25*(1), p.4235.

### METABOLOMIC ANALYSIS AND SYMBIOTIC N FIXATION OF COWPEA (*VIGNA* UNGUICULATA L.) SUBJECTED TO COWPEA-BLACKJACK INTERCROPPING

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#### Introduction

Intercropping has been practised for decades in farming systems to improve soil nutrient status, diversify cropping systems and food security, and address farming land scarcity challenges. Intercropping has been reported to influence plant biomass, biological nitrogen fixation, and secondary metabolites (Ngwene *et al.*, 2017). This study assessed the effects of cowpea-black intercropping on cowpea's biological nitrogen fixation and metabolomic response.

#### **Material and Methods**

The experiment was conducted at the University of Venda experimental farm. The experiment was laid out in a 3 x 2 randomized complete blocked design (RCBD) with three replicates. Treatments included two cropping systems (intercropping and monocropping) and three cowpea genotypes (Dr Saunders, Bechuana white, and Glenda). Irrigation was scheduled when necessary, and there was no fertilizer application. The <sup>15</sup>N natural abundance was used to evaluate the N contribution of the three cowpeas. Samples were oven-dried to constant weight and processed for <sup>15</sup>N stable isotopic analysis and metabolomic data.

#### **Results and Discussion**

A two-way analysis of variance revealed significant differences in plant shoot dry matter yield, however, no remarkable variation was observed for N concentration, N content,  $\delta^{15}$ N, %Ndfa, and the amount of N fixed across the cowpea genotypes and between the two cropping systems. The low amounts of N fixed suggest that blackjack and cowpea intercropping suppressed the N fixation potential of cowpea. This study demonstrated distinct groups per genotype and cropping system through PLS-DA indicating that cowpea metabolome was highly altered by genotypic and cropping system variations.

#### Conclusion

This study successfully assessed the effects of cowpea-black intercropping on symbiotic performance and metabolome of cowpea. The metabolomics analysis suggests that different genotypes and cropping systems significantly influenced cowpea metabolites and accumulation.

Keywords: Blackjack, cowpea N2 fixation, intercropping, metabolites, monocropping

#### CLIMATE CHANGE IMPACTS ON CANOLA GROWTH AND YIELD CHARACTERISTICS: CHALLENGES AND OPPORTUNITIES

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#### INTRODUCTION

The increase in atmospheric greenhouse gasses causes climate change and leads to rising temperatures. This, in turn, altered rainfall amounts and distribution patterns, which will affect canola growth and yield characteristics. A systematic literature review investigated the influence of changing climatic factors on canola growth during its vegetative stage and canola yield development through its reproductive stage.

#### MATERIAL AND METHODS

Twenty-two peer-reviewed journal papers were selected following the screening of 2055 papers according to the effects of climatic factors on canola growth and yield characteristics. All factors were compared to the control within the study and expressed in a percentage.

#### **RESULTS AND DISCUSSION**

During its vegetative growth stage, canola growth responded positively to an increase in CO<sub>2</sub> concentration by improving the carbon assimilation rate by, on average, 40%, which resulted in plants producing 58% more biomass. If temperatures were closer to the optimum (i.e., 20-25 °C), biomass production improved, with colder temperatures (5 °C) having a ,more significant impact on the biomass (34% reduction) than extreme hot conditions (34 °C)(9% reduction). Moderate soil moisture stress caused an average decrease in leaf area of 41%, a 44% reduction in stomatal conductance, and a decrease of 17% in evapotranspiration. Climatic factors mainly affected canola seed yield during its reproductive growth stage. Elevated CO<sub>2</sub> improved the seed yield by, on average, 38%. Daytime temperatures above 28 °C (heat stress) caused canola flower abortion and resulted in a 16% reduction in pollen viability, ultimately leading to an 87% decrease in seed yield. Heat stress also reduced the oil extraction by 50%. Soil moisture stress during the flowering stage resulted in a 43% reduction in seed yield, on average, and an oil extraction reduction of 36%. Soil moisture stress during the seed fill stage had the same effect, but to a lesser extent; a 22% reduction in seed yield and an oil extraction reduction of 27% were observed.

#### CONCLUSIONS

This literature-based study illustrates that i) the effect of rising atmospheric  $CO_2$  concentration has a fertilising effect on canola growth and production; ii) increased heat stress occurrence during the reproductive growth stage has a more significant effect on production than heat stress during the vegetative growth stage; iii) the effect of drought stress during the reproductive stage is detrimental to canola production; iv) elevated atmospheric  $CO_2$  concentration may offset the yield-limiting effects of heat and drought stress during the vegetative growth stages.

Keywords: heat stress, drought stress, CO<sub>2</sub> fertilisation, vegetative, reproductive

#### EFFECT OF INTERCROPPING DRY BEAN WITH INDIGENOUS CROPS ON GROWTH AND CROP PHYSIOLOGY UNDER REGULATED DEFICIT IRRIGATION

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#### INTRODUCTION

Intercropping is considered a significant soil conservation technique aiming at improving crop growth and yield (Ikazaki *et al.*, 2020). However, instability between water demand and water availability is making it difficult to produce viable sustainable crops. The aim of this study was to investigate intercropping of leguminous dry bean with indigenous *Cleome gynandra* and *Cucumis myriocarpus* on the crop's growth and physiological properties, under different water stress levels.

#### MATERIAL AND METHODS

The study was conducted at University of Limpopo Experimental Farm (UL Farm), South Africa. The experiment was achieved as a split split plot design arranged in a randomized complete block design (RCBD) with three (3) replications. Regulated deficit irrigation was set based on 4 growth stages. Three different irrigation levels included; 1 = full irrigation (control); 2 = 75% ETc and; 3 = 50% ETc. Cropping systems included; 1 = mono cropped drybean; 2 = mono cropped *Cucumis myriocarpus*; 3 = monocropped*Cleome gynandra*; <math>4 = intercropped dry bean x*Cucumis myriocarpus*and <math>5 = intercropped dry bean x*Cleome gynandra*. Crop physiological parameters were measured using portable photosynthesis system and SPAD 502 chlorophyll meter. Data was subjected to analyses of variance (ANOVA) using STATA. Turkeys HSD Test was used to calculate mean differences at <math>p = 0.05 to check the level of significance.

#### **RESULTS AND DISCUSSION**

The study observed similar trends of increase on leaf gaseous parameters under control full irrigation, followed by 75% ETc deficit irrigation under both solo planted dry bean and dry bean intercropped with *Cucumis*. Subsequently, irrigation withheld prior to the flowering stage at 75% ETc stage indicated significant increases in photosynthesis rate, whereby dry bean x dry bean intercropped with *Cucumis* was 35.1  $\mu$ mol m<sup>-2</sup> s <sup>-1</sup> dry bean readings, 20.16  $\mu$ mol m<sup>-2</sup> s <sup>-1</sup> *Cucumis* readings which was significantly higher as opposed to irrigation withheld at vegetative and maturity stages. Intercropping dry beans with Cleome plant indicated lower leaf gaseous parameters, chlorophyll content and decreased plant height, especially under both deficit irrigation levels 75% Etc & 50% ETc and a significant variation as opposed to control treatment (full irrigation).

#### CONCLUSIONS

It is evident that regulated deficit irrigation can be adopted for the cultivation and productivity of dry beans and indigenous crops. Restricting water at the flowering stage could be ideal under deficit irrigation of 75% when cultivating dry beans intercropped with *Cucumis gynandra*.

#### REFERENCES

Ikazaki, K., Nagumo, F., Simporé, S., Iseki, K. & Barro, A. 2020. Effects of intercropping component of conservation agriculture on sorghum yield in the Sudan Savanna. *Soil Science and Plant Nutrition*, *66*(5): 755-762

Keywords:, dry bean, intercropping, irrigation, indigenous crops, growth & physiology.

#### QUANTITATIVE TRAIT LOCI MAPPING OF GRAIN IRON AND ZINC IN A DOUBLED HAPLOID BREAD WHEAT LINE POPULATION

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#### INTRODUCTION

Bread wheat consists of various components that are essential for human health and play a significant role in nutritional and food security in developing countries. However, wheat grains are inherently deficient in some micronutrients, including grain iron (GFe) and grain zinc (GZn) concentrations. Mineral malnutrition is considered among the most serious global challenges to humankind. Thus, the objective of the study was to determine genomic regions influencing GFe and GZn using single nucleotide polymorphism genotype-by-sequence (SNP GBS)-based and silicoDArT markers in a double haploid wheat population.

#### MATERIAL AND METHODS

A population of 139 doubled haploid (DH) derived from a cross between cultivars Tugela-DN and Elands were evaluated for GFe and GZn concentrations. The genotypes were planted in one-meter rows with an inter-row spacing of 50 cm, using an augmented design, under rain-fed field conditions at Arlington, Bethlehem, and Harrismith in the 2017/18 and 2018/19 seasons. Seed (7 g) samples were finely milled into flour, and the mineral concentration was determined using inductively coupled plasma-optical emission spectroscopy (ICP-OES). Analyses of variance (ANOVA), Pearson's correlation, and principal component analysis (PCA) were estimated using GenStat 23<sup>rd</sup> edition. A QTL analysis was performed using Windows QTL Cartographer version 2.5.

#### **RESULTS AND DISCUSSION**

A wide range of variation for GFe and GZn was 37.6–96.6 and 35.4–75.2 mg/kg, respectively. Several DH lines had higher mineral values as compared to the parental cultivars. The GFe and GZn correlated positively and significantly with each other ( $r^2 = 0.44$ ), suggesting that these traits can be improved simultaneously. A total of 20 QTLs, with LOD scores ranging from 2.6 to 4.0, were detected, mapping to six different chromosomes (1A, 4B, 4D, 5A, 6B, and 7D), and explaining 10.27–28.95% of the phenotypic variation (PVE). Most of these QTLs were environment-specific, indicating that the variation in the genotypes was highly influenced by environmental factors. One stable QTL for Fe (*QFe.sgi-6B*) on chromosome 6B was consistently expressed in two environments, and the proportion of the PVE by *QFe.sgi-6B* was explained between 13.25% and 19.16%.

#### CONCLUSIONS

From this study, we can conclude that there is a sufficient variation in nutritional quality among the DH genotypes, which can be exploited for wheat biofortification breeding programs. Moreover, both GFe and GZn are quantitative traits exhibiting normal and transgressive segregation in nature. The stable QTL identified in the present study may be utilized in marker-assisted selection for improving GFe and GZn contents in bread wheat. However, more analyses are required to validate the results.

Keywords: Bread wheat, Grain iron (GFe), Grain zinc (GZn), Quantitative Trait Loci (QTL), Genotypic variation.

#### EXPLORATION OF NEW ALLELE SOURCES UTILISING HISTORICAL WHEAT CULTIVARS TO IMPROVE YIELD

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#### INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most widely grown food crop, providing> 20% of the dietary calorie intake worldwide. The demand for wheat production is expected to increase by 60% in 2050 due to the ever-increasing population (Tadesse et al., 2019). Moreover, climate change continues to intensify, and extreme climates affect wheat production negatively. Therefore, it is crucial to continue breeding for higher grain yield to fulfil global food security. The study aimed to determine cultivars with higher yield potential.

#### MATERIAL AND METHODS

A historical bread wheat panel of 280 cultivars was evaluated in Bethlehem during the 2021/22 and 2022/23 growing seasons using a completely randomised design with two replicates. The panel was categorised into three groups based on the year of release [pre-green revolution (1965 or earlier), green revolution (1965-1979), and post-green revolution (1980 or later)]. These are historical cultivars from major breeding companies in South Africa. The cultivars were planted in one-meter rows with an inter-row spacing of 0.45 m. The samples were evaluated for plant height (PH, cm), spike length (SL, cm), spikelet number per spike (SPS), kernel number per spike (KNS), kernel weight per spike (KWS, g), 1000-kernel weight (TKW, g), and a total yield (g). Descriptive statistics, correlation among traits, principal component analysis (PCA), and analysis of variance (ANOVA) were estimated for all the traits using GenStat 23<sup>rd</sup> edition.

#### **RESULTS AND DISCUSSION**

All traits showed approximately normal distributions. The ANOVA revealed significant variation (p < 0.001) between genotypes, environments, and G x E interactions for most agronomic traits, except for KWS, across the years. For example, SL ranged from 4.6 to 16.9 cm, KNS ranged from 22 to 65, and TKW ranged from 2.4 to 5.8 g. For both years, the post-green revolution group outperformed the two other groups for most traits (SPS, KNS, KWS, and TKW) (PCA results). This was possibly due to the introduction of dwarfing genes during the Green Revolution.

#### CONCLUSIONS

The findings of this study during 2021/22 help create new crosses for developing new dryland wheat varieties with high and stable yields. The next step is to conduct a genome-wide association study to determine the marker-trait associations and the genes influencing the traits before analysing genotypes for quality traits.

#### REFERENCES

Tadesse W, Sanchez-Garcia M, Assefa SG, Amri A, Bishaw Z, Ogbonnaya, FC. 2019. Genetic gains in wheat breeding and its role in feeding the world. *Crop Breeding, Genetics and Genomics*, 1, e190005.

Keywords: dryland production, historical cultivars, phenotypic variation, wheat yield

#### EXTENT OF SOIL ACIDITY IN NO-TILLAGE SYSTEMS IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA

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#### INTRODUCTION

Over 80% of farmers in the Western Cape province of South Africa have converted to no-tillage systems in an attempt to improve the efficiency of crop production. Implementation of no-tillage does however inhibit the mixing of soil amendments, such as limestone, into the soil. Therefore, stratification of nutrients and pH is expected between soil layers due to soils in this region being undisturbed for several decades, along with the fact that surface applied limestone moves slowly through the soil profile.

#### MATERIAL AND METHODS

A survey was conducted to determine the extent and geographical spread of soil acidity and pH stratification throughout the crop production regions of the Western Cape Province. Fields were selected based on the following criteria: the field had to be managed under no-tillage for at least eight years, no liming should have been done in the same year as the sampling for the survey and barley, canola or wheat should be part of the crop rotation system of the farmer. Samples were taken at three different depth increments: 0 - 5 cm, 5 - 15 cm and 15 - 30 cm.

#### **RESULTS AND DISCUSSION**

The mean pH<sub>(KCI)</sub> and exchangeable acidity for the entire surveyed area were deemed suitable for wheat, barley and canola production. It was, however, noted that the mean exchangeable acidity was higher and pH<sub>(KCI)</sub> was lower at all three depth increments sampled (0 – 5 cm, 5 – 15 cm and 15 – 30) for soils from the Swartland region compared to those from the southern Cape region. Stratification of Ca, Mg and acidity (pH<sub>(KCI)</sub>, exchangeable acidity and acid saturation) was observed between soil layers, and was more pronounced in the Swartland region. Furthermore, 19.3% of the samples from the Swartland had a soil layer with a pH<sub>(KCI)</sub> ≤ 5.0 and 6.2% ≤ 4.5, which is sub-optimal for the production of wheat (Triticum aestivum), barley (Hordeum vulgare) or canola (Brassica napus).

#### CONCLUSIONS

It is clear from the data that the stratification of soil acidity needs to be addressed. Previous research has found that implementing strategic one-off tillage may be a viable option to address this stratification of soil acidity.

Keywords: canola, limestone, no-tillage, Soil acidity, stratification, wheat.

# THE RISK INVOLVED WITH PLANTING FARM-RETAINED CANOLA SEED (Brassica napus)

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#### Introduction

Hybrid canola cultivars (F1) are created by crossing purebred parent lines, ensuring consistent traits in their offspring. Farm-retained seed (F2) no longer possesses the same combination of genes. This study focused on the feasibility of planting farm retaining canola seed.

#### Material and methods

A field trial was conducted at Langgewens Experimental Farm in the Swartland. Six F1 hybrid canola and their corresponding F2 farm-retained cultivars were planted in a split-plot design with three replications. The F1 seeds were treated with different fungicides by the supplier company, but the F2 seeds were planted untreated. The trial received a blackleg fungicide treatment at the 4-5 leaf stage. Plant counts were made 21 days after germination and immediately after harvest. Various parameters were recorded, including flowering dates, blackleg severity (*Leptosphaeria spp.*), seed yield, and seed oil content.

#### **Results and discussion**

Although seeding density was the same for all treatments, the F1 treatments differed from the F2 by an average of 9.6 plants per m<sup>-1</sup> across cultivars. Four of the cultivars had significantly more seedlings in the F1 treatment. The trial's internal blackleg infection (severity) increased from 11.0% for the F1 to 22.2% in the F2 treatments (20.2%). There were cultivar differences; the cultivar with the most significant difference in blackleg infection varied between 5.6% (F1) and 36.7% (F2). However, one cultivar did not show any increase in infection. The oil content of the retained seed was, on average, 0.8% less than the F1 seed, although not significantly different. The F2 cultivars exhibited a decline in seed yield between 5.5% and 24.1%. On average, there was a 13.9% reduction in the F2 yield. The estimated detrimental impact on gross margins averaged at R2103 ha<sup>-1</sup>.

#### Conclusion

The utilisation of farm-retained seed (F2) resulted in decreased crop yields. The advantages associated with company seed (F1) outweigh the potential cost savings attributed to farm-retained seed, particularly considering the elevated risk of disease pressure in the subsequent growing season when using F2 seed.

Keywords: canola, production, risks, yield

#### SUNFLOWER RESPONSE TO PLANTING DATE AND NITROGEN FERTILIZATION

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#### INTRODUCTION

Previous research has extensively examined the influence of planting date and Nitrogen fertilization on sunflower yield and quality. International studies have demonstrated that optimizing nitrogen fertilizer application can enhance sunflower growth, yield, oil content, and nitrogen use efficiency (NUE), leading to increased seed yield and oil content. Unfortunately, limited research has been conducted in South Africa on this matter. This study aims to address this topic in a scientifically sound manner. Therefore, this study aimed to determine the effect of planting date and N fertilization on sunflower seed yield, oil content, and oil yield.

#### MATERIAL AND METHODS

Five field experiments were established at ARC-Grain Crops Potchefstroom research farm  $(26^{\circ}44'09.95"S - 27^{\circ}04'24.83"E)$  over the last three 2020/21, 2021/22, and 2022/23, growing seasons. With different planting dates, the first planting date planted on (15 December) was considered the optimum planting date, and the second planting date planted on (26 January) was considered late. Five sunflower hybrids, were planted with five different levels of nitrogen fertiliser were applied and consisted of 0 (control), 45 kg ha<sup>-1</sup> nitrogen as a basal application at planting or as a treatment one month prior to planting this was followed with a topdressing before planting applied as (0, 45 or 75 kg ha<sup>-1</sup>). The experimental design used a split-plot in a Randomized Complete Block Design (RCBD) with four replications.

#### **RESULTS AND DISCUSSION**

The results revealed that seed yield, oil content, and oil yield were significantly affected by year, planting date, Nitrogen, and hybrids, as well as by most interactions between these factors. Trials (year and planting date) were the main source of variation for seed yield and oil yield, while hybrids were the main source of variation for seed yield and oil yield, while hybrids were the main source of variation for oil content. Optimal planting dates led to a substantial increase in seed yield (35%) and oil seed yield (30%), with late planting increasing oil content by 3.2%. The highest seed and oil yields were observed with higher nitrogen application levels (120 kg N ha<sup>-1</sup>), regardless of planting date. In contrast, the highest oil content was found with zero nitrogen application.

Agronomic and nitrogen use efficiency was the highest at (45 N kg ha<sup>-1</sup>), applied at planting. PAN 7160 CLP produced the highest seed yield (2.08 t ha<sup>-1</sup>), oil content (41.86%), oil yield (0.89 kg ha<sup>-1</sup>), agronomic efficiency (9.12 kg kg<sup>-1</sup>), and NUE (29.49 kg kg<sup>-1</sup>).

#### CONCLUSIONS

The study highlights the substantial impact of planting date, nitrogen fertilization, and hybrid choice on all studied parameters. The most favourable return on investment was achieved with the application of 45 kg N ha<sup>-1</sup> at planting.

KEYWORDS: Nitrogen fertilizers, oil content, oil yield, sunflower

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#### EFFECTS OF TILLAGE ROTATIONS WITH A RIPPER ON CANOLA PRODUCTIVITY IN THE SWARTLAND

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#### INTRODUCTION

Tillage rotations that involve a regular period of no-tillage followed by a period of tillage with a ripper have not been documented in the Western Cape province of South Africa. This tillage method could be a better alternative to continuous tillage or continuous no-tillage, which could negatively affect crop productivity due to the destruction of soil structure and increased nutrient stratification. The study aimed to evaluate the effect of tillage rotations with a ripper on canola productivity in a dryland cropping system.

#### MATERIAL AND METHODS

The study was conducted at Langgewens Research Farm in the Swartland, a winter rainfall region of the Western Cape. Five continuous tillage treatments; Mouldboard-(MB), Tine-tillage-(TT), Shallow-tillage-(ST), no-tillage-(NT) and zero-tillage-(ZT), and three tillage rotation treatments; tillage with a ripper (R) to a depth of 450 mm in rotation of NT after every two years (NT-R), three years (R-NT-NT) and four years (NT-R-NT-NT) were carried out after the first autumn rain. This is the first year of introducing a ripping treatment in a four-year crop rotation system, wheat-canola-wheat-legume, whereby canola cultivar, Blazer TT, was planted at 3.5 kg<sup>-1</sup> in May 2023. Standard agronomic practices were followed. Plant population and aboveground biomass productivity were measured and calculated following standard procedures. Seed yield quality will be determined after harvesting in November 2023.

#### **RESULTS AND DISCUSSION**

Plant population showed no difference (P>0.05) between tillage treatments. Biomass production at 60 and 90 days after emergence (DAE) was affected (P<0.05) by tillage treatments. In general, all tilled treatments, including tillage rotations, led to a higher (P<0.05) biomass production when compared to the NT and ZT treatments. At 90 DAE, the ripping treatment, R-NT-NT increased biomass production by 31% and 46% compared to the ZT and NT, respectively. Above-ground biomass production did not differ (P<0.05) between MB and ripping treatment.

#### CONCLUSIONS

The preliminary results show that tillage rotation treatments did not significantly improve biomass production relative to continuous tillage practices but were better than ZT and NT treatments. It can therefore be predicted that higher yields are expected in tilled treatments than from ZT and NT treatments.

Keywords: Aboveground biomass, crop productivity, intensive tillage

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#### GROWTH AND YIELD PERFORMANCE OF UMSOBO (SOLANUM NIGRUM L.) TO ORGANIC AND INORGANIC FERTILIZERS

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#### INTRODUCTION

Soil amendments are any inorganic or organic elements that are placed into the soil to improve soil fertility and plant productivity in terms of yield (Zhao *et al.*, 2009). Food demand is rising, and most of the future plant output will depend on soil fertility while minimizing environmental impact. The study aimed to assess the effect of organic and inorganic fertilizers on the agronomic and yield performance of umsobo genotypes.

#### MATERIALS AND METHODS

A two-season experiment was conducted at the North-West University Research Farm (Molelwane) to investigate the effect of organic and inorganic fertilizer on the agronomic and yield of umsobo genotypes (N.Scabrum, N0096, Ncampus, and N4457), laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of two levels of organic manure (Poultry and Cattle manure @ 8-ton ha<sup>-1</sup>) and NPK at 15:8:4 (27) kg ha-1 through inorganic fertilizers; fertilizer application was done at pre-planting through placement application. Pre-soil analysis was done, and fertilizer treatments were applied based on the recommendations prior to soil results. Five-weeks-old, uniform seedlings were transplanted at an open field of 50 cm × 50 cm at a planting depth of 10 cm. The research project was planted under dryland; however, supplementary irrigation was applied during the study period. Agronomic and yield-related traits were collected for the present study.

#### **RESULTS AND DISCUSSION**

The results showed significant differences between treatment, genotype, and treatment by genotype interaction. Maximum values for all studied characters were recorded in the 2019/20 cropping season; the NPK 15:8:4 (27) group, followed by poultry-treated groups. A similar trend was observed in the second cropping season (2020/21); however, the application of poultry manure produced the smallest and largest leaf area, followed by the application of NPK. The application of poultry manure produced the smallest and largest leaf area, followed by NPK. The interaction between fertilizer treatment and genotype was greatest in stem diameter, leaf area, leaf fresh mass, and stem fresh mass per plant with NPK, followed by poultry. All correlation coefficients between attributes were evaluated to analyze the relationship between these features and the yield of the four genotypes after applying NPK and organic manure. There were substantial positive correlations between the analyzed features.

#### CONCLUSION

The study suggests that poultry manure can be used instead of mineral fertilizers to improve marginal soil fertility and nightshade performance.

#### KEYWORDS: Correlation, Genotypes; NPK; Poultry; Yield

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#### COMPARATIVE ASSESSMENT OF GROWTH AND PHENOLOGICAL ATTRIBUTES OF SELECTED IMPROVED COWPEA (*VIGNA UNGUICULATA [L]. WALP*) LINES AND LANDRACE GROWN UNDER FIELD CONDITIONS IN MPUMALANGA PROVINCE

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#### INTRODUCTION

In South Africa, cowpea (Vigna unguiculata [L]. Walp) is one of the important but neglected indigenous crops cultivated for its grains, primarily by smallholder farmers. Cowpea grains contain approximately 23 to 32% protein, thus constituting an important and cheap plant protein source to complement the predominant cereal-based foods in many rural homes. However, its production remains constrained by low yields, which rarely exceed 500 kg ha<sup>-1</sup> due to the unavailability of improved seeds and poor farmers' cultivation practices. Hence, screening available lines to identify good-performing lines for recommendation to farmers is crucial for increasing cowpea production and grain availability.

#### MATERIALS AND METHODS

The study was conducted at the University of Mpumalanga (UMP) experimental farm (S25°25'30.8748"; E30°58'21.4356") during the 2022/2023-summer growing season. The trial comprised five improved cowpea lines (CV17A, CV17B, CV17I, PAN311, and CV18-1A) and a landrace. The trial was a randomised complete block design with four replications. Growth parameters measured during the vegetative growth stage included plant height, number of trifoliate leaves, number of branches, leaf area index, and chlorophyll content. Phenological parameters comprised the days to 50% flowering, pod formation and physiological maturity after seedling emergence. Data collected were subjected to analysis of variance using Statistix version 10.0, and the difference between treatment means was tested using Fisher's Least Significant Difference at a 5% probability level.

#### **RESULTS AND DISCUSSION**

Results revealed significant (p<0.05) differences in all measured growth and phenological attributes among the cowpea lines except for the mean number of branches and chlorophyll content. The CV18-1A line had the tallest plants, while the highest measured chlorophyll content (34 µmol m<sup>-2</sup>) was from the landrace (CV17D). The varietal effect was inconsequential on the measured phenological attributes, possibly due to limited genetic diversity among the evaluated materials. However, the CV17K attained flower initiation faster at 58 days than any other line, while a much longer day to flower initiation (65 days) was recorded with CV18-1A. Moreover, the CV17I line attained physiological maturity at 86 days compared to the landrace, which matured late at nearly 90 days.

#### CONCLUSIONS

We conclude that genetic variation among the evaluated cowpea lines contributed towards the differential growth but had an inconsequential effect on the phenological attributes of the different cowpea lines. Overall, the CV18-1A, CV17I and CV17K lines and landrace had unique attributes that can be explored for future breeding purposes.

KEYWORDS: Cowpea lines, grain legumes, indigenous crops, protein crops, phenology

#### EFFECT OF MAIZE PLANTING DENSITIES ON THE PRODUCTIVITY OF

#### **INTERCROPPED COWPEA VARIETIES**

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#### INTRODUCTION

Intercropping maize and cowpea are among the best cultivation practices to increase the crop yield per unit area. However, the great challenge researchers face is finding an appropriate combination of planting density and intercropping pattern to preserve cowpea production when maize population density is high under intercropping conditions. A field experiment was conducted to evaluate the effect of maize planting densities on the growth and yield of intercropped cowpea varieties.

#### MATERIALS AND METHODS

The study was conducted at the Aquaculture Research Unit Area, University of Limpopo, during 2022/2023 growing season. Maize variety (PAN7469) was intercropped with two cowpea varieties (Brown mix and Dr Saunders) in a 2x2x2 factorial arrangement in a Randomized Complete Block Design (RCBD) with four replications. The experiment consisted of eight treatments from three factors: two cowpea varieties (Brown mix and Dr Saunders), two maize densities (24 700 and 37 000 plants/ha), and two cropping systems which were sole and intercropping.

#### **RESULTS AND DISCUSSION**

The analysis of variance revealed that the interaction of maize density and cowpea varieties significantly influenced all yield and yield components of cowpea except above-ground dry biomass and the number of seeds per pod. Cowpea grain yields had the mean range of 0.8 to 0.32 (t/ha), and the sole crops produced the highest grain yield than intercropped cowpea. On the other hand, maize density planted at 37 000 plant/ha significantly reduced cowpea yield by 60%. Maize-cowpea intercropping had a Land Equivalent Ratio (LER) greater than one, showing high productivity and better utilization of growth factors in intercropping than sole cropping. Brown mix variety recorded the highest LER values of 1.86 at higher maize densities of 37 000 plants/ha. This indicates that intercropping had a yield advantage of 53 % over sole cropping, and suggests that maize density and cowpea variety offered less competition to intercrop productivity.

#### CONCLUSIONS

The current study concludes that the interaction of maize densities and cowpea varieties delayed the mean number of days to 50% flowering and 90% physiological maturity, thus decreasing pod length, pods per plant, hundred seed weight, and grain yield of cowpea. However, the rate of reduction differed with cowpea varieties. Among the two tested varieties, Brown mix is considered as a better-performing variety for both sole and intercropping system due to its ability to escape the competitive effect of maize by maturing early and producing better yield.

KEYWORDS: Cowpea variety, Intercropping, LER, Maize density, Productivity

#### ACKNOWLEDGEMENTS

The University of Limpopo and the Department of Agriculture, Land Reform and Rural Development are acknowledged for provision of resources and funding for this project.

#### THE EFFECT OF CASH CROP ROTATION SYSTEM, ZERO-TILLAGE (DISC PLANTER) AND NO-TILL (TINE PLANTER) ON SELECTED SOIL NUTRIENTS AT TYGERHOEK RESEARCH FARM.

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#### INTRODUCTION

The conventional tillage practices in the Southern Cape region of South Africa led to a decline in some of the soil nutrients. The Southern Cape farmers adopted no-tillage and zero-tillage practices, which became the preferred method for establishing crops. More recently, various crops were introduced into rotations to battle yield loss due to disease and weed pressure. Therefore, the study's aim is to evaluate the effect of no-tillage, zero-tillage and cash crop rotation on phosphorus, potassium and carbon.

#### MATERIALS AND METHODS

The Long-term trial was established in 2007 at Tygerhoek (-34.16238, 19.90739) near Riviersonderend in the Western Cape Province. The experiment consists of a cash crop rotation system - canola/wheat/lupine/wheat (CWLW). The tillage practices were as follows: zero-tillage planted with a disc planter and no-tillage planted with a tine planter. The experiment was arranged in a complete randomized block design with 4 replicates. Soil samples were collected with a 40 mm pipe to the depth of 0-5, 5-10, 10-15, and 15-20 cm.

#### **RESULTS AND DISCUSSIONS**

The mean carbon content was significantly higher (P<0.05) in no-tillage practice as compared to the zero-tillage practice at 0–5 cm depth. However, both tillage practices did not significantly differ on phosphorus, potassium and carbon content following the cash crop rotation system at different soil depth intervals. The higher carbon content in the topsoil may be due to reduced soil disturbance and residue retention. Including a legume in the cash crop rotation systems may have contributed to the soil carbon content.

#### CONCLUSIONS

The long-term trials have clearly shown an overall increase of soil nutrients throughout the 17-year trial period. With no-tillage practice has the largest effect on carbon at shallower soil depth intervals. It proves that a build-up of carbon is possible in the top 10 cm when the tillage is reduced

**KEYWORDS:** Cash-crop, No-tillage, Soil depth, Zero-tillage.

#### ACKNOWLEDGEMENTS

Western Cape Department of Agriculture for funding and supplying land to conduct this research.

#### CROP RESPONSE TO IRRIGATION WITH UNTREATED AND PARTIALLY TREATED MINE WATERS

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#### INTRODUCTION

Acid Mine Drainage (AMD) is produced when sulphide minerals, particularly pyrite, are exposed to water and oxygen and react to form sulphuric acid and ferric hydroxide. These waters are unsuitable for release to the environment without some form of treatment. The most common practice is to neutralize and clarify such waters in High Density Sludge (HDS) plants. Hydrated lime is used to neutralise and remove metals from AMD, resulting in large volumes of gypsiferous waters and sludges. The HDS process is expensive and energy intensive, and the treated mine waters are too saline for release in water courses, therefore, alternative mine water management options are sought. One such proposal is to irrigate with untreated or partially treated mine waters. Irrigating with such waters has the potential to lead to toxic metal contamination, low soil pH, and salinity. This study aims to investigate the response of selected crops and soil to irrigation with untreated and partially treated AMD.

#### MATERIALS AND METHODS

A glasshouse pot trial was established at the University of Pretoria's Innovation Africa campus. Winter crops (wheat, barley, and stooling rye) were planted and grown to maturity. Treatments consisted of a control (tap water), untreated AMD (soil was strategically limed), and neutralised mine waters (unclarified pH 9.5, clarified pH 9.5, and filtered and acidified pH 7.5) from an HDS plant in Mpumalanga. The experiment followed a RCBD and was replicated three times. Data collected included plant height, plant biomass, grain yield, and concentrations of potentially toxic elements in biomass and grain.

#### **RESULTS AND DISCUSSION**

Successful crop establishment was achieved with all irrigation waters and all barley and wheat crops reached the heading stage which suggests that the mine water did not affect reproductive development. Filtered acidified water recorded the highest yield for both wheat (18.3 g/pot) and barley (13.6 g/pot) crops. However, statistical analysis indicated that there were no significant (p < 0.05) differences in crop height, biomass accumulated, and grain yields produced between the different water treatments for all crops. Barley plants irrigated with the very acidic mine waters, however, developed necrotic dark spots and yellowing around the margins 10 weeks after planting.

#### CONCLUSION

These results indicate that untreated and partially treated mine waters from an HDS plant can be used for irrigation if careful management strategies are put in place. The outcomes of this study will assist in unlocking an alternative source of irrigation water, and to reduce mine water treatment costs. A field experiment is recommended to draw more practical conclusions.

Keywords: AMD, HDS plant, clarified, filtered and unclarified.

**ACKNOWLEDGEMENTS**: University of Pretoria, Water Research Commission, MINTEK, Thungela, National Research Foundation.

#### PHOTOSYNTHETIC RATES AND CARBON ASSIMILATION OF COWPEA SUBJECTED TO SEAWEED EXTRACT APPLICATION UNDER SIMULATED DROUGHT STRESS

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#### INTRODUCTION

Cowpea is an indigenous African legume crop with high nutritional value; however, its yield is often low due to drought. Drought affects the pathways triggering photosynthesis by reducing  $CO_2$  uptake and decreasing leaf water content (Zargar *et al.* 2017). Biostimulants such Kelpak seaweed extract are known for their potential to mitigate drought effects by promoting plant growth under adverse conditions. However, there is lack of literature on effects of seaweed extract on cowpea carbon acquisition and photosynthesis under drought conditions. This study determined the effects of seaweed extract on photosynthetic rates and carbon acquisition of cowpea under simulated drought conditions.

#### MATERIALS AND METHODS

The experiment was laid out in a 5 x 3 factorial completely randomised design with four replicates under glasshouse conditions at the University of South Africa, from October to December 2021. The treatments included three drought stress levels following Silva et al. (2019) where 25% pot capacity (PC) was severe stress, 50% PC moderate and 100% PC was well-watered level. The five-seaweed extract (SWE/Kelpak) concentration included control, 5 ml/L, 10 ml/L, 15 ml/L, 20 ml/L as foliar application per plant and Glenda cultivar was used. At flowering, gas exchange measurements (photosynthetic rate, stomatal conductance, transpiration and water-use efficiency) were taken using a portable infra-red gas analyser (LI 6400 XT, version 6.2). Leaves were oven-dried and processed for carbon isotopic analysis.

#### **RESULTS AND DISCUSSION**

Photosynthetic rate was significantly higher on the cowpea treated with 20 ml/L SWE under 100% PC with 32.20  $\mu$ molCO<sub>2</sub>.m<sup>-2</sup>.s<sup>-1</sup> while stomatal functioning was enhanced by 20 ml/L SWE under severe drought. Application of 10 ml/L improved water-use efficiency under severe drought (25% PC). Shoot C content was considerably higher on 20 ml SWE while  $\delta^{13}$ C value remarkably increased on 15 ml/L SWE treated cowpea under 100% PC.

#### CONCLUSION

This study evidently demonstrated that application of seaweed extract like Kelpak can promote cowpea photosynthetic rates and carbon assimilation under drought conditions.

KEYWORDS: Cowpea, seaweed extract, photosynthetic rates, carbon

#### REFERENCES

Silva, E.R., Zoz, J., Oliveira, C.E.S., Zuffo, A.M., Steiner, F., Zoz, T. and Vendruscolo, E.P., 2019. Can co-inoculation of *Bradyrhizobium* and *Azospirillum* alleviate adverse effects of drought stress on soybean (Glycine max L. Merrill.)?. *Archives of Microbiology*, *201*, pp.325-335. Zargar, S.M., Gupta, N., Nazir, M., Mahajan, R., Malik, F.A., Sofi, N.R., Shikari, A.B. and Salgotra,

R.K., 2017. Impact of drought on photosynthesis: Molecular perspective. Plant Gene, 11, pp.154-159.

#### VARIATION, HERITABILITY AND GENETIC GAINS OF LEAF AND VINE YIELDS, LEAF-VINE AND FLORAL TRAITS IN CITRON WATERMELON (*CITRULLUS LANATUS VAR. CITROIDES* [L.H. BAILEY] MANSF. EX GREB.)

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#### INTRODUCTION

Citron watermelon (*Citrullus lanatus* var. *citroides* (L.H. Bailey) Mansf. ex Greb.) is a multi-purpose cucurbit grown for its fresh succulent leaves for use as vegetable for human diets, and vines for animal fodder in sub-Saharan Africa (SSA). Therefore, this study aimed to determine phenotypic variation, heritability and genetic gains for leaf and fodder yields, leaf-and-fodder and flower traits to identify and recommend suitable accessions for vegetable and fodder production and breeding.

#### MATERIALS AND METHODS

Forty-five citron watermelon genotypes were planted under field conditions using a  $9 \times 5$  alattice design with three replications during the 2021/2022 growing season under rain-fed conditions at Towoomba Research Station, Bela-Bela, Limpopo Province, South Africa. Data was collected on leaf, flower and vine traits and subjected to parametric statistical analyses.

#### **RESULTS AND DISCUSSION**

The citron watermelon accessions showed significant (p < 0.05) variation for assessed traits for selection. Moderate broad-sense heritability (H<sup>2</sup>b) and genetic advance as percent of the mean (GAM) of 0.40% and 49.48%, and 0.39% and 50.84% were recorded for leaf yield (LfYld) and vine yield (VnYld), respectively. These indicated these traits were more conditioned by environmental factors than by genes. Using a 9 x 5, LfYld and VnYld exhibited strong and positive correlation (r = 0.97; p < 0.001), allowing simultaneous improvement of both traits. Step-wise regression analysis showed that LfYld explained 88% (R<sup>2</sup>=0.88) of variation in VnYld, whereas VnYld explained 87% (R<sup>2</sup>= 0.88) of variation in LfYld. Path analysis revealed that VnYld had a direct effect (p < 0.001) on LfYld (0.88; rg = 0.94) than LfYld on VnYld (0.57; rg = 0.94, p < 0.001). Therefore, higher direct selection for high VnYld will likely improve genetic gains for LfYld than direct selection for LfYld. Principal component analysis explained 81.25% of total variation for the assessed traits.

#### CONCLUSION

Accessions WWM14, WWM16, WWM26, WWM42, WWM46, WWM47, WWM50, WWM85, WWM87 and WWM89 with high LfYld and VnYld were found ideal for both vegetable and fodder production, and as useful genetic stock for breeding.

**KEYWORDS:** C. lanatus var. citroides, genetic gain, genotypic variance, phenotypic variance, variance components

#### HOST SUITABILITY OF TILLAGE RADISH (*RAPHANUS SATIVA* L.) TO THREE *MELOIDOGYNE* SPECIES

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#### INTRODUCTION

Historically, the management of nematodes has depended on synthetic fumigant chemical nematicides (Mashela *et al.*, 2011). However, due to their negative effect on the environment and non-target organisms, the products were withdrawn from the agrochemical markets. Since their withdrawal, alternative nematode management strategies have become increasingly important (Fourie *et al.*, 2015). Therefore, the objective of this study was to assess host suitability of tillage radish to three *Meloidogyne* species (*M. javanica, M. incognita and M. enterolobii*) under greenhouse conditions.

#### MATERIALS AND METHODS

Under greenhouse conditions, seven treatments of different nematode inoculum levels were arranged in a randomized complete block design with six replicates. Six weeks old tillage radish seedlings were transplanted into 20-centimere diameter plastic pots filled with a mixture of steam-pasteurised river sand, loamy soil and hygromix at ratio of 3:1:1 (v/v). The nematode inoculum required was extracted from susceptible greenhouse-grown tomato cv. 'Floradade'. At 56 days after inoculation plant and nematode data were collected and subjected to analysis of variance using statistix software program version 10.0, mean separation was achieved using Tukey HSD at 5 % probability level.

#### **RESULTS AND DISCUSSION**

Tillage radish is a tolerant host to all three test Meloidogyne species. Reproduction factor (RP = Pf/Pi) values ranged from less than zero to 6.3, 11.9 and 31.0 for M. javanica, M. incognita and M. enterococci, respectively. Although all three test Meloidogyne species managed to reproduce on tillage radish, there was no observed damage on the measured plant variables.

#### CONCLUSIONS

Tillage radish is not suitable for use in crop rotation systems intended to suppress population densities *of Meloidogyne species* since it would result in the build-up of nematode numbers for the successor crops.

#### REFERENCES

- Fourie, H., De Waele, D., McDonald, A.H., Miene, C.M.M. and A. De Beer. 2015. Nematode pests threatening soybean production in South Africa, with reference to *Meloidogyne*: A review. South African Journal of Science 111:1-9.
- Mashela, P.W., De Waele, D. and K.M. Pofu. 2011. Use of indigenous Cucumis technologies as alternative to synthetic nematicides in management of root-knot nematodes in low-input agricultural farming systems: A review. Scientific Research Essay 6:6762-6768.

KEYWORDS: Crop rotation, Meloidogyne species, Reproductive factor, Tillage radish.

#### ACKNOWLEDGEMENTS

The authors are grateful to ARC-VIMP for providing the research materials.

#### EFFECT OF FERTILIZATION ON SWEET POTATO PRODUCED BY SMALL-HOLDER FARMERS IN MPUMALANGA PROVINCE SOUTH AFRICA Malima P. A<sup>1, 2</sup>, P Soundy<sup>1</sup> and Marais D<sup>2</sup>

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#### INTRODUCTION

Sweet potato is cultivated in diverse environments within Sub-Saharan Africa by both commercial and subsistence farmers. Orange-fleshed sweet potatoes are rich in pro-vitamin A. The cultivation and consumption of vitamin A-rich sweet potatoes can thus address vitamin A deficiencies in the diets of people living in rural communities. Proper management and agronomic practices are essential when growing sweet potatoes to improve storage root yield and quality. Thus, the study assesses the agronomic performance of creamy and orange-fleshed sweet potatoes under small-holder Farming conditions.

#### MATERIAL AND METHODS

Field trials were conducted over a period of two growing seasons (2022 and 2023) comparing agronomic practices which are Farmer Practices (no fertilizer) and Recommended Practice (adding fertilizer) amongst small-holder farmers in the Nkomazi District of Mpumalanga. The trials were conducted successfully under dry land conditions on farms in Makoko and Mzinti.Each trial was laid out as a randomized complete block design repeated three times with different sweet potato cultivars (Khumo, Bophelo, Impilo, Monate, Dagga, and Ndou). Two orange-fleshed sweet potatoes cultivars Khumo and Bophelo were used for both areas in addition Impilo(orange-fleshed) and Monate(cream fleshed) were used in Makoko while Dagga(orange-fleshed) and Ndou(cream fleshed) were added in Mzinti.A performance on yield and tuber mass was also compared against sweet potato cultivars in both Famer Practice and Recommended Practice(UP).At the end of the trial, vegetative growth parameters such as root tuber weight, number of tubers, and the above-ground material weight were measured.

#### **RESULTS AND DISCUSSION**

The results indicated that the orange-fleshed cultivars on both Recommended Practice and Farmer Practice had a significantly higher yield than creamy cultivars. The main difference between Farmer Practice and Recommended Practice was the application of fertilizer, adding fertilizer increased the yield for all the cultivars except for Ndou, Impilo, and Monate. Ndou gave poorer yields than Khumo and Bophelo while Dagga gave the best results when comparing the cultivars.

#### CONCLUSIONS

The results indicate that for both areas, Khumo had a significantly higher yield than Bophelo, while Dagga gave the best results when comparing Orange fleshed cultivars.

**KEYWORDS:** Agronomic practices, recommended practice, cultivars, sweet potatoes, yield.

ACKNOWLEDGEMENTS: University of Pretoria and InnoFood Africa for funding.

#### VARIATION IN THE GROWTH AND NODULATION OF CHICKPEA GENOTYPES

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#### INTRODUCTION

Preliminary studies highlight the potential of chickpeas as a winter rotational crop in northeastern South Africa (Thangwana & Ogola, 2012). However, no recommended chickpea cultivars have been identified for the region. Continuous screening is necessary for the identification of genotypes exhibiting superior agronomic performance.

#### MATERIALS AND METHODS

Field experiments were conducted in 2023 at Thohoyandou (22.97556° S and 30.44444° E), Limpopo, and Sikhwahlane (25.7097° S and 31.7195° E), Mpumalanga. Sikhwahlane is the warmer of the two testing sites. Six chickpea genotypes (ACC#7, ACC#8, ICCV07304, ICCV3110, ICCV92944, ICCV97105) were evaluated. Plant height (PH) and number of branches and nodulation were assessed at 50% flowering.

#### **RESULTS AND DISCUSSION**

The growth response of the genotypes varied across sites. At Thohoyandou, ACC#7 and ICCV07304, respectively, exhibited the lowest and highest PH (39 cm & 49 cm) and number of secondary branches (46 & 79). Similarly, ICCV92944 and ICCV07304 had the lowest and highest primary branches, (12 and 21). At Sikhwahlane, in contrast, PH varied from 31 cm (ICCV07304) to 38 cm (ICCV97105). ACC#7 recorded the lowest number of primary (9) and secondary branches (40), while ICCV07304 exhibited the highest number of primary (13) and secondary (50) branches. ACC#7, a heat-tolerant genotype (Makonya et al., 2019), performed consistently across the sites. ICCV07304 is drought and heat-tolerant (ICRISAT, personal communication) and superior at both locations. Significantly, ICCV07304 appeared to allocate more resources to developing branches at the expense of plant height at the warmer Sikhwahlane site. Nodulation was insignificant at both sites.

#### CONCLUSION

ICCV07304 shows huge potential and needs further investigation for yield performance across several sites.

KEYWORDS: Number of branches, Plant height, Temperature regime, Yield stability

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## COMBINING ABILITY AND HERITABILITY OF COWPEA (*VIGNA UNGUICULATA* L. WALP) FOR YIELD AND YIELD COMPONENTS

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#### INTRODUCTION

Cowpea is a nutrient-dense grain and vegetable legume crop, however, its grain yield remains low in South Africa. Hence, it is important to embark on research to develop high-yielding and stable cowpea varieties through parental evaluation, combining ability, progeny evaluation and mid-parent heterosis studies, as well as the gene action involved in the expression of grain yield and yield components.

#### MATERIALS AND METHODS

A total of 55 cowpea genotypes consisting of 10 parents and 45 first-generation progenies were planted in a randomised complete block design with three replications at two different field environments in the 2021 and 2022 cropping seasons. Data were collected for grain yield and yield components. All data were subjected to a half-diallel analysis to determine the combining ability and heritability using AGD-R software.

#### **RESULTS AND DISCUSSION**

The results observed significant general combining ability and specific combining ability effects for all traits measured, which indicated that both additive and non-additive gene action was involved in the expression of the traits. Genotypes TV13953 and IT96D-602 were the best combiners for grain yield, hundred seed weight, number of pods per plant and number of seeds per plant, and these parents could be further used for cowpea improvement. Six crosses (TVU13953 x Glenda, ITOOK-1060 x TVU13953, 98K-5301 x Glenda, 98K-5301 x TVU13953, IT96D-602 x Glenda and IT96D-602 x TVU13953) were superior for grain yield and yield components. The positive and significant mid-parent heterosis for GYP observed suggests the importance of either dominant or partial dominant genes in the expression of grain yield.

#### CONCLUSIONS

The current study revealed that both additive and non-additive gene effects were involved in the inheritance of all traits measured in cowpea genotypes. The selected parents could be used as basic parental breeding materials for future cowpea breeding. The crosses could be evaluated at multiple locations to confirm general and/ or specific adaptations in South Africa.

**KEYWORDS:** combining ability, cowpea progenies, gene action, heterosis

#### ACKNOWLEDGEMENTS

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#### THE EFFECT OF DIFFERENT INDOOR LED LIGHTS ON MORPHOLOGICAL PARAMETERS AND PHYTOCHEMICAL CONTENT OF RED MUSTARD MICROGREENS

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#### INTRODUCTION

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Microgreens have gained popularity due to their low-calorie content, and micronutrient- and antioxidantrich composition. They may be grown indoors using artificial lights such as light-emitting diodes (LEDs). Lighting may generate stressful or non-stressful effects on plants, depending on the species. The optimal selection of lighting during cultivation aims to optimise each species' morphological appearance and phytonutritional value. This study aimed to screen for the best-performing LED light treatment on the overall quality of red mustard (*Brassica juncea*) microgreens at harvest.

#### MATERIALS AND METHODS

The trials were conducted at Tshwane University of Technology (Pretoria), over two growing periods in a temperature-controlled unit. Red mustard microgreens were grown under 7 LEDs for 14 days. Light treatments included Red, Blue, Green, Blue+Red (B+R), Blue+Green (B+G), Green+Red (G+R) and White as control treatment, with a photosynthetic photon flux density of 128  $\mu$ mol/m<sup>2</sup>/s, 235  $\mu$ mol/m<sup>2</sup>/s, 109  $\mu$ mol/m<sup>2</sup>/s, 290  $\mu$ mol/m<sup>2</sup>/s, 239  $\mu$ mol/m<sup>2</sup>/s, 128  $\mu$ mol/m<sup>2</sup>/s and 572  $\mu$ mol/m<sup>2</sup>/s, respectively. A temperature of 18-24°C, RH of 75-80% and photoperiod of 12 h were maintained within the unit during growing periods. Morphological parameters were determined and statistically analysed according to standard procedures. The total phenolic content (TPC), antioxidant power (FRAP) and total carotenoids (TC) were determined and statistically analysed soon after harvest.

#### **RESULTS AND DISCUSSION**

The highest yield was obtained under white and R+B treatments due to R+B lights' ability to expand the hypocotyl and enhance photosynthesis and biomass accumulation. The highest TPC was obtained in microgreens grown under white (7.878 mg/100 g-FW) and R+B (7.263 mg/100 g-FW) light treatments, and this has been attributed to an increase in light intensity/PPFD. Total carotenoids were the highest (1.0789 mg/100 g-FW) under blue light treatment. This may be due to oxidative stress-induced carotenoid production, because carotenoids are fundamental for reducing stress caused by high irradiance. Conversely, microgreens grown under white light (0.922 mg/100 g-FW), had the highest antioxidant capacity than all other light treatments, which may be due to increased sinigrin production.

#### CONCLUSIONS

White, blue and R+B LEDs produced the highest yields and enhanced the accumulation of total phenols, total carotenoids and the antioxidant power of red mustard microgreens.

KEYWORDS: LEDs, microgreens, phytochemical content

#### ACKNOWLEDGEMENTS

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#### PHENOTYPIC DIVERSITY OF THE SOUTH AFRICAN-BRED POTATO VARIETIES FOR TUBER YIELD AND PROCESSING QUALITY

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#### INTRODUCTION

Potato (*Solanum tuberosum* L.) is a nutritious starchy tuber crop and in most countries producing the crop it is consumed as staple food. Its productivity and production are limited by climate change. Thus, it is of utmost importance to tap into the diversity of germplasm resources, hence diversifying potato varieties. The objectives of this study were to determine the phenotypic diversity among the selected potato varieties housed at the Agricultural Research Council (ARC)-Vegetable, Industrial and Medicinal Plants for tuber yield variables and processing quality and to determine the correlation between measured traits.

#### MATERIALS AND METHODS

Two imported and 22 local potato varieties were planted at Cedara in March 2017 and at Roodeplaat in August 2017 and March 2018 in a randomized complete block design with three replicates. Each trial was treated as single environment. The Data were collected for tuber yield and cooking and frying quality. Variance and clustered heat map were analysed using GenStat and XLSTAT, respectively.

#### **RESULTS AND DISCUSSION**

Significant (*P*<0.001) differences were in the tested varieties across all environments for all measured traits. The broad-sense heritability (*H*<sup>2</sup>) estimates were high (>0.6) for most of the traits except for fry colour and unmarketable yield tubers. The high *H*<sup>2</sup> estimates indicated high selection efficiency in these traits. There were significant and positive correlations among the tuber yield variables. Significant positive correlations between specific gravity (SG), cook colour, dry matter (DM), DM yield and fry colour indicated that these traits could be improved and selected simultaneously. Significant and positive correlations between DM, DM yield, and fry colour with medium tubers indicated potential for simultaneous selection and improvement of these traits. ARC varieties ERYN, DARIUS, ESCO, FREEK, ROPEDI, AVIVA, PT1302, FABIEN, ARNO and FRODO, as well as PENTLAND DELL, BP1 and UP-TO-Date, were associated with high tuber yield and quality traits indicating their suitability for the fresh market and processing industry. Varieties MONDIAL and ARC varieties VANDERPLANK, BUFFELSPOORT, SANDVELDER, CAREN, PT1301 and RONN were associated with high tuber yield, indicating their suitability for the fresh market. Varieties released between 2004 and 2021 had high tuber yield, DM and SG compared to the checks and varieties released between 1980 and 1999. However, there were slight differences in the magnitudes of traits measured.

#### CONCLUSIONS

The superior potato varieties could be recommended for commercial production for specific markets and use as potential parents for further genetic improvement of the potato crop.

KEYWORDS: Phenotypic diversity, potato varieties, processing quality, tuber yield

#### EVALUATING THE EFFECTIVENESS OF LEGUME COVER CROPS IN WEED CONTROL AND NUTRIENT CYCLING IN APPLE ORCHARDS Mento J.E., Tshuma F., and Swanepoel P.A

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#### INTRODUCTION

In South Africa, most studies on orchard cover crops have focused on evaluating cover crops grown in the working rows but not within the growing ridges. The growing region is often left without the potential benefits of the cover crops. This study aimed to understand how legume cover crops impact weed suppression and soil nutrient contents in newly established, shallow-rooted apple orchards. It was hypothesized that a diverse legume cover crop mixture would enhance nutrient availability and weed control compared to less diverse treatments.

#### MATERIALS AND METHODS

The study was conducted in 2023 at Glenfruin farm (34°11 S, 19°3 E) in Grabouw, which has a typical Mediterranean-type climate. The study was laid out as a randomized complete block design with four replications. Eight treatments; annual medics (*Medicago polymorpha*) (TR1), white clover (*Trifolium repens*) (TR2), strawberry clover (*Trifolium fragiferum*) (TR3), medics-white clover mixture (TR4), medics-strawberry clover mixture (TR5), medics with both clovers (TR6), mulch (TR7), and an untreated control (TRC), were investigated. An auger was used to collect bulk soil samples from each plot to a depth of 20 cm before planting (April) and at the end of the trial in October. All plots were hand-sown on the growing ridges. Biomass samples were collected per treatment using a reference frame tool (m²), involving counting, species identification, weighing, and drying at 60°C in an industrial oven for 72 hours.

#### **RESULTS AND DISCUSSION**

The annual medics (TR1) and medics-white clover (TR4) treatments exhibited the strongest competition against weeds (P<0.05). The treatment TR1 comprised 87% cover crops and 12% weeds, and TR4 had 75% cover crops and 15% weeds per square meter, respectively. Conversely, TR2, TR3, TR7, and TRC were less effective at weed suppression, as they had little (<3% cover crops per m<sup>2</sup>) or no cover crops, and higher weed proportions (>90% weeds per m<sup>2</sup>). The treatments, TR5 and TR6, demonstrated varying degrees of weed competition, (63% cover crops and 37% weeds) and (49% cover crops and 51% weeds), respectively. The annual medics were generally more effective as cover crops relative to the clovers because the clovers completely failed to establish in all treatments. The clovers struggled to establish themselves due to aggressive weed competition during their germination phase.

#### CONCLUSION

The diverse cover crop mixture (TR6) failed to effectively suppress weeds relative to the TR1 which only comprised of medics. The clovers failed to establish and were suppressed by weeds.

KEYWORDS: Cover crops, soil health, weed suppression.

#### ACKNOWLEDGEMENTS

We thank Barenbrug for supplying the cover crop seeds, Glen Fruin farm for providing the trial site and crop management, and the Department of Agronomy, Stellenbosch University for funding the technical assistants and sample analysis.

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#### INTRODUCTION

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Soybean (Glycine max. L Merri) is an economically important annual leguminous crop widely cultivated for its edible seeds (Sharma et al., 2014). Although soybeans are grown worldwide, individual cultivars demonstrate a limited adaptation to specific geographical areas. Here we present a soybean trial that was conducted in Mthatha locality as part of the National Cultivar Evaluation Program by the Agricultural Research Council (ARC). The main aim was to compare the agronomic performance of different soybean cultivars.

#### MÁTERIALS AND METHODS

The trial was conducted at Dimanda Senior Secondary School (31°C 33" 12.95" S and 28°C 54' 28.69" E) in O.R Tambo district. The trial was planted in a randomized latin square row-column design with three replications. Thirty-two commercially available soybean cultivars from five different seed companies were included. An inorganic fertilizer was applied at a rate of 60 kg P and 170 kg K per ha in all plots. Pesticides were used when pest and pant diseases were observed. Growth and yield parameters were collected and subjected to analysis of variance (ANOVA) using Genstat fourteenth edition.

#### **RESULTS AND DISCUSSION**

Soybean cultivars varied in terms of plant emergence, plant height and time to maturity. The latest cultivars to reach 50% flowering were DM 59I60RSF IPRO, LS 6851R, NS 5258R and RA 5722BR. Medium maturity cultivars (DM 5351RSF and LG 60260IPR) had the highest yields of 4.9 and 4.5 tons per ha respectively. High yields can be attributed to an increase in 100 seed weight supported by extended seed filling duration.

#### CONCLUSION

Cultivar growth habits and maturity groups are important considerations in selecting a cultivar. Cultivar DM 5351RSF (medium-maturity cultivar), LG 60260IPR (medium maturity cultivar) and PAN 1502R (late-maturity cultivar) gave higher average yields compared to other soybean cultivars and are recommended for cultivation under semi-arid conditions of O.R Tambo district.

#### REFERENCE

Sharma S, Kaur M, Goyal R, Gill B. 2014. Physical characteristics and nutritional composition of some new soybean (Glycine max (L.) Merrill) genotypes. *Journal of food science and technology* 51(3): 551-557.

**KEY WORDS:** Soybean cultivar, grain yield **ACKNOWLEDGEMENTS** Grateful to ARC, DRDAR, Agricultural Assistant Practitioners and farmers

#### APPLICATION OF HEAT UNITS FOR SUSTAINABLE MANAGEMENT OF MAIZE CROP PRODUCTION IN THE FREE STATE PROVINCE, SOUTH AFRICA

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#### INTRODUCTION

Environmental conditions during the growing period have a significant impact on growth and development of a crop. In the Free State province of South Africa, low temperature is one of the major climate hazards that affects maize production, resulting in crop failure in some agricultural seasons.

In this study, the thermal index (heat unit) concept is used to determine the length of the growing period of short season (1340 GDD), medium season (1420 GDD) and medium-late season (1470 GDD) maize crop varieties for different sowing dates.

#### MATERIALS AND METHODS

The study utilized over 60 years of daily temperature data from 1960 to 2022. Accumulated heat units were calculated for the agricultural season and averaged over the number of years [1960 - 2022].

The number of days it takes for different maize varieties (short, medium and medium-late) to reach maturity was determined for different planting periods at selected sites in the Free State.

The Mann-Kendall statistic was used to determine trends for the following:

- Accumulated seasonal heat units.
- Number of days it takes to reach maturity for short, medium and medium-late maize cultivars at different planting dates and stations.

#### **RESULTS AND DISCUSSION**

On average, short cultivars take between 140 and 155 days to mature. Medium and medium-late cultivars mature in 145-160 and 155-175 days respectively. The variation in the number of days to maturity is also dependent on the date of planting, with planting in October and late November to December resulting in extended periods. The planting period increases exponentially in most places starting from the 2<sup>nd</sup> dekad of November to the 2<sup>nd</sup> dekad of December, depending on the elevation of an area and crop variety.

There is considerable spatial variability of seasonal heat units in the Free State province with the eastern and northeastern parts having low accumulated heat units as compared with the western and central parts. Thus planting period for maize is shorter for the eastern parts of the province as compared with the western parts. The trends in heat units are not significant for the selected stations but show a bias towards increased heat units accumulation with time.

Extended growing periods especially in December onwards would most likely align the maize growing period to coincide with dates of high frost risk and water shortages, especially over the high-lying areas. Thus appropriate choice of sowing date taking into consideration the thermal time requirements of the cultivar is crucial for proper growth and development of a maize crop.

#### CONCLUSIONS

In most parts of the eastern Free State, planting of medium-late and late season cultivars is highly unsuitable due to short planting window. The results also showed increasing and decreasing trends on accumulated heat units and growing period to achieve maturity at selected sites indicating increasing heat during the growing period. The results of the study are important for agricultural advisors to ensure that their recommended maize crop cultivars are closely aligned to the climatic conditions of the areas and planting period.

Keywords: climate variability and change; Temperature sums, Man Kendall test, Trends.

#### IN-FIELD ASSESSMENT OF SOIL WATER DYNAMICS OF IRRIGATED POTATO GROWN ON SANDY SOILS

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#### INTRODUCTION

Potato (*Solanum tuberosum* L.) is highly sensitive to water stress; therefore, irrigation is required to supplement low and unreliable rainfall in semi-arid regions. However, the management of irrigation for potato production in sandy soils with a low water-holding capacity can be challenging because of the risk of drainage and nutrient leaching associated with such soils. Consequently, monitoring soil water content and deep drainage are critical for improving irrigation efficiency and maximizing water use efficiency. The primary objectives of this study were to (i) assess the seasonal variations in the soil water content of irrigated commercial potato fields and (ii) determine the relationship between soil water dynamics and tuber yield.

#### MATERIALS AND METHODS

This study was conducted on 11 commercial centre-pivot irrigated potato fields in the North West (NW), Sandveld (SV), and Western Free State (WFS). Daily weather, irrigation and rainfall, soil water content, deep drainage, crop management, and yield were recorded. The soil water content in each field was continuously monitored at depths of 10, 20, 30, 40, and 50 cm using Decagon capacitance probes (10-HS ECH2O; Decagon Devices Inc., Pullman, WA, USA). Drainage beyond a depth of 1 m was monitored using a passive drainage gauge lysimeter (DG G3, Decagon Devices). Soil hydraulic properties were estimated using the SPAW hydrological model. Soil water balance, soil water deficit, and available water percentage (AW%) were calculated. The observed soil water dynamics were compared with Soil Water Balance (SWB) model simulations.

#### **RESULTS AND DISCUSSION**

The mean water storage in the top 50 cm of soil between emergence and harvest ranged from 69 mm to 122 mm for NW, 43 mm to 70 mm for SV, and 64 mm to 100 mm for WFS fields. The AW% ranged from 53 to 90% for NW, 52 to 80% for SV, and 41 to 80% for WFS. This implies that some fields in all the regions experienced moderate water stress during the season. This was evidenced by a large positive soil water deficit (20 - 85 mm) from full canopy cover until crop harvest. Negative soil water deficits observed between emergence and full canopy cover coincided with the occurrence of drainage. The measured drainage ranged from 7 to 488 mm, with a mean of 96 mm. There was no correlation between soil water storage and tuber yield, possibly because of variations in irrigation management and soil water storage characteristics for the different fields.

#### CONCLUSIONS

Information about the soil water content dynamics of irrigated potato fields in sandy soils can be used to determine the occurrence of water stress, soil water deficits, and drainage events during the season. This is important for improving irrigation water use efficiency and minimizing drainage from irrigated potato fields, particularly during the early stages of the crop.

KEYWORDS: drainage, irrigation management, soil water content, soil water deficit, water stress

#### ACKNOLEDGEMENTS

Potatoes South Africa for research funding and the potato growers for allowing us to work on their farms.

## REGENERATIVE AGRICULTURE VS CONSERVATION AGRICULTURE: EFFECTS ON SOIL QUALITY AND CROP PRODUCTIVITY

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#### INTRODUCTION

Small-grain farming systems in Mediterranean climatic regions are characterised by poor-quality soils, high climate variability, and resulting agrochemical reliance. The adoption of Conservation Agriculture (CA) has improved soil quality, enhanced crop productivity, as well as help mitigate financial risk. However, emerging sustainability issues such as herbicide resistance, input costs rising disproportionately to product prices, and increasing climate variability drive the need for ongoing innovation. The use of selected agroecological practices, constituting a Regenerative Agriculture (RA) concept, were tested, and evaluated for their potential to address these challenges from a soil quality and crop productivity perspective.

#### MATERIAL AND METHODS

The experiment was conducted on Tygerhoek Research Farm (34°09'34" S, 19°54'53 E) over two growing seasons. The experiment was laid out in a split-plot design with two factors. The whole plot factor (system) had two levels: RA and CA. The subplot factor (crop type) consisted of four levels: canola, wheat, barley, and cover crop (grazed multi-species cover for RA and ungrazed peas for CA). Each treatment-combination was replicated thrice. The CA treatments received current best practice synthetic inputs, whereas the RA cash crops were subjected to biological inputs. Soil chemical and biological parameters for the respective systems were measured after the 2022 growing season. Crop productivity data (crop establishment, biomass, leaf area index, and yield parameters) from the respective systems was measured in both seasons. Analysis was done through a mixed model ANOVA in R (Imer package) in Statistica and Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means.

#### **RESULTS AND DISCUSSION**

The RA system had no effect on soil chemical properties, except for available phosphate, which was higher under the RA cereals ( $p \le 0.05$ ). Soil microbiological properties did not significantly differ between systems. However, there were often trends ( $0.05 ) of higher microbial activity and diversity under the RA system, particularly for cover crops and wheat. There was an improvement in crop productivity under RA from 2022 to 2023 (<math>p \le 0.05$ ), suggesting the preceding grazed cover crop may have provided additional fertility to the RA cash crops in the second year. The organic nature of the pelletised chicken manure fertiliser and the resulting slow mineralisation of nutrients may account for the incidences of lower crop productivity under RA relative to CA, particularly for barley and canola.

#### CONCLUSIONS

Although long-term testing is required, RA practices show promise for improving soil phosphate availability, enhancing soil microbial health, and sustaining crop productivity with fewer synthetic inputs.

**KEYWORDS:** Agroecological intensification, biodiversity, bio-stimulants, management-intensive grazing, multi-species pastures, organic inputs.

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#### DETERMINANTS OF THE ACCURACY OF USING CARBON ISOTOPES IN ESTIMATING WATER USE EFFICIENCY OF SELECTED CEREAL AND LEGUME CROPS: A GLOBAL PERSPECTIVE

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#### INTRODUCTION

Field assessments of crop water use efficiency (WUE) are resource-consuming since they require simultaneous assessment of the total amount of water consumed by crops for biomass and/or to grain production. Alternative methods exist, such as estimating the carbon isotopic ratio (<sup>13</sup>C/<sup>12</sup>C) of the crop's leaf, shoot biomass, or grain samples. There is limited information on the determinants of the accuracy of carbon isotopes in estimating water use efficiency between crop types and environments.

#### MATERIAL AND METHODS

This study aimed to evaluate the extent to which the estimation of the <sup>13</sup>C/<sup>12</sup>C ratio in cereal and legume crop parts constitutes an accurate proxy of WUE, globally. Data on observed WUE (WUE<sub>obs</sub>) was collected from 518 experiments conducted worldwide on major cereals and legumes and compared with WUE estimates (WUE<sub>est</sub>) from carbon isotopes.

#### **RESULTS AND DISCUSSION**

The mean WUE<sub>obs</sub> amongst all cereals and legumes experiments was 3.4 gl<sup>-1</sup> and the mean absolute error (MAE) was 0.5 gl<sup>-1</sup> or 14.7% of WUE<sub>obs</sub>, corresponding to accurate predictions at p < 0.05. However, the percentage mean absolute error of observed water use efficiency (%MAE) estimated from the grain was 11.5%, which was lower than the %MAE from shoot biomass collected at harvest (22.8%). In addition, the %MAE increased from 5.1% for soybean to 16.2% for bush bean legumes, whilst on cereals, the %MAE increases from 7.2% for maize to 39.3% for oat. The (WUE<sub>est</sub>) were, in all cases, unbiased but slightly overestimated by 0.8% (maize) to 15.4% (oat). The accuracy in estimating WUE significantly decreased with the increase in soil clay content, with sand showing a positive correlation of 0.3 with %MAE, but negatively correlated with the silt content (r = - 0.4). Furthermore, a multivariate analysis pointed out a tendency for prediction errors and bias to increase with the decrease in WUE<sub>obs</sub> and air temperature.

#### CONCLUSIONS

The carbon isotope technique tended to perform better under high WUE conditions, such as those generally found in maize and soybean cropping systems. Air temperature and soil clay content appeared to have an impact on the accuracy of WUE estimations.

**KEYWORDS**: carbon isotopic ratio, estimated water use efficiency, mean absolute error, observed water use efficiency

#### ACKNOWLEDGEMENTS

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### BIOCHEMICAL RESPONSE OF UPLAND RICE CULTIVARS TO DROUGHT ON POOR SOIL AUGMENTED WITH COMPOST, *GLOMUS MOSSAE* AND NPK 15-15-15 FERTILIZER

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#### Introduction

About 900 million of the world's poor rely on rice as consumers or producers. There is a remarkable disequilibrium between the demand and supply of rice caused by diverse biotic and abiotic variables. Unpredictable rainfall (pattern and volume) is one of the major factors. Soil augmentation with materials like compost and arbuscular mycorrhizal fungi could promote better growth under drought conditions. Understanding the physiological responses of upland rice cultivars (URC) to drought stress is important to selecting drought-tolerant cultivars with stable performance. Therefore, the biochemical response of four URC to drought on poor soil amended with compost, NPK and *Glomus mossae* at panicle initiation was investigated.

#### **Materials and Methods**

The study was a 4x4x2 factorial, arranged in a randomized complete block design replicated three times. The research was conducted during the dry seasons of 2019 and 2020 at the Teaching and Research Farm, University of Ibadan, Nigeria. Treatments included four URC: Ofada, FARO-44, IR-64 and NERICA-7, which were predisposed to water stress at the Panicle Initiation (PI) stage, and Well-Watered Field (WWF) served as the control. Four-week-old rice seedlings were transplanted to the prepared field amended with 10 g *Glomus mossae* and 200 kg N/ha each, of compost and NPK 15-15-15, while the unamended soil was the control. Physiological data assessed were relative water content (RWC), total chlorophyll, carotenoid and porphyrins, proline and glycine betaine using standard laboratory procedures.

#### **Results and Discussion**

Chlorophyll content on field amended with compost under drought condition was significantly higher than the unamended field. This implies that drought reduced chlorophyll content drastically. Carotenoid content increased greatly in water-stressed URC on the unamended field. The highest carotenoid content was under water deficit conditions on the field fertilized with NPK 15-15-15, while the lowest was recorded in water-stressed comost-amended. It appeared higher carotenoid was synthesized to enhance tolerance of upland rice to drought. Treatment with water-stress and fertilized with NPK 15-15-15 recorded the highest porphyrin content, while irrigated and fertilized with NPK 15-15-15 the lowest. Application of inorganic fertilizer under drought had deleterious effect on antioxidants. Water-stressed on unamended plots had significantly higher in the field amended with AMF than the concentration recorded in water-stressed and fertilized with NPK. Osmolytes increased considerably under drought without soil amendment. Higher relative water content was recorded in the irrigated plot amended with compost, while lowest relative water content was recorded in water-stressed unamended plots.

#### Conclusions

Drought stress caused a significant reduction in physiological parameters of upland rice such as: chlorophyll and RWC. It increased proline, porphyrin and carotenoid content compared to the unstressed plants. Photosynthetic pigment and relative water content of water-stressed upland rice grown on compost amended plots improved considerably than on unamended field. Soil augmented with *Glomus mossae* caused a reduction in osmolyte concentration augmented with other amendments. NERICA-7 and Ofada tolerated drought better than FARO-44 and IR-64 cultivars on compost augmented field.

Keywords: Relative water content, Chlorophyll, Proline and Osmolytes

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#### MORPHOLOGICAL CHARACTERISTICS, FE CONTENT AND STARCH PROPERTIES IN STORAGE ROOTS OF FIVE PURPLE-FLESHED SWEET POTATO GENOTYPES

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#### INTRODUCTION

Sweet potatoes (*Ipomoea batatas* (L.) LAM) from the *Convolvulaceae* family play a crucial role in ensuring food security and providing nutrition. This root crop is widely cultivated in over 100 developing countries and is considered one of the top five important food crops in more than 50 of those countries. The Purple sweet potato was identified as a promising source of resistant starch. The main objective of this study was to investigate the morphological characteristics, Fe content and starch properties of roots of five purple-fleshed sweet potato genotypes.

#### MATERIALS AND METHODS

Samples of one locally sourced variety (Purple-Purple), two ARC breeding lines (2019-11-2 and 2019-1-1) and two imports from the USA (08-21P and 16-283P) were acquired from Agricultural Research Council, Roodeplaat north-east of Pretoria (25.6080°S, 28.3525°E). Morphological characteristics of the storage roots were recorded, and Fe content was determined using an aliquot of the digest solution and inductively coupled plasma optical emission spectrophotometer (ICP- OES) [Agilent 725 Series Santa Clara, California, USA] device. Total starch, resistant starch and non-resistant starch were determined according to the Neogen Megazyme assay kit (AOAC method 2002.02) and expressed as g/100g on a fresh weight basis.

#### **RESULTS AND DISCUSSION**

The most prevalent shape in samples was long elliptic, while the flesh colour ranged from fully dark purple to combinations of violet, cream and orange in colour. The surface defects ranged from absent to long thick veins, severe cracks and grooves of alligator skin. The Fe content varied among genotypes,  $2019-1-1(2.77\pm0.06 \text{ mg } 100g)$  and 16-283P ( $2.60\pm0.13 \text{ mg}/100g$ ) obtained the highest Fe content followed by Purple, 08-21P and 2019-11-2. 16-283P obtained the lowest non-resistant starch ( $2.70\pm0.15 \text{ g}/100g$  FW). Among all genotypes, Purple-Purple obtained the highest resistant starch ( $0.39\pm0.05 \text{ g}/100 \text{ g FW}$ ). Purple-Purple had the highest macronutrients (N, P, Ca and Mg), except for potassium. There was no statistically significant difference between the copper and boron contents of the five purple-fleshed genotypes.

#### CONCLUSION

Iron is one of the essential heavy metals for human nutrition, and it is a vital element for human life. The average daily Fe intake from foods is 15.1 mg/day in children, 18 mg/day in women and 8mg/day in men. The highest Fe was obtained from 16-283P, (2.77 mg/100g) therefore, 2.88g will be needed to meet the men Fe RDA, 5.45g for children and 6.49g for women. Non-resistant starch is simply starch that is digestible; the highest non-resistant starch was obtained from 08-21P and Purple-Purple.

**KEYWORDS:** breeding, genotypes, nutrients, resistant starch, root crops.

#### ACKNOWLEDGEMENTS

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#### THE IMPACT AND PERCEPTION OF MAIZE SMALLHOLDER AND SEMI-COMMERCIAL FARMERS ON CLIMATE CHANGE IN SEMI-ARID AREAS OF NORTH WEST, SOUTH AFRICA

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#### INTRODUCTION

South Africa is vulnerable to the impact of climate change due to the semi-arid nature of the country. However, the perception of the farmers on climate change is very important to adopt adaptation measures for climate change. Dr RSM District of North West Province suffers from drought yearly during the winter months as the area experiences low erratic or no rainfall during the summer seasons. This study was conducted to evaluate the perception of small holder farmers on climate change and climate variability in Dr RSM District of South Africa.

#### MATERIALS AND METHODS

The study was conducted during the 2022/2023 season in Tlakgameng and Morokweng villages. A structured questionnaire was developed for the farmers around the district to evaluate their perception about climate change and climate variability. The questionnaire was an open-ended and closed-ended for household interviews. Research findings were verified by using scales such as nominal and ordinal scales. Some of the questionnaires require a yes or no response, thus coding in numbers were used. Frequency distributions were applied to indicate the most and least frequently occurring scores and whether any scores are isolated from others. Variables used in the study were categorised, also frequency per variable were used and indicated as well by the percentage (%).

#### **RESULTS AND DISCUSSION**

Most of the farmers interviewed engaged in mixed farming (70%) while the rest are small holder farmers (30%). The farmers in these areas are mostly educated male black farmers with 80% of them unemployed. These farmers cultivate maize as their main crop on relatively large plot of land (10 - 50ha). The farmers in these areas have heard about climate change before and believe in the existence of climate change and climate variability. Their perception of climate change is the incidence of drought (60%) and heat waves (25%). They believe excessive rainfall is also part of climate change events. During the event of drought, they reduced their cropping land and were able to change their planting dates to accommodate the event.

#### CONCLUSIONS

The targeted area perceived climate change and variability as drought, heat waves and excessive rainfall. Regardless of the devastating drought situation, farmers have to manage and cope with drought consequences with very limited resources at their disposal. However, the farmers in these areas can be educated in adaptation measure for climate change and climate variability.

KEYWORDS: adaptation measures, climate change, drought, perception

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#### RESPONSE OF SORGHUM GENOTYPES FOR AGRONOMIC TRAITS AND ATMOSPHERIC CARBON SEQUESTRATION

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#### INTRODUCTION

Sorghum is a vital food and feed crop in the world's dry regions. It has high biomass production and can be critical in atmospheric carbon (C) sequestration and building soil organic matter. There is limited knowledge on how different sorghum genotypes respond with agronomic traits, balanced biomass allocation, and C sequestration. The objective of this study was to assess agronomic performances, plant biomass and carbon accumulation in selected sorghum genotypes.

#### MATERIALS AND METHODS

Fifty sorghum genotypes were planted at the ARC Agricultural Engineering facility in Pretoria, South Africa (Lat 25° 44' S and Long 28° 14' E). The trial was laid out in a lattice design with three replications. Carbon analysis involved collecting shoot samples to determine shoot carbon content, root samples for root carbon content, and grain samples for grain carbon content. These samples were oven-dried at 70°C for 48 hours and transformed into fine powder, with each sample weighing 5 grams. The total carbon content of the plant, root, shoot, and grain samples was determined by combustion using a LECO TruMac CNS Analyzer. The following data were collected: total plant biomass (PB), shoot biomass (SB), root biomass (RB), root-to-shoot biomass ratio (R/S), grain yield (GY), harvest index (HI), total plant carbon stock (Pcs), shoot carbon stock (Scs), root carbon stock (Rcs), root-to-shoot carbon stock ratio (Rcs/Scs), grain carbon content (Gcc), shoot carbon content (Scc), and root carbon content (Rcc).

#### **RESULTS AND DISCUSSION**

There was a significant genotypic variation (P < 0.05) in GY, HI, Gcs, Scc, Rcc, and Gcc. Genotype AS115 produced the highest GY and Gcs at 12.88 g plant-1 and 5.61 g plant-1, respectively). Genotype AS115 produced the highest GY (12.88 g plant-1) compared to all evaluated genotypes, possibly due to its higher number of grains per head, likely influenced by its higher shoot biomass. Genotype SS27 had the highest SB (100.83 g plant-1), RB (64.29 g plant-1) and PB, (165.12 g plant-1), which increased its capacity to sequester more C. Genotype AS251 had the highest R/S and Rcs/Scs (0.52 and 0.50, respectively) compared to all the assessed genotypes. Grain yield showed higher positive correlations with HI and Gcs (r = 0.87 and 1.00, respectively). Root biomass positively correlated with all the agronomic traits and carbon variables except for Rcc and Gcc. The other genotypes exhibited low C stores because of their low biomass production. All genotypes generally stored more carbon in their shoots, indicating that roots are weaker C sinks than shoots.

#### CONCLUSIONS

The genotypes that showed the highest potential for carbon sequestration were SS27, AS138, AS115, AS203, and AS251, while producing optimum yield and biomass. The current study demonstrated that sorghum genotypes store more C in their shoots than their roots, and selection based on biomass production and allocation will allow for a more effective selection of sorghum genotypes with high-yielding and carbon sequestration potential.

KEYWORDS: carbon sequestration, sorghum, yield components

#### ACKNOWLEDGEMENTS

Water Research Commission for funding and Agricultural Research Council in Pretoria for supplying land.

#### INFLUENCE OF MYCO-SYNTHESISED CUO-ZNO HYBRID NANOPARTICLES ON THE PHYTOTOXICITY OF ASPERGILLUS PARASITICUS AND AFLATOXINB1 ON MAIZE (ZEA MAYS L.) SEED GERMINATION.

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#### INTRODUCTION

AflatoxinB1 is a potent carcinogen to humans; it is one of the structurally related toxic secondary metabolites produced by the Aspergillus species, especially *A. parasiticus* and *A. flavus*. Maise (*Zea mays* L.) is mostly contaminated with aflatoxinB1 (AFB1) because they are often grown in soils that are inherently home to these fungal species. The main objective of this study was to use myco-synthesised CuO-ZnO hybrid nanoparticles to protect maise seedlings against these aflatoxins in an *in-vitro* germination.

#### MATERIALS AND METHODS

The study was carried out at North-West University. Myco-nanoparticles were synthesised using spent mushroom substrate extract. AflatoxinB1-producing fungal strain of Aspergillus parasiticus was inoculated into brown rice, maise meal and wheat flour to produce AFB1. CuO-ZnO hybrid NPs treatments were: 0, 5 mg/L; 25 mg/L; 125 mg/L and Aflatoxin treatments were: 0, 10µg/L (AFB1); 100µg/L (AFB1); 40 spores/ml of A.parasiticus; 80 spores/ml of A.parasiticus making total treatments of twenty. These were replicated five times. Data collected included chlorophyll content of the plumule and the AFB1 uptake into radicle and plumule cytoplasm. Analysis of variance was performed on all the collected data using GenStat Software, and the least significant difference was used to separate means at P< 0.05.

#### **RESULTS AND DISCUSSION**

The study's solid–liquid extraction method revealed that wheat flour produced more AFB1 of 104.04 µg/g (57.29%) than brown rice and maise meal. The growth inhibition % of the AFB1 and *A. parasiticus* spores on the plumule and radicle of the seedling of maise showed to be more sensitive to the *A. parasiticus* spores (80 spores/ml). The radicle growth inhibition effect of the AFB1 (11.7%) was significantly lower than that of the *A. parasiticus* spore (41.70%). There was also a significant reduction of the aflatoxins in the chlorophyll content of the plumule. To control the aflatoxigenic fungi growth and aflatoxins production using the CuO-ZnO hybrid myco-nanoparticles, variance analysis revealed a significant decrease in inhibitory by adding CuO-ZnO NPs in the seedling vigour index.

#### CONCLUSION

Maise seeds absorb AFB1 during the imbibition process, thus the growth inhibition effect and the reduction of the chlorophyll content. AFB1 have a significant effect on seedling growth. Therefore, these findings demonstrated the potential of the myco-synthesized CuO-ZnO hybrid NP to be used as an alternative antifungal agent to control aflatoxin production in maise to improve food security and safety by removing the threat posed by aflatoxins.

Key words: AflatoxinB1, Aspergillus parasiticus, germination, maise, myco-synthesised.
## THE IMPACT OF ACCESS TO CLIMATE SERVICES ON SMALLHOLDER FARMERS' CROPPING DECISIONS AND HOUSEHOLD FOOD SECURITY IN ELUNDINI MUNICIPALITY, EASTERN CAPE PROVINCE

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## Introduction

Climate change and variability have garnered increasing attention in respect to agricultural production, food security, and the livelihoods of smallholder farmers in South Africa. Smallholder crop farming, primarily rain-fed, is characterized by high sensitivity to climatic fluctuations, rendering these farmers particularly vulnerable to changing weather patterns. Promoting climate services has emerged as a potential strategy to mitigate these challenges. Despite the recognized potential of climate services, there is a dearth of information regarding the quantitative impact of access to such services on farmers' decisions and household food security. Therefore, the present study aims to assess how access to climate services influences cropping decisions and household food security.

## **Materials and Methods**

Employing a cross-sectional research design, the study surveyed 217 smallholder crop farmers selected through a multi-stage sampling approach, using a semi-structured questionnaire, and both descriptive statistics and a Propensity Score Matching (PSM) model were employed for data analysis. Household food security was assessed using households' dietary diversity (HDDS).

## **Results and Discussion**

The study's findings highlight that 45% of the surveyed farmers had access to weather forecasts, while only 13% had access to seasonal forecasts. Consequently, farmers with access to climate services exhibited changes in their farming decisions, including daily farm activities, planting timing, crop selection, and land preparation. Approximately 35% of the respondents were identified as food insecure. The application of the Propensity Score Matching model revealed that access to climate services had a statistically significant positive impact on farmers' decision-making processes and household food security.

## **Conclusion and recommendations**

In light of these findings, it is recommended that efforts to expand access to climate services among smallholder farmers in South Africa should be intensified. This can be achieved by developing and disseminating more accessible and tailored climate information. Additionally, policymakers and stakeholders should collaborate to ensure that climate services are integrated into agricultural extension services and support systems.

Keywords: Climate services, Access, smallholder farmers, Eastern Cape, South Africa

## Acknowledgements

NRF grant: Global Change Social Sciences Research Programme, Project: Engaging South African farmers on climate variability and change through the use of climate services: a behaviour change approach (2021-2023).

## PHENOTYPIC DIVERSITY AMONG COWPEA MUTANTS AND ACCESSIONS FOR GRAIN YIELD AND YIELD COMPONENTS

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## INTRODUCTION

The Agricultural Research Council cowpea germplasm has a narrow genetic diversity. Cowpea is an important unutilised legume crop with the potential to eradicate hunger and malnutrition in Sub-Saharan Africa. Superior cowpea mutants for grain yield and yield components were sourced and used as potential parents to diversify the existing germplasm collection. The objectives of this study were to determine the phenotypic diversity and characterize the cowpea mutants and accessions for grain yield and yield components, to identify their superiority, and to determine the correlation between all measured characteristics.

## MATERIAL AND METHODS

Thirty-one cowpea genotypes were used for the study. The field trials were planted in Bloemfontein, Mafikeng, Polokwane, Potchefstroom and Taung during the 2021/2022 summer cropping season. The cowpea trials were laid out in a randomized complete block design with three replications across all the environments. Data for grain yield and yield components were recorded from five randomly selected plants per genotype in each plot. The data was subjected to analysis of variance and phenotypic correlations using GenStat. Principal component analysis and clustered heat maps were done using XLSTAT software.

## **RESULTS AND DISCUSSIONS**

Significant genotype, environment and genotype-by-environment interaction effects were observed for all grain yield and yield components. Moderate to high broad-sense heritability was observed for all yield components. Four superior Namibian Mutants, one IITA genotype and one South African genotype, were identified for grain yield and yield components. There were significant positive correlations between most of the yield components. The clustered heat map identified a group of Namibian mutants, IITA genotype and South African genotypes, which were associated with high grain yield.

## CONCLUSIONS

Significant differences indicated sufficient genetic variation in cowpea germplasm collections, which can be exploited for further crop improvement. Heritability values for all yield traits indicated the potential for genetic improvement and high selection efficiency for these traits. A cluster of Namibian, IITA and South African genotypes identified superior cowpea mutants, and accession could be used as potential parents to diversify the current narrow germplasm collection.

KEYWORDS: Broad-sense heritability, characterization, cowpea, diversity, grain yield, mutation

## ACKNOWLEDGEMENTS

National Research Foundation for funding the project. Agricultural Research Council grain crops for providing the germplasm.

## POTATO TUBER QUALITY AND NITROGEN USE EFFICIENCY RESPONSES TO INTEGRATED NUTRIENT MANAGEMENT

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## INTRODUCTION

Tuber quality and nitrogen use efficiency (NUE) in Limpopo potato growing areas is limited by poor soil fertility, which is caused by soil degradation, poor fertilizer application and management, and high temperatures that increase soil water evaporation and nitrogen volatilization. This study aimed to assess the potential of integrating cultivar selection, mulch and fertiliser application in improving tuber quality and NUE,

## MATERIALS AND METHODS

The experiment was carried out as 3 x 2 x 4 factorial, arranged in a completely randomized design (CRD) at University of Limpopo. Treatment factors were: three N fertilizer application rates (control, 50%, and 100% of recommended N rates), two soil cover levels (grass mulch and no mulch), and four potato cultivars (Mondial, Sababa, Panamera and Tyson). Crop data collected included tuber grading based on tuber size, tuber dry matter content and NUE. NUE was calculated as a percentage of N taken up by the crop per soil total N. Means were separated using the least significant differences (LSD) at 5% level of significant and multiple mean comparisons were conducted using the Bonferroni test.

## **RESULTS AND DISCUSSION**

Panamera produced significantly higher dry matter accumulation, proportion of medium and large tubers (22, 38 and 36%, respectively) compared to other potato cultivars. The percentage of large tubers tended to increase with an increase in fertilizer application rates and mulch application. The application of 50% fertilizer recommended rate had a significantly higher NUE (31.28%) than 100% recommended fertilizer application rate (19.78%). NUE significantly decreased linearly with increasing N application rate. High tuber quality and NUE associated with Panamera was linked to its extended period of nutrient and water uptake that supported the development of tubers. Low NUE under 100% fertilised conditions suggest that fertilizer saturated states tend to lose more nutrients than unsaturated states.

## CONCLUSIONS

Production of Panamera under mulched and 50% fertilised conditions is recommended for improving NUE while optimising tuber quality.

KEYWORDS: cultivars, fertiliser rates, mulching

## ACKNOWLEDGEMENTS

FoodBev SETA for funding, Wesgrow® for supplying potato seeds and Cedara College of Agriculture for tuber and soil nutritional analysis.

## THE EFFECT OF DIFFERENT WATERING REGIMES ON PLANT GROWTH AND YIELD OF SOYBEAN (*Glycine max* (L.) Merr.)

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## INTRODUCTION

Soybean is an important cash crop and can help contribute to soil fertility and food security. Climate change exacerbates environmental stressors like water stress and this may cause a significant reduction in crop yield, which threatens food security. The main aim of this study was to assess plant growth and yield of soybean subjected to 45%, 65% and 90% plant available water (PAW) under field conditions. In addition, the effect of *Bradyrhizobium japonicum* inoculation and fertiliser application (different nitrogen sources) under these conditions was also investigated.

## MATERIALS AND METHODS

The indeterminate soybean cultivar DM 5953 RSF was grown at 45% and 65% PAW under a rain excluding shelter. The control was grown under open field conditions at 90% PAW. Each irrigation regime had two treatments: seeds inoculated with *Bradyrhizobium* with applications of superphosphate and KCl; and uninoculated seeds with applications of superphosphate, KCl and limestone ammonium nitrate (LAN). There were four replicates of each treatment conducted in a complete random block design and the trial was repeated in the same year. Plant height was recorded throughout the growing period and dry stem weight and yield were measured at harvest.

## **RESULTS AND DISCUSSION**

There were no significant differences in final height between the three irrigation treatments and between the different nitrogen sources in the first trial. In trial 2 the 90% PAW treatment had significantly lower height as compared to the 45% and 65% PAW and the fertilised soybeans had higher final heights compared to the *Bradyrhizobium* treatments. The fertiliser treatment had a higher aboveground dry mass in both trials. Soybean yield was significantly decreased following exposure of plants to 45% and 65% PAW in both trials.

## CONCLUSIONS

The growth of soybean is less affected by drought stress than the yield. *Bradyrhizobium* inoculated plants are more affected by drought than fertilised soybean plants. Climate change that result in periods of drought could lead to reduced soybean yield.

KEYWORDS: Fertiliser, Bradyrhizobium, soybean, water stress, yield

## EXPLORING AGRICULTURAL CONSERVATION PRACTICES IN SMALL-SCALE AND COMMERCIAL FARMING ENTERPRISES OF SOUTH AFRICA: TOWARDS BUILDING SUSTAINABLE AGROECOSYSTEMS

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## INTRODUCTION

The agriculture sector in South Africa is marked by a dualistic economy that comprises small-scale and commercial farming. Small-scale farming is perceived as an eco-friendly approach to agriculture, while the inverse is true for commercial farming. In recent years, conservation agriculture (CA) has been promoted as one of the sustainable approaches to farming that is environmentally friendly and sustainable – especially within the agroecological and economic contexts.

## MATERIAL AND METHODS

The overarching objective of this project was to explore agricultural conservation practices in smallscale and commercial farming enterprises of South Africa as a means of contributing to the knowledge gap pertaining to resilient and sustainable farming systems. Using a descriptive analysis approach from data obtained through an online survey, the study presents different challenges that small-scale and large-scale (commercial) farmers encounter in their farming enterprises.

## **RESULTS AND DISCUSSION**

The researcher narrows the study by exploring conservation agriculture (CA) practices that are applied within the farms and present their associated benefits. The results show a myriad of challenges that farmers experience in their enterprises. Some of these challenges include (a) pests and diseases, (b) lack of financial support, (c) poor access to production resources, (d) degraded land, (e) water scarcity, (f) climate-related challenges, and (g) drought. These gaps are not new in the agriculture fraternity; however, they contribute to a failing agroecosystem. Thus, a need for the promotion of CA. Some of the common CA practices adopted by farmers which were found to be effective include (among others) crop rotation practices, using integrated pest management approaches, cover cropping, conservation tillage, and species diversification.

## CONCLUSIONS

The presented approaches significantly contribute to overall biodiversity as healthy natural systems serve as conducive habitats for the growth and development of different plant and animal species. The paper concludes by discussing the implications for making investments that are focused on CA promotion.

**KEYWORDS:** Agroecology, Climate Change, Commercial farming, Conservation agriculture, Land use management, Sustainable agriculture.

## ACKNOWLEDGEMENTS

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## EVALUATION OF THE DSSAT-CERES MAIZE MODEL IN ESTIMATING YIELD IN SOUTH AFRICA'S NORTH WEST PROVINCE

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## INTRODUCTION

Crop production models are useful tools with the potential to be used in answering questions in research, crop management and policy. In more recent years, crop models have been used at informing climate change adaptation strategies. Therefore, understanding the accuracy and reliability of such models to predict the impact of climate change at a local scale is of great importance. In this study we evaluate the ability of the DSSAT model to estimate observed patterns at a municipal level across the North West Province of South Africa.

## MATERIALS AND METHODS

The DSSAT model was forced with observed meteorological parameters such as daily rainfall, minimum temperatures, maximum temperatures, and solar radiation from the quinary catchment database (QCD) and simulations ran from 1950 to 1999. Predominantly grown maize cultivars such as PAN6479 and ZM521 were chosen as inputs into the model. Management practices such as planting density and row spacing were derived from literature. Planting date was calculated with the onset of the rainy season and to assess the sensitivity to planting date all quinary catchments were also simulated with an early planting date criterion (October). The model performance was evaluated using four criteria describing how well simulated outputs compared with observed yields from 1981 to 1999, namely the R<sup>2</sup>, RMSE, NSE and PBIAS.

## **RESULTS AND DISCUSSION**

The model displayed varying performance with six out of the fifteen municipal districts meeting three out of the four model evaluation criteria when the PAN6479 variant was modelled. Only three districts met three out of the four model evaluation criteria when the ZM521 variant was used. At a provincial level, a comparison between averaged simulated yield and averaged observed yield reflected an acceptable level of performance for both variants with PAN6479 (R<sup>2</sup> = 0.80, RMSE = 0.39, NSE = 0.75 and PBIAS = 0.11) performing better than ZM521 (R<sup>2</sup> = 0.78, RMSE = 0.49, NSE = 0.59 and PBIAS = -0.06). The model parameterised with early planting dates performed poorly throughout demonstrating the sensitivity of the model to planting date. The anomaly correlation of observed versus PAN6479 estimated yield shows a strong correlation of 0.90 for the years 1981 to 1999. The better performance of the model which used the PAN6479 variant could be attributed to the fact that the PAN6479 was more commonly planted during the analysed period.

## CONCLUSIONS

At a provincial level, the DSSAT model can be used to estimate maize yields for the North West Province. However, the use of the DSSAT model to estimate maize yield at a municipal district level should be done with caution. Parameter inputs such as the planting date and variant characteristics are important considerations, as this study found that the performance of the model is influenced by these inputs.

KEYWORDS: DSSAT, estimation, yield, performance

ACKNOWLEDGEMENTS Land Bank for funding.

# CANOLA WEED SUPPRESSION AT VARIOUS LEVELS OF PLANTING DENSITIES.

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## INTRODUCTION

Canola production in South African farming systems is important to increase diversity within a farming system. There is reliance on herbicides due to high losses associated with weed infestation. The risk of herbicide resistance has called for alternative weed management practices. Some of these methods include agronomic practices like adjusting the planting density to suppress weed infestation or selecting more competitive canola cultivars. This study investigated the weed suppression ability of different canola cultivars at various planting densities in the presence and absence of herbicides.

## MATERIAL AND METHODS

The trials were conducted at the Langgewens Research farm near Moorreesburg. It was planted in early May 2023. Data collection occurred over one growing season. It was a split-plot design with four replications. Two cultivars, Triazine tolerant canola (TT) and Imidazolinone tolerant canola (Clearfield) were used as the main plot factor. One-half of the plot received herbicide application according to best practices (cultivar specific) whilst the other received no application (sub-plot). Four planting densities 1, 2, 3 and 4 kg/ha were randomly allocated to the sub-plot, resulting in Individual plot sizes of 2 m by 6 m. At 30,60 and 90 days after emergence (DAE), canola and weed plant counts were done randomly with a 1 m<sup>2</sup> stick and within a 0.0225 m<sup>2</sup> quadrant respectively.

## **RESULTS AND DISCUSSION**

The following data has not been statistically analyzed. Without herbicides, the TT cultivar planted at 1 kg/ha resulted in 192.2 weeds biomass  $g/m^2$ , compared to the 4 kg/ha planting density which had 79.6 weeds/m<sup>2</sup> at 90 DAE. Clearfield generally had lower weeds/m<sup>2</sup> compared to TT. Planting densities resulted in 59.8, 62.9, 64.8 and 42.4 weeds biomass  $g/m^2$  in the 1, 2, 3 and 4 kg/ha planting densities at 90 DAE, respectively.

With the use of herbicides, Clearfield planted at 1 kg/ha had 3.6 weeds biomass g/m<sup>2</sup> compared to 4kg/ha which resulted in 0.6 weeds/m<sup>2</sup> at 90 DAE, Clearfield showed poorer weed suppression than TT cultivars, which had between 0.1 and 0.6 weeds biomass g/m<sup>2</sup> at 90 DAE, likely due to more effective herbicide (Atrazine) used on the TT cultivar.

## CONCLUSIONS

Higher planting densities could potentially lead to higher yields; however, higher planting densities did not ensure better weed suppression. More competitive cultivars such as Clearfield did not show any difference in weed suppression ability across the four planting densities but showed better suppression than the TT canola cultivar in the absence of herbicides.

Keywords: Canola planting density, canola weed suppression ability, weed infestation, weed suppression.

## THE EFFECT OF SALICYLIC ACID AND ANTIOXIDANTS ON GROWTH AND PRODUCTION OF FIELD-GROWN WHEAT (*TRITICUM AESTIVUM* L 'MATLABAS') SUBJECTED TO HEAT AND WATER STRESS

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## INTRODUCTION

Heat and drought stress are a major causes of low yields and reduced levels of carbohydrates and proteins in wheat grains. Yields of rain-fed wheat pastures in South Africa are between 2 and 4 tons per hectare compared with 7 tons per hectare under irrigation. This study aimed to determine if a mixture of salicylic acid and antioxidants, applied exogenously, may reduce the effects that heat and water stress may have on wheat planted during winter to lead to subsequent improvements in yields and grain quality. Salicylic acid was shown to improve the tolerance of plants to abiotic stress factors.

## MATERIALS AND METHODS

A mixture of 0.1% salicylic acid, ascorbic acid and □-tocopherol encapsulated in an amphiphilic nano oil delivery system was applied to 'Matlabas' wheat plants, planted during the winter. This specific mixture was applied at 1 litre per hectare, five weeks after sowing. Data was collected before harvest, including plant height, number of spikelets per plant, number and mass of grains per spikelet, and root and above-ground dry mass content. This field trial was laid out in a randomized block design with two treatments and 10 replicates per treatment.

## **RESULTS AND DISCUSSION**

Weather data at the trial site indicated that drought and heat stress conditions occurred during late winter, coinciding with the wheat's tillering and heading stages. A negative effect on yield and grain quality could be expected. The treatment improved the vigour of the plants, the number of spikelets per plant, and grains per spikelet by 23.6, 33.5 and 8%, respectively. The treatment resulted in a significant increase in grain mass, where mean grain mass of the treated plants was 46.3 mg per grain, compared with 36.7 mg per grain for the untreated control. As a result, yield was increased with the treatment and yielded 6.2 tons per hectare compared with 2.9 tons per hectare for the control. There was also some indication that the treatment increased grain protein content.

## CONCLUSIONS AND RECOMMENDATIONS

Exogenous application of a mixture of salicylic acid, ascorbic acid and  $\Box$ -tocopherol significantly increased plant vigour and yield of winter-grown wheat. This was possibly due to these compounds stimulating the plant's defence mechanisms, subsequently increasing tolerance towards heat and drought stress.

Keywords: grain mass, salicylic acid, vigour, yield

## INVESTIGATING WEATHER INFORMATION NEEDS OF SMALLHOLDER FARMERS IN THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

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## INTRODUCTION

Climate change and variability will hit the agricultural sector the hardest, especially for smallholder farmers. Seasonal forecasts allow farmers and agricultural experts to enhance their resilience to climate change. Crop farmers could incorporate such information into their decision-making processes. Therefore, the study objective was to investigate the use of climate services by smallholder farmers. However, access and use of weather information that applies to the context of smallholder farmers, which is tailored to meet smallholder farmer's needs, has been limited and has contributed to limited understanding and low use levels of weather information.

## MATERIALS AND METHODS

In this study a mixed-method approach was used to collect and analyse data. Interviews with openended and closed-ended questions were conducted with agricultural extension officers, and smallholder farmers were interviewed in the Eastern Cape, Maclear. The interview questions were altered for each interviewee's role to understand their needs for climate services. The interview questions were used to obtain information on the use and access of climate services, particularly seasonal forecasts, in the context of smallholder farmers.

## **RESULTS AND DISCUSSION**

Seasonal forecast information is not easy to understand by the smallholder farmers; it has been identified to be complex to analyse and interpret the information for the needs of the farmers. In this study, learners from the nearby schools were involved to help analyse, interpret, and disseminate the seasonal forecast information. Eastern Cape farmers were less inclined to trust the seasonal forecast. They were more aligned with indigenous knowledge.

## CONCLUSIONS

It is evident that smallholder farmers have limited knowledge about using seasonal forecast information as they found it difficult to understand. To improve the use of climate services could be better when learners are involved in disseminating the seasonal forecast information to the local farmers.

Keywords: Climate change, Climate services, Seasonal forecast, Weather information.

#### REFERENCES

Naab, F. Z., Abubakari, Z. and Ahmed, A. 2019. The role of climate services in agricultural productivity in Ghana: The perspectives of farmers and institutions, Climate Services, 13(January), 24–32. Neves, D. and Du Toit, A. 2013. Rural Livelihoods in South Africa: Complexity, Vulnerability and Differentiation. *Journal of Agrarian Change*, *13*(1), 93-115.

## NON-LINEARITY OF THE ETO RELATIONSHIP: AN EXCEL VBA IMPLEMENTATION AS A RESEARCH AND TEACHING TOOL

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## INTRODUCTION

The calculation of grass reference or tall-crop reference evaporation ETo, at hourly or daily timescales, using the Penman-Monteith approach (Monteith 1965), requires complex iterative procedures due to the non-linearity of the ETo equation. For example, the method requires the saturation water vapour pressure *vs* temperature slope at canopy temperature and the specific latent energy of vapourisation requires the wet bulb, both unknown temperatures. A simple spreadsheet-based iterative method is used for the estimation of the radiative and aerodynamic components of ETo for short grass and tall crop surfaces for hourly and daily timescales for Davis, California, USA and for South Africa in Pretoria and Pietermaritzburg. Implementation of the methodology is based on Allen et al. (2006), the method recommended by the American Society of Civil Engineers (2005), using Excel VBA, allowing the spreadsheet to be used as a research and teaching tool for crop, soil and agrometeorology students.

#### MATERIALS AND METHODS

Hourly and daily weather data used were from field experiments at Davis, California, USA and for South Africa for Pretoria, Gauteng and Pietermaritzburg, KwaZulu-Natal. Measurements included solar irradiance, air temperature, relative humidity and wind speed. The hourly and daily ETo procedures were implemented using Microsoft Excel VBA and validated against a data logger implementation of ETo provided by Campbell Scientific Inc. (Logan, USA) for use in a data logger in real time. The Excel implementation allowed for hourly, daily, weekly and monthly calculation of ETo and their graphical display.

## **RESULTS AND DISCUSSION**

The validation of the Excel VBA method for estimation of hourly short grass ETo against the data logger implementation was excellent for all sites. An example is demonstrated for the Agrometeorology Instrumentation Mast (AIM) system in Pietermaritzburg.

## CONCLUSIONS

An accurate spreadsheet-based iterative procedure was implemented and validated for ETo grass reference evaporation. The procedure was applied to estimate wet bulb temperature and hence grass reference evaporation. The spreadsheet procedure conveniently allows simultaneous visual inspection of input data, graphical display(s) and the iterative results of the radiative and aerodynamic components of ETo.

## ACKNOWLEDGEMENTS

We thank the Water Research Commission, Teaching and Learning Office of UKZN and the National Research Foundation for funding and acknowledge assistance in the field from many UKZN staff and students. We acknowledge the supply of hourly weather data from the University of California, Integrated Pest Management Program, Davis, California, USA; for Pretoria from South African Weather Service, Pretoria, South Africa.

Keywords: Energy balance, iterative procedure, Penman-Monteith.

## ASSESSMENT OF 17 COWPEA GENOTYPES GROWN UNDER FIELD CONDITIONS: PLANT BIOMASS RESPONSES, N-FIXATION AND ROOT CHARACTERISTICS Shabangu, D, Dladla, N, Leshilo, J.R, Maduna, M.K, Dube, S.P, Thosago, S.S and Kutu, F.R

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## INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) cultivation in South Africa is mostly limited to smallholder farmlands where grain yield rarely exceeds 600 kg/ha due to different reasons. Although, cowpea plants have an inherent ability to fix nitrogen (N), success is largely influenced by the availability of compatible native *Rhizobia* on crop fields, while the observed yield is affected by the varietal yield potential and favourable growth conditions. Similarly, cowpea root characteristics play crucial role in nutrients and water acquisition and its overall performance. Hence, the study objective was to evaluate root characteristics and biomass production under rain-fed condition at the University of Mpumalanga.

## MATERIALS AND METHODS

The study was conducted under field conditions at University of Mpumalanga Experimental farm (25°25'28.5"S 30°58'19.7"E) during 2023-summer season. The trial was laid out in a randomized complete block design (RCBD) with three replications. Plant samples were collected at 50% flowering stage to assess root characteristics (root length, number of basal roots, taproot diameters, branching root density at 5,10, 15 and 20 cm) using Shovelomics, nodulation and plant biomass. Ammonium and Nitrate were determined using (N - NH4+NO3 = 1:5 Ext-0.1N K2SO4) and N-fixation using nitrogen difference method. Data generated were subjected to Statistix 10.0 software and mean separation was done using Tukey HSD at 5% level.

## **RESULTS AND DISCUSSION**

Results revealed significant (p<0.05) variation in stem root diameter, taproot diameter at 15 and 20 cm, and branching root diameter at 5 cm depths among tested cowpea genotypes. The CV17B and CV17F-3 had thicker root stem diameter (mean: 8.67 mm), while both CV26A and CV17I had the smallest (mean: 5.33 mm). Furthermore, there was a significant variation ((p<0.01) in the amount of N-NO3 and N-NH4 fixed by cowpea genotypes. CV17F-3 recorded the highest mean N-NO<sub>3</sub> (43.52 mg/kg) and N-NH4 (32.80 mg/kg). Followed by KT20 (19.48 mg/kg) and CV17H (15.20 mg/kg). While CV18-1A and CV17K had the least amount of 1.62 mg/kg N-NO<sub>3</sub> 0.32 mg/kg N-NH<sub>4</sub>, respectively. Interestingly, despite these variations in root characteristics and N fixation abilities, there was no significant difference in dried plant biomass yield among the cowpea genotypes studied.

## CONCLUSION AND RECOMMENDATION

The CV17F-3 genotype gave more outstanding root stem diameters, and N-NO3 can be adapted to drought prone areas, and a breed to improve.

Keywords: nitrogen fixation, cowpea genotype, root characteristics.

## ALTERNATIVE HERBICIDES FOR THE CONTROL OF GLYPHOSATE-RESISTANT AMARANTHUS HYBRIDUS (SMOOTH PIGWEED) IN RSA

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## INTRODUCTION

Amaranthus hybridus has been a known crop weed in the Republic of South Africa for a long time, and herbicide resistance has not been a problem. In recent times, however, there was growing anecdotal evidence from farms in KwaZulu Natal Province (KZN) that this previously easy-to-control weed was no longer effectively controlled by glyphosate. Glasshouse and molecular studies conducted at the University of Pretoria in 2022 indicated a high glyphosate resistant population with a rare triple mutation in the *EPSPS* gene. In the present study, we investigated herbicides from different sites of action groups as alternative herbicide options.

## MATERIAL AND METHODS

In an earlier investigation on the KZN *A. hybridus* populations seeds from 50 plants that survived glyphosate application were collected from farmers' fields at Bergville and Winterton (21 km apart), and a glyphosate susceptible population from Hendrina District (500 km from KZN Province). The same seeds and their F1 generations from the glasshouse experiment were grown on seedling trays and at the 3-leaf stage transplanted to pots, and herbicides were applied at the 5-6 leaf stage. Atrazine (PSII inhibitor), mesotrione (HPPD inhibitor), atrazine and tembotrione mixture (PSII and HPPD inhibitor), chlorimuron-ethyl (ALS inhibitor) and fomasefen (PPO inhibitor) were applied at 0.5X, 1X, 2X and 4X the recommended rate. Plant responses were compared to untreated controls (zero herbicide). Herbicides were applied using an Oxford Small-Plot Precision Sprayer calibrated to deliver a spray volume of 300 L ha<sup>-1</sup> at 180 kPa through a TeeJet E80015 EVS nozzle. At 21 DAT, survival percentage and biomass reduction were determined. A four-parameter log-logistic non-linear regression model in R was used to ascertain herbicide dose that causes 50% survival (LD<sub>50</sub>) and biomass reduction (GR<sub>50</sub>).

## **RESULTS AND DISCUSSION**

Atrazine and tembotrione mixture, and fomasefen alone, were effective in controlling all glyphosateresistant populations even at 0.5X recommended doses. For Atrazine alone, Bergville and Winterton populations were not effectively controlled at the recommended dose, but effectively controlled at 2X normal dose. Mesotrione was also effective in controlling glyphosate-resistant populations from 1X recommended dose (100% control) and  $GR_{50}$  138.04 and 141.26 g.ai.ha<sup>-1</sup>, compared to 120 g.ai.ha<sup>-1</sup> recommended dose. However, populations were not effectively controlled by chlorimuron-ethyl, with the Bergville population highly resistant.

## CONCLUSION

In conclusion, a mixture of HPPD and PSII inhibitors had a synergistic effect can be used in maize, and PPO inhibitors can be used in soya beans for the control of Bergville and Winterton populations.

## KEYWORDS: Glyphosate, Amaranthus hybridus, herbicides

**ACKNOWLEDGEMENTS:** This work is funded through the South African Herbicide Resistance Initiative (SAHRI) supported by Bayer SA, Syngenta SA, and The Maize Trust. The National Research Foundation (NRF), as well as the Oil- and Protein Seeds Development Trust, are also acknowledged.

## IDENTIFICATION AND CHARACTERIZATION OF MICRORNAS AS ROLE PLAYERS IN THE WHEAT (*TRITICUM AESTIVUM*) DEFENCE RESPONSE AGAINST THE RUSSIAN WHEAT APHID

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#### INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most dominant human and livestock feed crops. Yields of wheat have declined worldwide due to pathogens and pests. *Diuraphis noxia* (Russian wheat aphid, RWA) is the most devastating aphid pest affecting wheat cultivation in South Africa and other regions. Feeding by this insect causes severe symptoms, including necrosis, streaking and trapping of the heads of the wheat plant. This reduces crop yield and can lead to the death of susceptible cultivars. The emergence of resistance-breaking biotypes negates the use of resistant cultivars against the RWA. Feeding by the RWA on wheat induces differential expression of microRNA genes. Thus, this study used next-generation sequencing to identify a larger pool of microRNAs and further characterise them and their putative targets.

## MATERIAL AND METHODS

In this study, 12 microRNA libraries (3 bioreps) from Tugela uninfested, Tugela Dn uninfested, Tugela infested and Tugela Dn infested were constructed respectively. The expression of candidate miRNAs and their targets was determined by quantitative real-time PCR. The predicted target genes were analysed for their gene ontology placement to determine their biological role in plants.

### **RESULTS AND DISCUSSION**

Five hundred three miRNA candidates were obtained; only 87 matched the known *Triticum aestivum* miRNA. The identified miRNAs seem to target known resistance gene family members and previously identified resistance responses from wheat after infestation by the RWA. The gene ontology results indicated that most of the identified targets in this study play a role in regulating some biological pathways known to be regulated during wheat-RWA interaction.

#### CONCLUSIONS

The use of the next-generation sequencing method has boosted small RNA discoveries at an unprecedented scale. However, a few of several thousand discovered small RNAs have been functionally characterised. The field of small RNA functional genomics research is still in its early phase, and in the case of complex crops like Triticum aestivum, the progress is even slower. More work needs to be done to characterise more miRNAs. Identifying and characterising more small RNA and their target genes will contribute to our understanding of wheat and RWA interaction. Once a better understanding of this interaction is achieved, then this knowledge can be utilised in the future production of crops with better resistance against RWA.

Keywords:, microRNA, Next-generation sequencing, Russian wheat aphid, Triticum aestivum

## CURRENT STATE OF HERBICIDE RESISTANCE IN AMARANTHUS PALMERI POPULATIONS IN SOUTH AFRICA

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## INTRODUCTION

Amaranthus palmeri was first identified in South Africa in the Northern Cape, in 2018, after reports of poor control following glyphosate treatment. Herbicide resistant profiling of this population was carried out by our group (SAHRI) and resistance to ALS inhibitors and glyphosate was confirmed. Elevated *EPSPS* gene copy number was reported as the resistance mechanism to glyphosate. In 2021 and early 2022 more populations of this species were found in Limpopo and Potchefstroom respectively. In this study we investigated the herbicide resistance profile of the populations as well as the mechanism of glyphosate resistance in order to devise more informed management practices.

## MATERIALS AND METHODS

Leaf and seed samples were collected from suspected Amaranthus plants from these locations. Species identification was done through molecular sequencing of the 16S ITS genetic barcoding region. The *EPSPS* and *ALS* genes were also sequenced to identify possible target site mutations. Furthermore, the relative copy number of the *EPSPS* gene was investigated using quantitative real-time PCR.

## **RESULTS AND DISCUSSION**

Sanger sequencing of the ITS region confirmed the identity of all populations to be Palmer amaranth and no target site mutations were found in the *EPSPS* and *ALS* genes. No *EPSPS* gene duplication was recorded in the Limpopo population, yet the Potchefstroom population had elevated *EPSPS* gene copy numbers ranging from two to 140, relative to the *ALS* gene. This suggests that the Northern Cape population might have spread through human assistance to Potchestroom as they have similar resistance mechanisms.

## CONCLUSION

The results obtained suggest that the Limpopo population is sensitive to ALS and EPSPS inhibitors and the Potchefstroom population is resistant to glyphosate and might also be resistant to ALS inhibitors.. Further studies are currently being conducted to asses the resistance spectrum to additional herbicide sites of action and to investigate the genetic relatedness of all the confirmed populations in South Africa.

Keywords: Amaranthus palmeri, glyphosate, EPSPS, ALS

**ACKNOWLEDGEMENTS:** This work is funded through the South African Herbicide Resistance Initiative (SAHRI) supported by Bayer SA, Syngenta SA, The Oil- and Protein Seeds Development Trust and The Maize Trust.

## GROWTH, YIELD AND QUALITY OF SIX HIGH-YIELDING TOMATO CULTIVARS GROWN IN THE OPEN-BAG HYDROPONIC SYSTEM

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## INTRODUCTION

The cultivated tomato (*Solanum lycopersicum* L.) is the second most important herbaceous vegetable after the potato crop globally and in South Africa. Production has increased in recent decades, but fruit yield and quality improvements remain suboptimal. Limited access to tomato cultivars that are well adapted to local conditions for hydroponic cultivation is the main factor preventing increased productivity in non-temperature-controlled greenhouse production. Therefore, the aim of this study was to investigate the performance of six high-yielding greenhouse tomato cultivars (HY2753, HY2756, HY2754, HY2439, HY2755, 1722) in terms of their morphological and physico-biochemical attributes.

## MATERIALS AND METHODS

The trial was conducted during the 2022 – 2023 growing season, in an open-bag hydroponic system, operated under a non-temperature controlled plastic tunnel covered with a shade net over the plastic sheeting at the Agricultural Research Council – Vegetable, Industrial and Medicinal Plants (ARC – VIMP) research station, located at Roodeplaat, Pretoria. Research treatments (six Hygrotech-originated tomato cultivars) were laid out following a Randomized Complete Block Design (RCBD), with four replications.

## **RESULTS AND DISCUSSION**

All cultivars performed similarly with regard to growth. However, there were significant differences in terms of crop yield. Cultivars HY2754 and HY2756 revealed the highest significantly different number of marketable fruits (37.2 – 33.4 fruits/plant) and marketable yield (4670-5790 g/plant) compared to the rest of the cultivars (18.2 – 12.7 fruits/plant and 1350-2430g/plant of marketable yield). The highest unmarketable yield was observed in HY2439 (250g/plant), followed by HY2753 (310g/plant). Beta-carotene contents were the highest in cultivar 1722 (8.32 mg/100g of dry weight "DW"), followed by HY2754 (7.97 mg/100g DW), and HY2753 (7.89 mg/100g DW). The highest lycopene content was recorded in cultivar HY2753 (41.62 mg/100g DW), followed by 1722 and HY2439 with 33.06 to 30.39 mg/100g DW.

## CONCLUSIONS

Improved yield and quality of tomatoes are important for producers and consumers. This study evaluated the productivity of six high-yielding cultivars grown in hydroponics and identified HY2754 and HY2756 as the best cultivars for increased tomato productivity. This will enable increased productivity and profitability of farmers and improved societal well-being.

KEYWORDS: HY2753, HY2756, HY2754, HY2439, HY2755, 1722

## ACKNOWLEDGEMENTS

The authors would like to thank the ARC – VIMP for implementing the study, the Gauteng Department of Agriculture, Rural Development and Environment (GDARDE) and the Department of Agriculture, Land Reform and Rural Development (DALRRD) for the financial support, as well as Hygrotech for the provision of seeds.

## YIELD AND QUALITY OF TOMATO CULTIVARS GROWN IN THE OPEN-BAG HYDROPONIC SYSTEM

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## INTRODUCTION

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## MATERIALS AND METHODS

The trial was conducted during the 2022 – 2023 growing season, in an open-bag hydroponic system, operated under a non-temperature controlled plastic tunnel covered with a shade net over the plastic sheeting at the Agricultural Research Council – Vegetable, Industrial and Medicinal Plants (ARC – VIMP) research station, located at Roodeplaat, Pretoria. Plants were grown at a density of 2.5 plants/m<sup>2</sup>. The electrical conductivity of the nutrient solution was kept between 2.1 and 2.3 and mS.cm<sup>-1</sup>. The nutrient solution pH was maintained within a pH range of 5.8 to 6.5. Six indeterminate tomato cultivars were laid out following a Randomized Complete Block Design, with four replications.

## **RESULTS AND DISCUSSION**

All cultivars performed similarly with regard to growth. However, there were significant differences in terms of crop yield. Cultivars HY2754 and HY2756 revealed the highest number of marketable fruits (37.2 – 33.4 fruits/plant) and marketable yield (4670-5790 g/plant) compared to the rest of the cultivars (18.2 – 12.7 fruits/plant and 1350-2430g/plant of marketable yield). The highest unmarketable yield was observed in HY2439 (250 g/plant), followed by HY2753 (310 g/plant). Beta-carotene contents were the highest in cultivar 1722 (8.32 mg/100 g of dry weight "DW"), followed by HY2754 (7.97 mg/100 g DW), and HY2753 (7.89 mg/100 g DW). The highest lycopene content was recorded in cultivar HY2753 (41.62 mg/100 g DW), followed by 1722 and HY2439 with 33.06 to 30.39 mg/100 g DW, respectively.

## CONCLUSIONS

Improved yield and quality of tomatoes are important aspects for both producers and consumers. This study evaluated the productivity of six high-yielding cultivars grown in hydroponics and identified HY2754 and HY2756 as the best cultivars for increased tomato productivity. This will enable increased productivity, profitability of farmers and improved societal well-being.

KEYWORDS: lycopene, beta-carotene, marketable yield, unmarketable yield

## ACKNOWLEDGEMENTS

The authors would like to thank the ARC – VIMP for implementing the study, the Gauteng Department of Agriculture, Rural Development and Environment (GDARDE) and the Department of Agriculture, Land Reform and Rural Development (DALRRD) for the financial support, as well as Hygrotech for the provision of seeds.

## EXAMPLES OF IODINE AS MICRONUTRIENT IN PLANTS, FOR IMPROVEMENT OF THE MAIN COMMERCIAL GREENHOUSE CROPS CULTIVATION

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## INTRODUCTION

Kiferle et al. (2021) recommended that lodine (I) should be considered as a plant beneficial nutrient and a study was done to evaluate the effect of lodine on yield and quality of vegetable crops. Kiferle et al. (2021) identified natural occurring iodinated proteins in higher plants, which had never been described or published before. Eighty-two iodinated proteins have been identified that take part in important biological processes in higher plants, such as photosynthesis, carboxylation, stress-related pathways, and ATP-synthesis. Similar to deficiency in any other plant nutrient, a deficiency in iodine is predicted to cause yield losses.

## MATERIAL AND METHODS

Four case studies are presented: tomato in Turkey, cherry tomato on the vine in Spain, Italian sweet pepper (Capsicum) in Morocco, and lettuce and coriander in Brazil. In each location, separate fertigation units were present to apply the crops nutrient solution by drip irrigation or NFT, separately in at least two sectors (four in Turkey) of the greenhouse or tunnel. Crop parameters such as cultivar, planting date, plant density and overall crop management were identical for both separately fertigated sectors. The composition of the nutrient solution was determined by the grower's standard practice. Two treatments were compared, the control (KNO<sub>3</sub> without I) and KNO<sub>3</sub>+I.

## **RESULTS AND DISCUSSION**

The results of the application of lodine as a micronutrient with the nutrient solution in the tested crops show an improvement in root development and fresh weight of lettuce and coriander in hydroponics, total season yield in round tomato and Italian sweet pepper. Additionally, an increase in fruit fresh weight and the concentrations of antioxidants and calcium in cherry tomato was revealed, and prevention of blossom end rot in sweet pepper fruits was noticed. Water samples for I analyses, collected from 42 sites in South Africa, showed that >90% contained less than 1 µmol L<sup>-1</sup>.

## CONCLUSIONS

The application of I containing potassium nitrate in four commercial horticultural crop systems, resulted in an increased I concentration in leaf tissue. A positive response on crop yield was observed in crops receiving I compared to control crops fed with a nutrient solution containing less than 0.1  $\mu$ mol I L<sup>-1</sup>. The scientific results and the experiences of commercial growers indicate that iodine is needed for the crops tested.

KEYWORDS: fertigation, fruit quality, lettuce, potassium nitrate, tomato, sweet pepper,

## CROPPING SYSTEMS CAN IMPROVE PROFITABILITY ON LOWER NITROGEN APPLICATIONS

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## INTRODUCTION

Wheat producers are under increasing pressure due to low commodity prices and rising input costs. To be profitable, farmers need to optimise production. On the other hand, agriculture is under increased pressure due to the industry's environmental impact. Conservation agriculture can have a positive effect on profitability and the environment.

## MATERIAL AND METHODS

The trial was conducted under rain-fed conditions in the Western Cape South Africa Swartland region with a Mediterranean climate. Eight cropping systems under conservation agriculture (2002 to 2021) practices were assessed. Four systems are cash cropping systems, and the remaining four are a combination of cash crops and pasture systems. The four mixed pasture/cropping systems and two cash cropping systems contain legumes. Production and quality of the main cash crop were included in all the systems tested, and the total system gross margins were compared. The aim was to determine if the systems with the highest yields and quality related to the systems' gross margins. The experimental design was a randomised block design with two replications.

## **RESULTS AND DISCUSSION**

Wheat yields, protein content and gross margins do not correlate with the amount of nitrogen applied. Less nitrogen fertilisers were applied in mixed cropping systems, but these systems contained more protein in the grain than cash cropping systems, with no reduction in wheat yield. In the cash cropping systems, which include legumes, more nitrogen was applied compared to the mixed systems. This may be because the mixed systems contain 50% legumes compared to the two cash cropping systems, which include 25% legumes.

The benefits of incorporating legumes into a cropping system are clear, as this leads to a reduction in nitrogen fertiliser and an increase in gross margins. The frequency of legumes in a cropping system and the type of legume (cash crop or pasture) may influence the benefits of the legume.

## CONCLUSIONS

Cropping systems containing legumes can improve financial sustainability by reducing the amount of nitrogen fertilisers while sustaining production and increasing quality. This can reduce the negative environmental impact while enhancing wheat production's profitability.

Keywords: Conservation agriculture, gross margin, pasture, protein, wheat,

## ECONOMIC SYSTEM STABILITY OF SHORT ROTATIONS IN THE OVERBERG

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## INTRODUCTION

Crop diversity and sequence are important in Conservation Agriculture (CA) systems. Although yield is an important factor driving the crops planted in rotation, the stability of the economics of these different systems is key. The aim of this paper is to evaluate the economic stability of the short rotation systems tested in the Overberg production area.

## MATERIALS AND METHODS

The experimental design was a randomized block design with a nested treatment design. Data was taken from 13 crop rotation systems over a 19-year period from 2002 to 2020. The 13 rotation systems included pasture/crop and crop-only systems. For each year, all direct and in-direct allocatable variable input costs per hectare and gross income per hectare (excluding marketing costs) for each crop and for the sheep component of each rotation system being tested in the trial were recorded. An EXCEL version of MICRO-COMBUD was written specifically to accommodate the experimental design to determine the gross margins of any treatment. The data was subjected to analysis of variance (ANOVA), and Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means.

## **RESULTS AND DISCUSSION**

Significant differences were noted in the year and system interaction at the 95% confidence level. The two crop-only systems were less stable over time than the pasture/crop systems. The 6-year crop-only system had the highest returns over the 19 years but was less stable than most of the pasture/crop systems. Including lupin in these two systems contributed to the large variation over time. Seven of the 11 pasture crop systems were higher in their financial returns. These systems combined variations of wheat, canola and barley with the pastures. The 4-year crop-only system performed differently than all the other systems. Although it included lupin, the soil type of one of the repetitions of the system was located in very poor soil, which had a tremendous impact on the system's stability.

## CONCLUSIONS

The crop/pasture systems are more stable in terms of profitability over time than pure cropping systems, although the 6-year crop-only system had higher returns. Cash crop choice in the pasture/crop systems is important. Current legume options restrict the crop-only system performance.

Keywords: crop rotation, conservation agriculture, economics, financial sustainability

## TWO NEW GROUNDNUT CULTIVARS DEVELOPED AND REGISTERED

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## INTRODUCTION

More than six decades ago, groundnuts (Arachis hypogaea L.) were recognised as one of the most important crops in the world at the time (Higgins, 1951). As a result of the past seven years of work, two new cultivars from the ARC were registered at the Department of Agriculture. The breeding division of the ARC:GC is responsible for the development of groundnut breeding lines. Promising asseccions are tested in national cultivar trials. The best-performing breeding lines are then identified.

## MATERIALS AND METHODS

In the past seven years, 14 breeding lines were developed by cross-breeding promising breeding lines with traits as requested by the industry. This includes tolerance to drought, diseases, and a shorter growing period. ARC's and ICRISAT's genetic material were used in the crosses. Following the crosses, the F1-generation seeds are recovered and planted in elite line and advanced trials. This is done for five years to ensure homogenous and uniform new lines. These lines are then evaluated against existing breeding lines and registered cultivars in cultivar trials, followed by three years in the national cultivar evaluation trials.

## **RESULTS AND DISCUSSION**

Through this method, the two promising lines, PC 474-K9 and PC 435-K6, were identified and registered with the Department of Agriculture, Land Reform and Rural Development. The two cultivars were bred and developed by Me Alana Pretorius and Me M van der Merwe at the ARC:GC Groundnut Division. In terms of Section 20 of the Plant Improvement Act, 1976 (Act No. 53 of 1976), the Registrar of Plant Improvement has decided to approve the listing of the following varieties in the National Varietal List.

## CONCLUSIONS

Seed from the two new cultivar will be multiplied during the 2022-2023 season and released shortly after.

Since the seeds of the two cultivars are currently multiplied, no data is available to state their yield per hectare. According to the trial results, these two cultivars outperformed the other breeding lines and cultivars. The groundnut industry is anxiously awaiting the release of these two new cultivars. The trial results were disseminated through the industry and presented at the yearly national cultivar results meetings held annually at the ARC:GC's offices in Potchefstroom.

## ACKNOWLEDGEMENTS

We thank the support ARC sister institutes and processors (SA Peanuts, Roba Foods, Quality Seed, VGM and JES-C Farms) provided in the cultivation of the national cultivar trials.

Keywords: breeding lines, elite trials, advanced trials, accessions

## ESTIMATION OF POTATO CROP COEFFICIENTS AND EVAPOTRANSPIRATION FROM CANOPY MEASUREMENTS AND SATELLITE-BASED NDVI

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## INTRODUCTION

Accurate estimation of crop evapotranspiration (ET) is crucial to optimize irrigation management and water use efficiency. Various irrigation management approaches are available. The FAO56 approach uses pre-determined crop coefficients (Kc values) for different growth stages, which is multiplied with Penman-Monteith reference evapotranspiration (ETo) to obtain daily crop ET. However, this approach is often not accurate, as local conditions may affect crop development and, therefore, actual Kc values. Alternative methods, which estimate crop coefficients in real-time, can help solve this problem. Normalized difference vegetation index (NDVI) has previously been applied to estimate Kc's and used with ETo to estimate ET for various crops. However, the potential of following this approach to estimate ET and manage the irrigation of potatoes has never been assessed. This study aimed to assess the use of NDVI to estimate Kc values and ET of potatoes and to compare these with values derived from the measured fraction of green canopy cover (FGCC) and the FAO-56 approach.

## MATERIALS AND METHODS

The study was conducted on six commercial centre-pivot irrigated fields in Gauteng and the Western Free State. Several plant growth variables were monitored three-weekly, including FGCC, fraction of intercepted photosynthetically active radiation (FI<sub>PAR</sub>) and satellite-based NDVI. Daily weather, irrigation, rainfall, soil water content, deep drainage, crop management and yields were recorded. Real-time Kc values for different crop stages were calculated from canopy variables and NDVI measurements, and compared with those using FAO56 Kc's. ET estimated using the various approaches was also compared with ET simulated by the LINTUL-Potato model.

## **RESULTS AND DISCUSSION**

Kc values based on FGCC and NDVI were, on average, 0.16 lower than those based on FAO-56 Kc values during the mid-season stage. ET estimated from FGCC and NDVI compared well with those calculated using the LINTUL-Potato model. These results suggest that dynamic crop coefficients and potato ET can accurately be estimated from canopy cover and NDVI measurements. The outcomes of this study should assist potato growers in accurately estimating crop water requirements, using real-time NDVI-based Kc values and ETo from automatic weather stations.

## CONCLUSIONS AND RECOMMENDATIONS

Real-time remotely sensed NDVI can be successfully used to estimate real-time crop coefficients, which when combined with real-time ETo, should help growers to accurately predict daily ET for improved irrigation management of potatoes.

KEYWORDS: potato irrigation management, remote sensing, soil water balance, water use efficiency, canopy state variables

## LONG-TERM CONSERVATION AGRICULTURE EFFECTS OF WHEAT PRODUCTION ON THE ECONOMY AND ENVIRONMENT

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## Introduction

Global wheat yields are under pressure to meet global demand despite the increasing threats to production due to a changing climate. The Western Cape of South Africa has adopted conservation agriculture (CA) as a possible mitigation strategy and was included in the SmartAgri-plan for the Western Cape Province.

## Materials and Methods

This study conducted a stepwise Life Cycle Assessment (LCA) to estimate the environmental and economic impacts of switching from conventional wheat production to CA's zero tillage (zero-till) and no-tillage (no-till) systems. The data was obtained from the long-term trials of the Western Cape Department of Agriculture's Langgewens and Tygerhoek research farms. It included a data set of 1,043 plot-level wheat observations from 2002 to 2020.

## **Results and discussion**

The results indicate that CA is more profitable and has a higher environmental efficiency than conventional tillage wheat production. In Langgewens, zero-till and no-till are 113% and 55% more efficient than conventional tillage when comparing the environmental impact of producing one kg of wheat. Findings also suggest that, compared to 100% conventional tillage wheat production, CA systems have reduced ecological damage in the Western Cape.

## Conclusion

The use of LCA analysis is a valuable tool to underpin the results from the long-term trials and the benefits not only to producers but also to the environment.

Keywords: conservation agriculture, economic benefits, environmental, sustainability

## ASSESSMENT OF PROTEIN, SELECTED MINERAL AND SECONDARY METABOLITE CONTENTS OF 16 COWPEA GENOTYPES GROWN UNDER FIELD CONDITIONS IN MBOMBELA

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## INTRODUCTION

Cowpeas (*Vigna unguiculate* (L.) Walp.) is a component of many traditional African household dishes that can help to alleviate nutritional and food insecurity challenges in many resource-poor homes where starch-based foods are dominant. As a protein- and mineral-rich crop, it has the potential to assist low-income families in achieving their daily protein needs as opposed to the more expensive animal protein and minerals sources or commercial food supplements. The purpose of this study was to compare the protein and nutritional contents of 16 cowpea genotypes.

## MATERIALS AND METHODS

Agronomic field trial comprising 16 cowpea genotypes (CV17A, CV17B, CV17C, CV17D, CV17E, CV17F, CV17I, CV17K, CV18-1A, CV23A, K20, KT-1A and KT3) as treatments were planted during 2022-summer growing season at the University of Mpumalanga experimental farm. The trial was a randomised complete block design (RCBD) with three replications. Crude protein and mineral (P, K, Ca, Mg, Zn and Fe) contents of harvested grains were milled and used for laboratory analysis. Determination of the mineral composition was according to (AOAC, 2000), while the crude protein content was computed from the equation %N x 6.25 (AOAC, 2000). Secondary metabolites determination (anthocyanin, flavonoids and total soluble sugars (TSS)) were determined according to Aquino-Bolanos et al. (2016), Makoi et al. (2010), and Al-Amri 2023), respectively. Data were analysed using Statistix 10.0, while the difference between treatment means was tested using the least significant difference at a 5% probability level.

## **RESULTS AND DISCUSSION**

Results of the descriptive analysis showed that the mean crude protein content ranged from 20.19 to 25.89% (mean = 22.88%), while other important mineral constituents such as P, K, Ca, Mg, Zn, and Fe had highly variable content among the different genotypes. Although the content of TSS showed no significant variation among the 16 cowpea genotypes, anthocyanin and flavonoid contents differed significantly (p<0.001), with the highest value recorded in CV18-1A and CV17C, respectively.

## CONCLUSION

The CV18-1A genotype had the highest grain yield and anthocyanin contents than any other genotypes, while CV17C had higher flavonoid content. The results also revealed that beyond the high protein and mineral contents, cowpea also constitutes a rich source of secondary metabolites.

Keywords: Cowpea, grain legumes, nutritional contents, protein, secondary metabolites.

## IMPROVED WHEAT YIELD IN CHALLENGING ENVIRONMENTS

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## INTRODUCTION

Diverse challenges constrain the production of wheat *Triticum aestivum*, one of the most important food crops in the world. Roughly half of South Africa's wheat requirement is imported. To maintain or improve production, South African cultivars with high yield and good adaptation to a variety of stressors are required in order to meet higher demand.

## MATERIALS AND METHODS

Since 2017 more than 400 wheat accessions were identified, planted and evaluated in multiple field trials in three wheat production areas of South Africa. During 2021 six accessions were identified to include in a randomised complete block design trial with an automated phenotyping platform. The trial was planted in July 2023 with 20 replicates of 12 entries (six test and 6 check accessions) under the Phenospex in Potchefstroom (ARC-Grain Crops). Mini-plots of 0.7 m<sup>2</sup>, each contained three rows with an inter-row spacing of 20 cm and 120 seeds per plot. Scans were performed 4 times per day and were taken from 8 August - 10 November 2023. Amongst other parameters digital biomass [mmÅ<sup>3</sup>], leaf angle [Ű], leaf area [mmÅ<sup>2</sup>], leaf area index [mmÅ<sup>2</sup>/mmÅ<sup>2</sup>], leaf area (projected) [mmÅ<sup>2</sup>], leaf inclination [mmÅ<sup>2</sup>/mmÅ<sup>2</sup>] and light penetration depth [mm] data were supplied by Phenospex software. An onsite automated weather station recorded temperature, humidity and wind amongst other parameters and soil moisture was recorded with soil moisture sensors.

## **RESULTS AND DISCUSSION**

Traits that provide stable but high yield under challenging environments such as drought and high temperature stress were shown to be of utmost importance by Shew et al. (2020) using South African data. Exposure to temperatures above 30°C was linked to high wheat yield loss with on average a 12,5 % yield loss associated with an extra day 24 h of exposure to temperatures above 30°C. Initial data exploration will look into the influence of hot conditions on leaf characteristics of the 12 wheat accessions in the trial.

## CONCLUSIONS

Phenotyping platforms generate large data sets affording researchers the opportunity to understand which crop traits are most involved in plant response to heat stress.

KEYWORDS: Agronomic adaptation, phenotyping platform

## ACKNOWLEDGEMENTS

Agricultural Research Council, DALRRD, South African Winter Cereal Industry Trust and Winter Cereal Trust for funding

### **REFERENCE LIST**

Shew, AM, Tack JB, Nalley LL & Chaminuka P. 2020. Yield reduction under climate warming varies among wheat cultivars in South Africa. Nature Communications 11:4408. https://doi.org/10.1038/s41467-020-18317-8 | www.nature.com/naturecommunications

## DIURAPHIS NOXIA RESISTANCE IN COMMERCIAL SOUTH AFRICAN CULTIVARS

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## INTRODUCTION

*Diuraphis noxia* (Mordvilko), known as the Russian wheat aphid (RWA) has been a serious pest of winter wheat in South Africa since 1978. After 45 years of continuous presence in the country, five different biotypes of this aphid species occur here. To address emergent concerns that RWA may become problematic in spring wheat production areas due to changes in climatic conditions, all commercial wheat cultivars were tested for host plant resistance to this aphid.

#### MATERIALS AND METHODS

South African commercial wheat cultivars from three distinct production areas were screened against prominent RWA biotypes in the glasshouse using a modified bioassay originally developed by Du Toit (1988). A split-plot design was used where each biotype was kept in a separate, closed cubicle with natural day/night conditions 13:11 h L:D and temperatures of 22/12°C to prevent cross contamination during the evaluation. A tray with 98 cones measuring 40 x 40 x 95 mm each, was used for cultivars from each region, for each biotype tested, with three replicates of each genotype per tray. The cultivars Gariep, Yumar and PAN 3144 were used as differential checks with Hugenoot and CItr 2401 as susceptible and resistant checks, respectively. Seedlings were infested with *circa* five RWA per plant and damage symptoms were evaluated 21 days post infestation using a 1-10 scale (Tolmay and Booyse, 2017).

## **RESULTS AND DISCUSSION**

Winter wheat for production in the central interior of South Africa had the highest number of cultivars with resistance to RWA, though no cultivars showed resistance to biotype RWASA5. Both the spring type cultivars for irrigation areas and spring dryland cultivars for use in the Western Cape showed no resistance to RWA. Most concern is for the Western Cape production region due to the increasing variability of the rainfall and potential for damage from this aphid to wheat in this area.

### CONCLUSIONS

Should RWA resistant cultivars be required for control of this pest in the spring wheat production areas of South Africa in future, specific breeding to develop the cultivars will be required.

KEYWORDS: Host plant resistance, Russian wheat aphid, spring wheat

#### ACKNOWLEDGEMENTS

Agricultural Research Council, DALRRD, South African Winter Cereal Industry Trust and Winter Cereal Trust for funding.

## **REFERENCE LIST**

Du Toit F, 1988. A Greenhouse test for screening wheat seedlings for resistance to the Russian wheat aphid, *Diuraphis noxia* (Homoptera: Aphididae). Phytophylactica 20: 321 322.

Tolmay VL, Booyse M, 2017. Valuable Russian wheat aphid-resistant bread wheat accessions identified using four South African *Diuraphis noxia* biotypes. South African J Plant Soil. 34(1), 65–70.

## LEAF HARVESTING PERIOD AFTER PLANTING INFLUENCES CAROTENOIDS AND IRON ACCUMULATION IN PURPLE-FLESHED SWEET POTATO (*Ipomoea batatas*) LEAVES

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## INTRODUCTION

Sweet potatoes (*Ipomoea batatas*) can contribute to global food security as well as climate change economically. Sweet potato leaves (SPLs) are rich in carotenoids such as  $\beta$ -carotenes, lutein, zeaxanthin, and mineral contents. SPLs, however, are less commonly consumed. The study investigated the accumulation of carotenoids and minerals in leaves of five genotypes with purple-fleshed storage roots harvested during three harvesting stages at 8, 12 and 16 weeks after planting (WAP).

## METHODOLOGY

Newly formed leaves (leaf 1 to 5) were harvested from genotypes Purple-Purple, 08-21p, 2019-11-2, 16-283p, and 2019-1-1 at 4 weeks intervals from 8WAP to 16WAP during vegetative (Harvest 1=H1), tuber initiation (Harvest 2=H2) and tuber bulking stages (Harvest 3=H3) over two growing seasons (Season 1 and Season 2). The plants were grown at the Agricultural Research Council, Vegetable, Industrial and Medicinal plants at Roodeplaat (GPS coordinates: 25, 56°S; 28, 35°E) in 2022 and 2023. Total carotenoids (TC) and mineral contents were determined using a spectrophotometer. The isolation of individual carotenoids was achieved using high-performance liquid chromatography. The data was statistically analysed using SPSS, separating the means with Tukey's HSD.

## **RESULTS AND DISCUSSION**

SPLs harvested during H1-8WAP showed high TC, lutein,  $\beta$ -carotene, zeaxanthin, and cis- $\beta$ -carotene. Synthesis of carotenoids is influenced by high temperature in the presence of light and increases to help disperse the excess energy absorbed as heat under high temperatures, hence high accumulation at H1-8WAP. The  $\beta$ -carotene contributed 26.99% of the TC, and the highest value obtained was 60.20 mg/100 g dry weight (dw). The  $\beta$ -carotenes are converted to vitamin A in the human body, and the recommended daily allowance (RDA) is 3-6 mg/day and 6-15 mg/day in children and older people, respectively. On the other hand, lutein contributed 56.01% of the TC, with the highest level of 128.35 mg/100 g dw. This compound protects the eyes against the ultraviolet rays from sunlight. SPLs harvested at H1-8WAP also accumulated high K (macro) and Fe (Micro) minerals. Fe content ranged from 21.55-48.53 mg/100g dw. The RDA of Fe required is 8 mg in men and 27 mg in pregnant women daily. The results show that genotype 16-283p had high TC, whereas lutein,  $\beta$ -carotene, K, and Fe were high in genotype 08-21p.

## CONCLUSION

Our results suggest that harvesting SPLs from genotype 0821p at H1-8WAP will provide the daily dietary intake level for Fe and  $\beta$ -carotene nutrients by serving 10-60 g of powdered SPLs. Additionally, it contributes to 1/3 of the amount needed for maintaining good eye health.

KEYWORDS: Bioactive compounds, Fe content, Leaf harvesting period, Minerals, leafy vegetables

## ACKNOWLEDGEMENTS

SARCHI-National Research Foundation (Grant no. 98352) and the Agricultural Research Council (ARC-VIMP) for funding this research study.

## EFFECT OF ADDITIONAL FOLIAR NITROGEN ON GRAIN YIELD AND PROTEIN CONCENTRATION OF WHEAT

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## INTRODUCTION

Nitrogen (N) is required in large quantities for wheat production. Field trials were conducted to study the effect of foliar N on yield and grain protein. Grain protein is an essential factor in determining wheat's milling and baking quality. Producers in South Africa are paid a premium for grain protein above 12.5%. The research was in the Western Cape at Langgewens (33°, 16'34.8" S 18°42'15.3" E) and Tygerhoek (34°08'56.6" S 19°54'09.9" E) on shallow sandy loam soil with a high stone content and a Mediterranean type climate.

## MATERIALS AND METHODS

Wheat was planted after either canola or medics with different nitrogen top dressing rates to end with the following rates: 0 (control), 25, 50, 75, 100, 130, 160,190 kg N ha<sup>-1</sup>. Additional foliar N (20 kg N ha<sup>-1</sup>) was applied at the flag leaf stage as urea ammonium nitrate (UAN). The data was collected between 2016 and 2020. The rainfall was low and sometimes erratic during these five years. The grain yield and protein content were measured and compared between foliar and non-foliar applications.

## **RESULTS AND DISCUSSION**

Foliar N applications on wheat (*Triticum aestivum* L.) after canola at Langgewens have increased the mean grain yield in all the years except 2019. There was no significant difference between the mean protein content, except in 2017. The grain protein increased from 15.5% to 16.2% this year, receiving less than half the annual rainfall. Wheat planted after medics, the mean yield decreased in all the years except 2017, which increased significantly. This could be due to the limited soil moisture for crop nitrogen uptake from soil. At Tygerhoek, with a milder climate, the average grain yield of wheat planted after canola decreased significantly in 2016 and showed no significant effect on the foliar applied N in 2017 and 2018, while increasing in 2019 and 2020. The average grain protein significantly increased in 2016 and 2017 but showed no response in 2018 and 2020, while decreasing in 2019.

## CONCLUSIONS

The foliar application of additional nitrogen fertiliser on wheat always successfully increased wheat yield and grain protein for specific seasons. There was a strong, significant negative correlation between yield and protein content at Langgewens for wheat after canola and medics. Additional foliar nitrogen application can be useful in dry conditions when soil moisture is limited for nitrogen uptake.

**KEYWORDS:** Wheat yield protein foliar nitrogen

## ACKNOWLEDGEMENTS

Winter Cereal Trust for financial assistance.

## EFFECT OF SELECTED BIOSTIMULANTS ON THE PHYSIOLOGY AND GROWTH OF THE COMMON ONION (*ALLIUM CEPA* L.)

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## INTRODUCTION

Onion (*Allium cepa* L.) is one of the most commercially valuable vegetables cultivated worldwide. Preceded only by tomatoes, onions rank second on the list of worldwide cultivated vegetable crops. Plant biostimulants are an emerging trend of crop management products that can enhance nutrient uptake, plant growth, and productivity under various conditions. Therefore, a study was conducted to investigate the ability of selected biostimulants to improve the growth and selected physiological parameters of onions.

## MATERIALS AND METHODS

A glasshouse experiment was conducted in the 2022-2023 season in the Department of Soil, Crop, and Climate Sciences at the University of the Free State. The experiment was laid out in a two-factorial, complete, randomized design with five replications. The experiments were consecutively conducted to study the effect of foliar application of different biostimulants on an onion cultivar's (Akamaru) growth, physiology, and soil microbial activity. All the biostimulants were tested at the recommended dosages as well as half and double the recommended concentrations. Data were subjected to ANOVA using the NCSS, and mean separation was done using TukeyTest at p = 0.05.

## **RESULTS AND DISCUSSION**

Results indicated that the onion cultivar's biostimulants significantly increased biomass production, bulb yield, leaf photosynthesis, pigments, and chlorophyll fluorescence compared with untreated control plants.

## CONCLUSION

The results of this study highlighted the potential impact of different biostimulants on the growth and physiological parameters of onions at different concentrations. Depending on the concentrations, most biostimulants significantly increase onions' growth and physiological parameters.

### **KEYWORDS**

Onions, biostimuants, growth, photosynthesis

## CONSERVATION TILLAGE PRACTICES FOR POTATO PRODUCTION AND THE ASSOCIATED SOIL BIOLOGICAL ACTIVITY SPANNING THREE PRODUCTION CYCLES

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## INTRODUCTION

Tillage plays a major role in modification of soil structure as it influences the distribution of energy rich organic matter within the soil profile and thus impacts the soil biological activity. The aim of this study was to investigate the effect of conservation tillage on the levels of biological activity in the soil spanning three production cycles of potato planting.

## MATERIALS AND METHODS

The trial was conducted in Aurora under a centre pivot from 2014 to 2022 spanning three production cycles on the same field. The trial layout was randomised complete block. Three tillage treatments were investigated, a conventional mouldboard tillage treatment, a conservation rip treatment and a conservation paraplough treatment. The soil respiration ( $CO_2$ ) samples were taken before commencement of treatments and then again ten weeks after emergence of plants. Samples were weighed (20.00-20.01 g) into glass vials of which the volume is known; thereafter the vials were closed and left for 30 min to create headspace. After 30 min the gas was drawn through septa in the lid. Agilent's gas chromatography was used in this procedure which was fitted with a thermal conductivity detector to measure  $CO_2$  and  $O_2$ . The apparatus was calibrated using a standard containing 7.9%  $CO_2$  and 11.9%  $O_2$ .

## **RESULTS AND DISCUSSION**

The soil biological activity, ten weeks after emergence, was the highest (P<0.05) in the rip treatments in the third cycle (2022) and the paraplough treatment the highest (P<0.05) in the first (2014) and second (2018) cycles whereas the mouldboard treatment consistently produced the lowest values. There were a gradual increase in the values attained in the paraplough and rip treatments from the first cycle to the last cycle from a base value of 5.36 mg/kg/h CO<sub>2</sub> in 2014 with an increase of 85% in the case of the paraplough and 109% in the case of the rip treatment. The mouldboard treatment led to a reduction of 65% in biological activity. The rip treatment, after three production cycles, showed a significant difference with the paraplough treatment which indicates it is more beneficial to soil biological activity than the paraplough treatment.

## CONCLUSION

Due to the less aggressive nature of the rip tillage action it is evident that it leads to higher soil biological activity in relation to the other treatments after three production cycles.

KEYWORDS: Carbon, Conservation tillage, paraplough, potato, rip

## EVALUATION OF CHICKPEAS FOR POSSIBLE INCLUSION IN THE SMALLHOLDER FARMER CROPPING SYSTEMS OF THE MPUMALANGA LOWVELD

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## Introduction

Chickpea (*Cicer Arietinum*) is a herbaceous, annual plant that grows normally to height of 70 cm. It is believed that the varieties grown in South Africa first originated from Turkey. In South Africa, the crop is not grown commercially, although in two provinces, Mpumalanga and Limpopo, the crop is grown on a small scale. However, large quantities of chickpea are consumed in South Africa, as whole grain or as dhal.

## **Material and Methods**

Field experiments were conducted during 2019–2020 and 2021-2022 at the University of Mpumalanga (25°25' 30"S, 30° 58' 14"E) on the same location. 10 chickpea varieties were laid out in a Randomized Complete Block Design (RCBD) with 3 replications, in plots 4 m long and with 4 rows per plot. An interrow spacing of 40 cm and an intra- row spacing of 10 cm were used, and seeds were placed at a depth of 7 cm. In each plot, stand establishment, hundred seed mass, shelling percentage, and grain yield were recorded. The data collected were subjected to analysis of variance (ANOVA) and mean separation using Tukey's Honestly Significant Different (Tukey HSD) with the Statistix 10.0 software package.

## **Results and Discussion**

Different variety yield results were obtained from the two cropping years, although the same varieties were planted in both cropping years. The highest three grain yielding varieties in 2019-2020 were ICCV 3111 (2080 kg/ha), ICCV 4105 (1969 kg/ha) and ICCV 97024 (1931 kg/ha), and in 2021-2022 the highest three yielding varieties wiz; ICCV 4110 (3566 kg/ha), ICCV 4105 (2779 kg/ha) and ICCV 92944 (2712 kg/ha) (Figure1). During the 2019-2020 cropping year, the highest shelling percentage was recorded in variety ICCV 8101 at 37%, and the lowest in variety ICCV 3110 at 25%. In 2021-2022 cropping year, the highest shelling percentage was recorded in variety ICCV 3203 at 28%, while ICCV 3110 was again the lowest at 20%.

## Conclusions

ICCV 3111 and ICCV 4110 were selected as outstanding varieties based on their grain yield and other parameters such as stand establishment, Hundred seed mass and shelling percentage. These selected outstanding varieties will be further introduced to the smallholder farmers in Lowveld of Mpumalanga Province through the collaboration with other stakeholders (Extension officers)

#### Keywords

Chickpeas, Cropping year, Seeds, Variety, yield

## THE EFFECTS OF MICRONUTRIENT FOLIAR APPLICATIONS ON THE POST-HARVEST YIELD AND QUALITY OF HYDROPONICALLY GROWN TOMATOES

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## INTRODUCTION

The success of soilless cultivation systems depends on the nutrient solution and the management thereof. This study explores the impact of micronutrient foliar applications such as silicon (Si) and boron (B) on the post-harvest yield and quality of two tomato varieties in different fertigation systems where the calcium ( $Ca^{2+}$ ) and potassium (K<sup>+</sup>) ratio is adjusted. Using these fertigation systems, the objective is to determine whether the nutrient use efficiency (NUE) can be improved within the respective treatments.

## MATERIAL AND METHODS

The study was conducted in a greenhouse on the Welgevallen Experimental Farm in Stellenbosch, Western Cape. Two types of tomatoes were used, Floradade and Solarino RZ F1 (72-150). Seedlings were planted into 20 L bags with coconut peat as the growing medium. The trial comprised of four treatments with an open-hydroponic system where a foliar feed of Si, B, or a combination of the two was applied in conjunction with a fertigation solution where the Ca:K ratio was adjusted or followed standard recommendations. This adjusted solution had reduced Ca<sup>2+</sup> and increased K<sup>+</sup>, whereas the standard solution had ratios according to Steiner. Analysis of the data was done using R (R Core Team, 2023) and STATISTICA Version 13.3 (TIBCO Soft Inc. 2016) for statistical software. A full nutrient analysis was also conducted on the fruits.

## **RESULTS AND DISCUSSION**

The adjusted Ca:K treatments reported an 18% increase in NUE for the marketable weight of the harvested product, and an 8% increase for the marketable weight of all the treatments combined, allowing growers to receive a larger percentage of marketable product at the same input cost and volume compared to the standard fertigation treatments. While Ca-deficiencies could not be prevented by Si and B foliar feeds, the occurrence of blossom-end-rot (BER) was reduced where they were applied, with fruit quality and shelf-life benefitting from this addition.

## CONCLUSIONS

It is confirmed that the NUE can be improved in hydroponic tomato production where Si and B are applied as foliar feed substitutes for Ca<sup>2+</sup> without compromising the quality and post-harvest shelf-life of tomato. Ca-deficiencies could not be prevented by Si and B foliar feeds but were reduced to a certain degree. This reduction allowed for an increase in the NUE of these treatments, which should enable growers to receive a larger percentage of marketable product for the input costs compared to the treatments that had a standard Ca:K ratio.

## REFERENCES

R Core Team (2023). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. <u>https://www.R-project.org/</u>.

STATISTICA Version 13.3 (TIBCO Soft Inc. 2016). Hamburg, Germany. https://www.statistica.com/.

Keywords: Boron, calcium, nutrient solution, nutrient use efficiency (NUE), silica, Solanum lycopersicum.

# **ARTICLE WRITING TIPS**

## South African Journal of Plant and Soil: Tips for authors January 2024 v2

The Board of the South African Journal of Plant and Soil (SAJPS) has agreed to changes in the way in SAJPS operates. Some of these changes are necessary and timely due to the increase in plagiarism and the increasing use of artificial intelligence (AI) software tools. Such tools may be used to develop funding proposals, research reports and even draft papers, for example. The Board is also considering an agro-environmental policy given the role of ethical standards in agro-environmental research in submitted articles.

Due to the difficulty in finding reviewers, the Board has also agreed that there be a mentoring process, involving a pre-review, to better prepare submitted manuscripts for the review process. This will certainly make the job of reviewers easier and benefit the author(s). This process will be before the manuscript (MS) has been submitted for a review. While this process is specific to SAJPS, many of the tips apply to any scientific journal submission, again benefitting the author(s).

The content here documents the requirements of the pre-review – the so-called tip list, but also gives SAJPS changes to some of the details required that are now to be included in the covering letter and in the submitted MS. Some information/requirements are also repeated here since many submissions do not include or deviate from such.

Please note that full papers submitted to the SAJPS should be based on data collected over at least two seasons to allow for validation – otherwise the manuscript (MS) is regarded as a Short Communication. Please make clear the duration of the study in the Materials and Methods.

The MS should be checked by someone proficient in English, prior to submission, before it can be sent to reviewers. If this is not the case, the MS will be returned for correction.

From January 2024, it is the responsibility of the corresponding author to submit a statement on the result of a plagiarism software check as part of the covering letter.

From January 2024, the role of each author must be explicitly stated in a section of the MS: "Author contributions".

From January 2024, the extent and role of the use of ChatGPT, or equivalent artificial intelligence (AI) software must be declared. This use must be explicitly declared by the author(s) in the MS and must appear as a statement before the reference list and after the Authors' contribution section, in a paragraph with the heading: **Extent of use of artificial intelligence tools** In particular, the author(s) must indicate which ideas, protocols, writings, data, results or sections of the submission stemmed from, made use of, or benefitted from the use of AI software.

## **Covering letter**

Please ensure that the covering letter addresses the following in detail and no further information. The covering letter needs to be a separately attached file and not included with the MS and contain:

• Title of the article.

• A statement that all authors have reviewed the MS and approved its submission to the SAJPS.

• A statement that the MS is not being submitted elsewhere.

• A statement indicating why the journal should consider publishing the work and outlining the importance/novelty of the research.

• A statement on the contribution of each co-author. This contribution of each author must be detailed in the MS in a section entitled "Author contributions" immediately after the "Conflict of interest" section.

• A statement on which ideas, protocols, writings, data, results or sections of the submission stemmed from, made use of, or benefitted from the use of artificial intelligence (AI) software.

• A statement on the result of a plagiarism software check. [Also, please note that the SAJPS reserves the right to check a submission for plagiarism prior to the review process. If plagiarism is found post-publication, the SAJPS reserves the right to retract the published paper and black-list the author(s) from publishing for a period of time.]

## Response to review/reviewer(s)

If the MS is a resubmission, following an Editor-in-Chief review or a full review, there should a separate file (*Response\_to\_review.pdf*) uploaded by the corresponding author that, point-by-point, addresses the concerns of the reviewers/editors.

## Journal format

Please carefully examine the attached pdf files for SAJPS manuscript format, including in-text referencing, referencing of tables and figures, and the format for the reference list:

## Reference exemplars for authors.pdf

## Soil management for carbon sequestration Example of format 300723.pdf

Please accurately check the MS or revised MS for errors, inaccuracies and deviations from SAJPS format before submission. Please also ensure that all authors review and have agreed to the MS (first submission) as well as revised version.

## English, grammar and tenses

The MS should be checked by someone proficient in English prior to submission before it can be sent to reviewers. If this is not the case, the MS will be returned for correction.

General principle – the KISS principle. Keep it short and simple. This refers to sentence structure. This makes for much easier reading for the reviewers.

With regard to tenses, "Introductory statements describing the current understanding of the issue should use the present tense, references to previous research should use the present perfect, and descriptions of the methods and results should use the past tense. The discussion may use past tense for reported data and future tense for future research directions" (https://www.unlv.edu/sites/default/files/page\_files/27/GradCollege-VerbTenseScientificManuscripts.pdf).

The tenses used in sentences of the Abstract should be based on what is being discussed: introductory statements – present tense; methods and results – past tense; discussion section – present tense when explaining the implications or significance of data or findings; concluding remarks – past and future tenses. The MS should then use these tenses for the relevant sections.

## <u>General tips – based on commonly occurring errors/omissions/grammar</u> <u>error/spelling errors, etc. from many submissions</u>

If applicable, please indicate countries in the address of the authors and countries of funding bodies in the Acknowledgements where appropriate.

The MS should have double-spacing throughout, including references and tables. Please use continuous line numbering.

Please ensure that Word is using a South African English dictionary and not an American one to avoid spelling errors such as behavior, modeling, endeavor, etc.

For tips on writing a good Abstract, Introduction and Conclusion section, please refer to the document, available on request: *Tips for Abstract Introduction Conclusions SAJPS 080124.docx* 

The Abstract needs to be one paragraph, not multiple paragraphs.

The word "Keywords" should be in bold. Keywords, not keyword. Keywords should not contain words already used in the title and should be listed alphabetically, comma separated, all in lower case excluding the first letter of the first keyword which should be capitalized.

Please consult the example paper attached for the format for figure captions and table headings.

Please consult other example manuscripts for formatting equations. Please note that datum refers to one value and data many values. Hence: These data are .....and not These data is ....or This data is .... Otherwise, This datum is...` Another example: data utilized for subsequent analysis are accurate and reliable not

data utilized for subsequent analysis is accurate and reliable

## Units, terms and reporting of data: selected examples

Please use SI units throughout the MS - cm in mm or m, S m<sup>-1</sup> or S mm<sup>-1</sup> not S cm<sup>-1</sup>, mmol kg<sup>-1</sup> not cmol kg<sup>-1</sup>. Note: the -1 should be superscripted. ppm should be  $\mu$ L L<sup>-1</sup> or mg kg<sup>-1</sup> where  $\mu$  should be the symbol for micro and -1 is superscripted.

Please report data with a number, a space and an SI unit.

Please use units such as mg kg<sup>-1</sup> where the -1 is a superscript and not mg/kg.

Please always leave a space between a number and a unit and a space between different units.

Numbers between 1 and 12 should be in words (one to twelve) and greater than twelve in numbers, i.e., 13, 14, etc.

In the materials and methods section, equipment or software details should contain model or version details and, in brackets, the company name, city and country.

Please use the term "air temperature" and not "temperature".

In-text list of items, or items in tables or figures should be in alphabetic order or in a logical order. For example, when there is a list of items, such as:

water, fertilizers, and pesticides

and there is no particular order, please arrange in alphabetic order.

A list of sites should be in alphabetic order or in a location order, e.g., west to east or north to south. Please do not included common knowledge statistical equations in the MS. For these, please use a reference.
Please avoid the extensive use of acronyms. If they are necessary, define them when first used and not again in the MS.

When reporting statistics, for example

(*p* < 0.001)

please use lowercase p in italics.

Please	always	leave	а	space	before	and	after	=,	<,	>
Not										
(p<0.001	)									
but										
( <i>p</i> < 0.001)										
with <i>p</i> in italics.										
sub-Saharan Africa (SSA)										
not										
Sub Saharan Africa (SSA)										
southern	Africa									
not										
Southerr	n Africa									
unless at the beginning of a sentence.										

## Figure labels

Figure labels should be a label name, followed by a space and the unit in brackets. For example: AIR TEMPERATURE (°C) [where the o is superscripted]

Another example: ELECTRICAL CONDUCTIVITY (mS m<sup>-1</sup>) [where the -1 is superscripted]

## <u>Tables</u>

Please list the rows of a table in a logical or alphabetic order. Once these are in that order, please list the columns of the table in a logical or alphabetic order.

## Normal MS structure – apart from reviews

Abstract Keywords Introduction Materials and methods Results Discussion (or combined Results and discussion) Geolocation Conflict of interest Author contributions Extent of use of artificial intelligence tools Acknowledgements – including funding statement, if applicable.

## **Acknowledgements**

Co-authors should not be acknowledged since they are already acknowledged by being co-authors.

Supervisors should not be acknowledged if they are co-authors.

This section not contain personal statements such as:

I would like to acknowledge the support of my colleagues/family in this research.

When acknowledging funding bodies, please include their country name.