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**South African Society of Crop Production  
Suid-Afrikaanse Vereniging vir Gewasproduksie**

*E-mail:* [sascp.secretariat@gmail.com](mailto:sascp.secretariat@gmail.com)  
*Website:* [www.sascp.org.za](http://www.sascp.org.za)

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**Soil Science Society of South Africa  
Grondkunde Vereniging van Suid-Afrika**

*E-mail:* [theo.dohse@webafrica.org.za](mailto:theo.dohse@webafrica.org.za)  
*Website:* [www.soils.org.za](http://www.soils.org.za)

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**Southern African Society for Horticultural  
Sciences  
Suider-Afrikaanse Vereniging vir  
Tuinbouwetenskappe**

*E-mail:* [Karin@arc.agric.za](mailto:Karin@arc.agric.za)  
*Website:* [www.sashs.co.za](http://www.sashs.co.za)

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**Southern African Weed Science Society  
Suider-Afrikaanse Vereniging vir  
Onkruidwetenskap**

*E-mail:* [mikefe@elsenburg.com](mailto:mikefe@elsenburg.com)  
*Website:* [www.weeds.org.za](http://www.weeds.org.za)

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**ABSTRACTS**

**POSTER PRESENTATIONS**

LISTED ALPHABETICALLY

## EVALUATION OF SOME PRE-EMERGENCE HERBICIDES FOR VOLUNTEER POTATO CONTROL

J Allemann<sup>1</sup>

<sup>1</sup>University of the Free State, P.O. Box 339, Bloemfontein 9300

Allemannj@ufs.ac.za

### INTRODUCTION

Volunteer potatoes can cause huge weed problems in crops following potatoes, as large numbers of potato tubers remain behind in the field after mechanical harvesting. These volunteer plants can create havoc with rotation programs and serve as a source of pests and diseases for potato crops in the vicinity. Control of these plants is both difficult and costly. The aim of this project was to identify a suitable product to control volunteer potato plants before they become a problem.

### MATERIALS AND METHODS

A glasshouse trial (28/18°C day/night) was conducted using 37x37x27.5 cm polyethylene pots filled with a sandy soil (9% Cl). Two potato cultivars (Mondial and Sifra) and five PRE herbicides (atrazine, clomazone, imazethapyr, mesotrione and picloram), together with a soil fumigant (metham potassium) and an untreated control were tested. The trial was laid out in a randomised complete block experimental design. All products, with the exception of metham potassium (which was drenched), were applied using a laboratory sprayer, calibrated to deliver 200 L ha<sup>-1</sup>, seven days after four potato tubers were planted in each pot. Products were all leached into the soil following application. Pots were monitored daily and watered as needed. Harvesting took place 65 DAP and stem numbers, plant height, and tuber number, as well as plant and tuber mass determined. Data were converted to a percentage of the control treatment in order to negate inherent cultivar differences prior to statistical analysis.

### RESULTS AND DISCUSSION

Metham potassium was the only product that provided 100% control, although both mesotrione and picloram also provided significant reduction in plant growth and tuber development. Although clomazone did not affect plant growth, it did reduce tuber numbers significantly (50%) over that of the untreated control. Picloram reduced haulm numbers and plant height by 99% and 75% respectively, with the use of mesotrione resulted in 83% and 54% reduction in these two parameters. These two herbicides reduced plant dry mass by 72 and 50% respectively. Tuber numbers were reduced by 94%, 92% and 54% by the use of mesotrione, picloram and clomazone respectively. Similar results were noted for tuber mass, although Mondial appeared to be more sensitive than Sifra when this parameter was analysed. The herbicide results were similar to those obtained overseas.

### CONCLUSIONS

The most effective treatment to control volunteer potatoes was metham potassium, but this also had the greatest application rate, making it an expensive option. Mesotrione showed great promise, and will be investigated in more detail during future trials. Picloram is not registered for use in cropping systems and cannot be recommended, despite its efficiency, even though numerous producers use it. These trials should be conducted using more cultivars as there do appear to be cultivar differences wrt herbicide sensitivity.

### ACKNOWLEDGEMENTS

Potatoes South Africa for funding this research

**Keywords:** Mesotrione, Metham potassium, Mondial, Picloram, Sifra

## APPLICATION OF IN-FIELD RAINWATER HARVESTING FOR SUSTAINABLE HOMESTEAD FOOD PRODUCTION

JJ Anderson & JJ Botha

*ARC-Institute for Soil, Climate and Water, Private Bag X01, Glen, 9360*

AndersonK@arc.agric.za

### INTRODUCTION

In sub-Saharan Africa millions of people living in rural areas depend on rainfed agriculture for food and income, but highly variable rainfall, frequent droughts, runoff, high evaporative demands and low water productivity are consistently undermining food security. In many rural villages households have given up cropland farming, but subsistence homestead gardening is still an important tool to relieve poverty and promote economic development. Rainwater harvesting can be applied to use water more productively whilst improving yields and reliability of production by concentrating rainwater as runoff from a larger area for its productive use in a smaller target area.

A study was undertaken to quantify the increase in homestead productivity in semi-arid areas through improved crop yields by applying the in-field rainwater harvesting (*IRWH*) technique.

### MATERIAL AND METHODS

In an attempt to address the food insecurity situation in rural villages, *IRWH* versus conventional tillage (*CON*) was demonstrated in the homestead gardens of selected villages in South Africa, Zimbabwe and Botswana. Maize was used as the indicator crop with a plant population that varied from 18 000 to 22 000 plants ha<sup>-1</sup>. Grain yield was used to assess the production potential of *IRWH*.

Villagers who showed interest in applying the *IRWH* technique were assisted to prepare their homestead gardens for rainwater harvesting and provided with relevant crop production information. In order to assess *IRWH* for improved homestead productivity in communal areas, the numbers of households and villages that implemented and utilized *IRWH* as well as their grain yields were recorded over a period of 13 years in the three countries.

### RESULTS AND DISCUSSION

The *IRWH* technique resulted in higher maize yields due to its ability to harvest and conserve rainwater far better than *CON*. For the South African villages the average yield of *IRWH* (2884 kg ha<sup>-1</sup>) was 1044% higher than that of *CON* (252 kg ha<sup>-1</sup>). The overall mean yield of the *IRWH* treatment at the homestead demonstration sites in all three countries was 140% higher than that of *CON*.

### CONCLUSIONS

The livelihoods in many rural villages were improved through the implementation and application of the *IRWH* technique. This was achieved through improved yields and crop diversity, income generated from the surplus, self-employment opportunities and improved nutritional status of household members.

**Keywords:** crop production, food security, in-field rainwater harvesting, semi-arid

## SOILS OF THE MGOBEZELENI ESTUARY CATCHMENT WITH A PARTICULAR EMPHASIS ON THEIR DISTRIBUTION AND AGRICULTURAL SIGNIFICANCE

JT Atkinson<sup>1</sup> and KR Barichievy<sup>1</sup>

<sup>1</sup> KZN Department of Agriculture and Rural Development, Private bag X9059, Pietermaritzburg 3201

jon.atkinson@kzndard.gov.za

### INTRODUCTION

National Government has identified the Jozini and Umhlabuyingana Local Municipalities in Northern KwaZulu-Natal (KZN) as a priority agricultural production area. Historically, these areas have been underperforming with regards to agricultural production, due to unheeded soil related limitations and poor land management and crop selection. The objective of this study is to improve our understanding of the spatial soil dynamics, identify soil limitations and ultimately provide workable land management solutions for the coastal plain section of this priority area.

### MATERIALS AND METHODS

The Mgobezeleni Estuary Catchment covers approximately 8 325 ha and is located in the south-eastern corner of aforementioned priority area. A soil sampling strategy was developed, based on a thematic map of variation and was created through the systematic combination of terrain covariate datasets. A total of 192 soil points were assessed up to a depth of 2.5 metre and 49 soil samples were extracted for detailed laboratory analysis. Samples were spread over a number of soil forms, soil horizons and land uses *inter alia* forestry, community gardens, natural veld and wetlands.

### RESULTS AND DISCUSSION

A strong correlation was found between the occurrence of clay and organic matter in selected soil forms. That is, soil forms which had the highest organic matter content also had amongst the highest values of clay percentage in the topsoil. The hypothesis is that the relationship between the dune topography, subsurface water recharge and coastal vegetation has created a feedback system for clay and humic material accumulation, particularly in pans and valley bottoms, resulting in "hotspots" of nutrient accumulation. Spatially, this trend is evident in that most subsistence activities are concentrated in these higher productive soils which are either in permanent or seasonal wetlands. The challenge is to identify potential soil management approaches that could be applied to the poorer quality, low yielding soils in the area but still provide the same yield benefits obtainable from the highly productive organic soils in the catchment. Preliminary results obtained from a community garden project, engaged in permaculture, have shown that with improved site management and soil nutrient conservation practices it may be possible to improve the agricultural potential of the typically dystrophic sandy soils of the coastal plains.

### CONCLUSION

Poor agricultural practices and rapid population growth has resulted in the unsustainable exploitation of highly nutrient-enriched areas such as wetlands in the Mgobezeleni catchment. Results have shown that there is a need to further explore agricultural practices that are both productive and environmentally sustainable.

**Keywords:** Mgobezeleni, wetlands, permaculture, coastal plains

## SITE VARIABILITY AT SAASVELD: INITIAL ASSESMENT OF THE RESEARCH SITE FOR THE LONG-TERM COMPARATIVE FARMING RESEARCH PROJECT

N-J Mashele<sup>1</sup> & RMB Auerbach<sup>1</sup>

<sup>1</sup>Nelson Mandela Metropolitan University, Pvt Bag X6531, George 6530 W Cape

Raymond.auerbach@nmmu.ac.za

### INTRODUCTION

A long-term comparative investigation into organic and conventional farming systems was recently initiated in George. The existing dense kikuyu (*Pennisetum clandestinum*) sward which looked uniform from a production perspective varied considerably with regard to soil fertility parameters. Further investigation through an indicator crop (Caliente mustard - *Brassica juncea*) showed that there was also considerable variation in pre-treatment crop yield. This variation was measured and quantified, as a baseline for the research trial.

### MATERIALS AND METHODS

The experiment is a randomised block design using four organic and four conventional treatments, plus two unfertilised control treatments with four replications planted twice each year. All weeds controlled by hand hoeing. Control plots with mono-cropped cabbage (*Brassica oleracea*), chemically treated for pests and diseases in line with common local practice, but not fertilised. Conventional treatment receives the same pest and disease control regime, fertilised with compound fertiliser with nitrogen top-dressing. One plot planted to mono-cropped cabbage, while the other three plots will rotate between cabbage, sweet potato (*Ipomoea batatas*) and cowpeas (*Vigna unguiculata*). Organic rotation is similar to conventional rotation, but is fertilised with a moderate dressing of compost, receives only biological pest and disease control, and the cowpea crop is followed by a green manure cover crop of oats and vetch. To quantify site variability, the mustard crop was planted on 21<sup>st</sup> March 2014. Of the 40 plots, 36 plots were classified as sandy loams, and four as sandy soils. The macronutrients N and P were below the required values; soil aluminium content was high. The pH (KCl) ranges from 4.8 to 6.3.

### RESULTS AND DISCUSSION

As expected, given that the crop was neither composted nor fertilised, crop growth was not vigorous. Initially, Replications 1 and 2 showed more vigorous growth, but eventually most of the plants exhibited purpling of the leaves and other nutrient deficiency symptoms. Initial soil analysis was followed by leaf analysis of the crop, and biometrical analyses performed included ANOVA, t-tests.

When soil factors and plant growth were compared, there was a weak correlation between yield heights of mustard and soil phosphorus levels ( $r = 0.416840$ ,  $p < 0.05$ ), and between the yield height and the soil pH ( $r = 0.303097$ ,  $p < 0.05$ ). A weak negative correlation was found between yield height and the replication number ( $r = -0.249380$ ,  $p < 0.05$ ). Comparison between leaf and soil analysis also showed a weak correlation between leaf P and soil P ( $r = 0.558270$ ,  $p < 0.05$ ).

### CONCLUSIONS

Poor growth of the mustard crop was weakly but significantly correlated to yield height, soil phosphorus, soil pH and replication. Soil analysis results characterise the soil for the future research, and foliar analysis shows that plants ran out of P and K. The yield of a crop is the end product of complex processes going on in the plant.

**Keywords:** baseline variability study.

## EFFECT OF BROILER MANURE, EFFECTIVE MICROORGANISMS ENRICHED COMPOST AND INORGANIC FERTILISER APPLICATION ON GROWTH AND YIELD OF TOMATO

K Shikwambana and VI Ayodele

School of Agricultural and Environmental Sciences, University of Limpopo,  
Private Bag X 1106, Sovenga 0727

victoria.ayodele@ul.ac.za

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown worldwide. Tomato plays an important role in the human nutrition as it is a rich source of vitamins, proteins and fibre. Resource poor farmers cannot invest in the use of mineral fertiliser for improved vegetable crop production. The objective of the study was to determine the effect of sole and combined application of broiler manure; effective microorganisms enriched compost and inorganic (NPK) fertiliser on growth and yield of tomato.

### MATERIALS AND METHODS

A field study was conducted during the 2013/2014 growing season on the field next to the horticultural skill centre (23° 53' 10" S; 29° 44' 15" E), University of Limpopo, South Africa. The experiment was arranged as a RCBD with six treatments and replicated three times. Each experimental unit was 2 m x 2 m with 1 m spacing between units and 1 m between blocks. The treatments were (a) Control (b) Recommended amount of EM (Ravivi) enriched compost (12.88 kg / 4 m<sup>2</sup>), (c) Recommended amount of broiler manure (4 kg / 4m<sup>2</sup>), (d) recommended amount of inorganic fertiliser NPK (2:3:4 (30) at a rate of 200 kg ha<sup>-1</sup> N, 85 kg ha<sup>-1</sup> P and 269 kg ha<sup>-1</sup> K, this was applied as N from urea at 166.7 g / 4 m<sup>2</sup>, P from single super phosphate at 809.52 g / 4 m<sup>2</sup> and K from potassium chloride (KCl) at 323.8 g / 4 m<sup>2</sup>, (e) 50 % of recommended amount of inorganic fertiliser + 50 % of recommended amount of broiler manure and (f) 50 % of recommended amount of EM enriched compost + 50 % recommended amount of inorganic fertiliser. Transplanting of tomato seedlings was done at 30 x 60 cm. The following parameters were recorded stand establishment, days to 50 % flowering, days to 50 % fruiting, plant biomass (fresh and dry), plant height, plant vigour, number of branches, chlorophyll content, number of fruits, fruit diameter and fruit yield.

### RESULTS AND DISCUSSION

Growth and yield of tomato increased irrespective of the type and source of fertiliser material. Tomato plants with significantly higher number of primary branches, plant vigour and fresh shoot mass were obtained in sole NPK and broiler manure treatments compared to the control. Furthermore, early fruiting (56 days after transplanting) was obtained in NPK treatment compared to 85 DAT recorded in the control. The significantly highest average number of fruits per plant (33), fresh fruit mass per plant (14.5 g) dry fruit mass per plant (24 g) was obtained in NPK treatment.

### CONCLUSION

Both inorganic and organic fertiliser application had a positive impact on tomato's growth and yield. Better performance of tomato was obtained in sole application of NPK and broiler manure. Thus of the two fertiliser materials can be used by smallholder farmers to improve tomato production in the Province.

**Keywords:** NPK fertiliser, plant vigour, sole and combined application

## ROOIBOS BREEDING: A CHALLENGE

C Bester<sup>1</sup>, A Manjati<sup>1</sup>, M Joubert<sup>1</sup>

<sup>1</sup>ARC Infruitec-Nietvoorbij, Private Bag X5026, Stellenbosch, 7599

manjatia@arc.agric.za

### INTRODUCTION

Rooibos (*Aspalathus linearis*), internationally known for its use as herbal tea, is endemic to the South African Fynbos biome. Initially a small industry originated depending on harvesting in the wild, but the demand soon escalated partly due to increasing interest in its perceived health properties. The first rooibos commercial plantings were established in the 1930s, and by 2010 more than 5600 tonnes were exported. However, a shortage of good quality plant material is currently hampering the growth of the industry. As a result the ARC has been involved in several research projects to support this growing industry and in 2013 a genetic improvement programme for rooibos was initiated.

### MATERIALS AND METHODS

The current honeybush tea genetic improvement strategy was adapted for the rooibos breeding programme. Focus is first on making selections in current commercial plantations, and to establish a clonal seed-orchard to supply the demand for good quality improved seed. The first 36 selections were made during 2013 in commercial plantations in the North Bokkeveld, near Nieuwoudtville. Cuttings of these selections were set on 4 December 2013 and again on 21 January 2014. Seed of all the selections were collected and planted in a progeny trial during October 2014 at Nieuwoudtville. During October 2014 more selections were made in commercial plantations in the South Bokkeveld, near Nieuwoudtville. The aim is to make enough selections in commercial plantations to compile a base breeding population and to broaden the population with selections from the wild.

### RESULTS AND DISCUSSION

More than 50% of the cuttings set at the beginning of December appeared dead by the end of the month and only about 4% still survived by the end of January 2014. The cuttings set in January 2014 looked more promising with about 40% still alive by the end of February. However, vegetative production of rooibos is challenging, and the success rate for rooting was very poor, resulting in too few plants for establishment of a seed-orchard. Genetic differences existed between the selections for rooting ability and trials to develop a protocol to improve rooting are currently being undertaken.

### CONCLUSION

It is envisaged that in the first few years calculated risks will have to be taken to deliver genetically improved seed as quickly as possible to the farmers, without comprising quality too much. This is however a challenge, due to a lack of important genetic information, propagation protocols and necessary research support and funding.

### ACKNOWLEDGEMENTS

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**Keywords:** rooibos, plant breeding, seed-orchard, vegetative propagation



## THE USE OF FLUCARBAZONE-SODIUM TO CONTROL WILD OATS (*Avena* spp.) IN WHEAT CROPS OF THE WINTER RAINFALL REGION OF THE WESTERN CAPE

DW Bester<sup>1</sup> and E Kempen<sup>1</sup>

<sup>1</sup> Department of Agronomy, University of Stellenbosch, Private Bag X1, Matieland 7602  
dirkwbest@yaho.com

### INTRODUCTION

Wild oats (*Avena* spp.) is a prominent weed in wheat cultivated fields of the Western Cape of South Africa. For the sustainable production of wheat it is crucial to apply the correct herbicide dosage at the correct growth stages of both wild oats and wheat in order to achieve maximum control. Flucarbazone-sodium has been shown to provide excellent activity against wild oats when applied as a post-emergence herbicide to wheat in field experiments conducted in Canada and the USA. Flucarbazone-sodium acts as inhibitors of the enzyme acetolactate synthase (ALS) also known as acetohydroxyacid synthase (AHAS), an important enzyme that acts as a catalyst in the biosynthesis of the branched-chain amino acids leucine, isoleucine and valine. This product known as Everest® 2.0 is a new sulfonylaminocarbonyltriazolinone herbicide on the South African market. The aim of this study was to test Flucarbazone-sodium under the South African conditions of the Western Cape.

### MATERIAL AN METHODS

Trials were conducted over the 2013 and 2014 growing season in the Moorreesburg and Piketberg area. The effect of flucarbazone- sodium (Everest® 2.0) was tested on wild oats (*Avena* spp.). A random block design was used for all three trials. There were four treatments, a control, 0.5R, R and 2R (R = recommended dosage). All treatments were applied at three different growing stages and repeated four times. The number of plants (*Avena* spp.) per square meter was determined at the end of the growing season and compared to the control. The effect of flucarbazone- sodium (Everest® 2.0) was tested on five different wheat cultivars (SST 88, SST 056, SST 027, SST 015 and Pannar 3804) to test for phytotoxicity. For this experiment four randomly placed blocks, were spaced on the trial site. Within each block the five different wheat cultivars were randomly sown (2m x 4m plots). The same treatment range (control, 0.5R, R and 2R) was used. All treatments were applied on three different growth stages and repeated four times. Yield, protein content, hectoliter mass and thousand kernel mass was measured and compared.

### RESULTS AND DISCUSSION

Flucarbazone-sodium has shown a strong and consistent activity on wild oats and has shown to have 98 to 100% control in most areas. It was found that flucarbazone-sodium is sensitive to growth stage, and half the recommended dosage at an earlier stage was more effective than double the recommended dosage at a later growth stage. However possible resistance has been found in the Piketberg area. Greenhouse trials and PCR testing is underway to better understand the nature of *Avena* spp. resistance to flucarbazone-sodium in the Piketberg area. There was no statistical evidence to suggest that flucarbazone-sodium has a phytotoxic effect on the cultivars tested in this study.

### CONCLUTIONS

Flucarbazone-sodium is an effective and safe chemical to use when controlling wild oats in wheat grown in the Western Cape of South Africa. Since resistance has been found in Piketberg, care should be taken when using Flucarbazone-sodium in this area.

**Keywords:** ALS-inhibitor, flucarbazone-sodium, phytotoxicity, wild oats (*Avena* spp.), resistance

## EFFECTIVENESS OF COMMUNICATION CHANNELS ON THE ADOPTION OF IN-FIELD RAINWATER HARVESTING

J.J. Botha<sup>1</sup>, J.J. Anderson<sup>1</sup>

<sup>1</sup>ARC-Institute for Soil, Climate and Water

BothaC@arc.agric.za

### INTRODUCTION

Technology exchange is the process applied by researchers, developers and extensionists through which new knowledge and techniques are introduced to potential users. In this case the ARC-ISCW research team at Glen were the developers of the in-field rainwater harvesting (*IRWH*) technique and the households in the communities in and around Thaba Nchu in the Free State Province were the potential users. Technology can be exchanged in a variety of ways and can be broadly categorized into three groups, namely individual, group and mass. Many communication channels are available, with their various advantages and disadvantages. The question that needs to be answered is: what are the best communication channels to exchange information and knowledge about *IRWH* to small-scale farmers? The aim of this study was to evaluate the different communication channels used in order to establish "best practices" in technology exchange.

### MATERIAL AND METHODS

In-depth interviews from a structured questionnaire were conducted with 240 households. Communication channels evaluated were: demonstration plots (group); drama (mass); video (group and mass); 3D model (group); posters (mass); focus group discussions (group); support by ARC-ISCW technicians (individual and group); and festivals (group and mass). Indicators for success of the technology exchange used were adoption, number of people exposed and effectiveness of conveying the correct messages.

### RESULTS AND DISCUSSION

The highly successful technology exchange phase was the result of different communication channels used during various stages which assisted in conveying different messages to the farmers. Support from ARC-ISCW technicians exposed more people, followed by festivals, focus group discussions and demonstration plots. Demonstration plots were found to be the most effective in conveying messages, followed by festivals, video and support by ARC-ISCW technicians.

### CONCLUSIONS

It was concluded that festivals was the most successful communication channel in terms of the number of people being exposed and effectiveness of communication, followed by demonstration plots. It is recommended to use a range of communication channels since the possibility of conveying the correct and intended message is much higher as compared to the use of a single channel. However, it must also be cautioned that even by using the best communication channels, success cannot be guaranteed without effort (hard work), passion, enthusiasm and a good action plan.

**Keywords:** communication channels, in-field rainwater harvesting, technology exchange

## RESPONSE OF COMMERCIAL SOYBEAN TO VARIANCE IN PLANT DENSITY ON SELECTED QUALITY TRAITS AT DIFFERENT ECOTYPES IN SOUTH AFRICA

GF Braga<sup>1</sup>, AS De Beer<sup>1</sup>, FR Kutu<sup>2</sup>

<sup>1</sup>ARC-Grain Crops Institute, Private Bag X1251, Potchefstroom 2520; <sup>2</sup>Department of Crop Science, North West University (Mafikeng Campus), Private Bag X2046, Mmabatho 2735, South Africa

bragag@arc.agric.za

### INTRODUCTION

Soybean (*Glycine max* L merril) is cultivated in many countries of the tropics and subtropics. It is popular in the far East, while its global consumption is increasing rapidly. Globally, soybean is probably the largest source of vegetable seed oil and protein. In South Africa farmers are more interested on obtaining the seed density that will concurrently improve seed yields and oil, thus lead to competitive market. This study was therefore initiated to evaluate the effect of plant density on the productivity of six soybean cultivars grown at three localities in South Africa.

### MATERIALS AND METHODS

Field trials were conducted at Potchefstroom, Rustenburg and Bethlehem during 2013/14 summer planting season. Treatments consisted of six plant densities and six round-up ready (R) soybean cultivars, in three row spacing. Treatments were laid out in a randomised complete block design in split-split plot arrangement. All data collected were tested for comparable magnitude before a weighted combined analyses of variance was performed using SAS. Shapiro-Wilk's test was performed on the standardised residuals to test for deviation from the normality. Pairwise comparison was also performed on the least square means of significant effects using the Fishers LSD-test at 5% probability level.

### RESULTS

The protein of soybean at Rustenburg was significantly affected by density, cultivar, locality x density and locality x cultivar interaction effects having higher protein (44.1%) than both Bethlehem (41.1%) and Potchefstroom (40.9%). Soybean planted at 400 000 plants ha<sup>-1</sup> using 75 cm row spacing gave the highest protein content of 44.5%. The cultivar LS 6164R had best protein content of 45.3% at Rustenburg. The oil content in soybean at Potchefstroom was significantly affected by density, cultivar and locality x cultivar interaction effects with higher oil content of 21.0% than either Rustenburg (20.2%) or Bethlehem (20.0%). The highest oil content of 21.9% was recorded at density of 350 000 plant ha<sup>-1</sup> using 75 cm spacing row with cultivar LS 6240R at Potchefstroom, while PAN 1664R had lowest oil content of 19.3% at Bethlehem.

### CONCLUSION

The percentage of protein was high at Rustenburg (45.3%) using plant density 400 000 plants ha<sup>-1</sup>, 75 cm row spacing and LS 6164R cultivar. The plant density of 350 000 plants ha<sup>-1</sup> using 75 cm row spacing gave the highest oil content of 21.9% at Potchefstroom with cultivar LS 6240R.

**Keywords:** Oil, plant density, protein, row spacing, soybean cultivars

**A NATURAL RESOURCES DATABASE AS DECISION SUPPORT TOOL FOR SUSTAINABLE  
ECONOMIC DEVELOPMENT PLANNING IN THE GREATER GIYANI MUNICIPAL AREA OF  
LIMPOPO PROVINCE**

JP Carstens<sup>1</sup>, M van der Walt<sup>1</sup>, JP Nell<sup>1</sup>

<sup>1</sup>ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria, 0001

johanc@arc.agric.za

**INTRODUCTION**

The development of a strategy for integrated rural development planning in a targeted area generally relies heavily on the contribution of agriculture. It is therefore important to generate an agricultural decision support database for the targeted area, with an initial focus on the evaluation of known natural resources as the basis for inclusion of the most suitable crop and livestock opportunities in the development plan of the area.

**MATERIAL AND METHODS**

A crucial first step in the development of a decision support system based on the natural resources of the targeted area at Giyani in Limpopo Province was to conduct a situation analysis, starting with a desktop natural resource audit. This provided an overview of the study area in terms of orientation, water availability and selected climate and soil attributes, as well as indicating land cover, land use classification, grazing capacity, and geology and mineral points. Crop suitability maps were derived from the application of crop requirement criteria, aimed at determining the biophysical viability of fruit, vegetables and other enterprises in the targeted area.

**RESULTS AND DISCUSSION**

A set of maps and a spatial database comprising natural resource related information (climate, soils, water availability and mineral distribution) and interpreted information (including crop suitability, livestock carrying capacity and land use classification) were supplied together with an evaluation of the likely agricultural opportunities existing in the targeted area.

**CONCLUSIONS**

A decision support system based on an extended natural resources database will support the development of a sustainable economic development plan for the targeted area at Giyani in Limpopo Province. It will assist the Greater Giyani Local Municipality in the application of scarce resources for unlocking development and in decision making regarding the allocation of funding.

**Keywords:** land suitability, economic planning strategy, sustainable rural development

## LONG-TERM EFFECT OF TILLAGE AND CROP ROTATION PRACTICES ON SOIL ORGANIC C IN THE SWARTLAND, WESTERN CAPE, SOUTH AFRICA

GD Cooper<sup>1</sup>, AG Hardie<sup>1</sup>, JA Strauss<sup>2</sup>, J Labuschagne<sup>2</sup>

<sup>1</sup>Department of Soil Science, Stellenbosch University, Private bag X1, Matieland 7602; <sup>2</sup>Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607

15478130@sun.ac.za

### INTRODUCTION

Soil organic C (SOC) can be regarded as one of the most important indicators of soil health, and accumulation of SOC an important component of sustainable agriculture. Little is currently known about the long-term effect of cultivation practices on SOC in the semi-arid Swartland region of South Africa, an important grain production area. Thus the aim of this study was to investigate the effect on commonly used tillage and crop rotation practices on soil organic matter distribution in the Swartland.

### MATERIALS AND METHODS

The trials were conducted on the Langgewens Research Farm near Moorreesburg, Western Cape. Two 20-year long-term trials are in progress, one in its 8<sup>th</sup> year (site A: soil quality study) and another in its 19<sup>th</sup> year (site B: cropping systems). The Site A trial involves three 4-year crop rotation systems, wheat monoculture (WWWW), wheat-medical/clover-wheat-medical/clover (WMcWMc) and wheat-canola-wheat-lupin (WCWL). Three tillage treatments were studied namely, no-till (NT) – soil left undisturbed until planting, minimum till (MT) – soil scarified late Mar and conventional tillage (CT) – soil scarified late Mar then ploughed. All crops are planted with a no-till planter. The Site B trial consists of four 4-year crop rotations all under no-tillage: wheat monoculture (WWWW), wheat-medical-wheat-medical (WMWM), wheat-medical/clover (WMc) and a wheat-medical/clover with an additional grazing on salt bush (WMcSB). Natural vegetated soil acted as reference SOM content in the area. Soil samples were taken shortly after wheat planting in 2014, at four depths: 0-5 cm, 5-10 cm, 10-20 cm and 20-40 cm. Total soil C and N (%) was determined using dry combustion.

### RESULTS AND DISCUSSION

At site A (8<sup>th</sup> year) at the 0-10 cm depth, the WMWM under NT had the highest %C (1.8%), while WCWL under CT had the lowest (0.6%). The NT and MT treatments had the highest C% at the 0-10 cm depths, whereas, the CT had the highest C% at the 10-20 cm across all crop rotations. This can be attributed to increased physical disturbance in the topsoil but deeper incorporation of residues in CT. The %C differences between tillage systems were most pronounced in 0-5 cm depth. The WMWM rotation generally had the highest C% at all soil depths compared to the WWWW and WCWL systems, across all tillage treatments. This can be attributed to less soil disturbance and denser rooting system of the medics.

At site B (19<sup>th</sup> year) under NT, WMWM had the highest C content at 0-5 cm (2.7%), but the lowest %C in the 5-40 cm depth (0.4-0.6%), while the WWWW had the lowest %C at the 0-5 cm (1.7%), but the highest %C in the 5-20 cm depth (0.5-1.3%). This can be attributed to greater extent of soil disturbance in the topsoil for WWWW than for WMWM.

### CONCLUSION

The greatest differences in %C between tillage and crop rotation treatments occurred between 0-10 cm. At these depths MT and NT treatments were found to have the highest C contents. However, at 10-20 cm depth, CT had the highest C content. Systems containing medics tended to have the highest C contents. Extent of surface disturbance and rooting density appear to have the strongest impact on SOC contents in these soils.

*Keywords:* conservation agriculture, soil carbon, tillage, crop rotation

## FULL-COVER ETHAPON SPRAYS APPLIED TO DORMANT TREES AFFECT TIME OF FLOWER PANICLE EMERGENCE AND FLOWERING OF LITCHI, CV. 'MAURITIUS'

R.B. Cronje and I.M. Ratlapane

ARC-Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit 1200

regina@arc.agric.za

### INTRODUCTION

The plant growth regulator Ethapon is used as spot spray by litchi growers to burn off unwanted young vegetative shoots before and during the flower induction period (April/May) as these shoots will not harden off in time to produce flowers. If ambient temperature and soil moisture stay high during the flower induction period, such shoot growth can be continuous and requires the grower to apply Ethapon at frequent intervals. The aims of the study were to determine whether a full-cover Ethapon application to dormant trees would prolong dormancy long enough until temperatures become conducive for flowering induction and also to investigate the effects of the different Ethapon concentrations and application times on the longevity of the dormancy period.

### MATERIALS AND METHODS

Two trials were conducted in the Nelspruit and Malalane areas on 'Mauritius' litchi trees during the 2014 litchi season. In Nelspruit, Ethapon (a.i. 48% ethephon) was applied on 25 March, 8 and 25 April 2014 as a full-cover spray after hardening of the last desired post-harvest flush at concentrations of 0, 500, 750, 1000 and 1250 ppm. Two controls were included. Control 1 was applied as per current farm practice (at 1000 ppm whenever young shoots appeared) and Control 2 was applied with a full-cover spray for the first spray (at 1000 ppm) followed by spot sprays whenever young shoots appeared. Shoot control on the control trees started at 28 March. In Malalane, Ethapon was applied at 0, 750, 1000 and 1250 ppm as full-cover spray to dormant trees on 3 April only. In addition, a combination of a 1000 ppm treatment followed by a 750 ppm treatment two weeks later was included. The standard farm practice (at 1000 ppm whenever young shoots appeared) was included as a control. At both sites, tree response after spray applications was monitored by observing 10 branches per tree at weekly intervals. Temperature and humidity was measured using data loggers.

### RESULTS AND DISCUSSION

Time and concentration of full-cover Ethapon applications to dormant litchi trees affected the time of flower panicle emergence. The later the time of application and the higher the concentration applied, the longer the dormancy period. As a result there was less vegetative growth during flower induction as well as later flower panicle emergence. Applications up to mid-April increased flowering. Application after mid-April delayed flower panicle emergence too long leading to reduced flowering and increased spring flush. In Malalane, the same trend was evident regarding the concentration effect, with the 1000 + 750 ppm treatment having the latest flower panicle emergence.

### CONCLUSIONS

Full-cover Ethapon sprays applied up to mid-April to dormant trees can prevent vegetative growth during the flower induction period, delay flower panicle emergence until inductive temperatures are low enough and increase percentage flowering.

*Keywords:* flower panicle emergence, Ethapon, application time, flower induction, *Litchi chinensis* Sonn.

## GLASSHOUSE SCREENING OF THE 13TH CIMMYT WHEAT SCAB NURSERY FOR RESISTANCE AGAINST LOCAL SOUTH AFRICAN ISOLATES

CIP De Villiers<sup>1</sup>, N Baloyi<sup>1</sup>

<sup>1</sup>Small Grain Institute, Private Bag X 29, Bethlehem, 9700

DeVilliersC@arc.agric.za

### INTRODUCTION

Fusarium head blight (FHB) is a disease of small grains that causes significant yield losses and reduces the grain quality. FHB infected cereals may contain mycotoxins that are a threat to the food and feed industry. No-till/minimum tillage, the use of susceptible cultivars as well as maize/wheat crop rotation increases the frequency and severity of this disease.

### MATERIALS AND METHODS

FHB wheat resistant varieties from CIMMYT (13<sup>th</sup> FHBSN) were imported and tested against local FHB isolates, previously isolated from wheat, to confirm Type II resistance. The cotton wool inoculation technique was used and after inoculation, plants were placed in a dew chamber at 98.5% RH for 18 hours. The entries were evaluated, using a CIMMYT scale, over a three week period where the number of bleached florets, in relation to the total number of florets, was expressed as a percentage to measure Type II resistance. AUDPC was calculated for each entry and ANOVA was performed using GenStat® Release 14.1 to determine the Fishers' protected least significant differences (LSD) test and coefficient of variance (CV) percentage.

### RESULTS AND DISCUSSION

From the 18 entries tested in the glasshouse, Gamenya was used as a susceptible control, showing high susceptibility, four lines showed susceptibility, two lines showed moderate susceptibility, three lines showed moderate resistance and eight lines showed resistance. The LSD at 5% confidence level was 64.17 and the CV for the trial was 21.1%. From this data it is evident that varieties need to be screened with local FHB isolates to confirm resistance before they can be utilised locally.

### CONCLUSIONS

Since there are no resistant cultivars available in South Africa, and no fungicides registered for commercial use, it is essential to breed for resistance. Diversifying and combining different resistant genes from different sources using a back cross programme to produce cultivars with FHB resistance, is considered to be the best strategy to control FHB.

### ACKNOWLEDGEMENTS

This research was funded by the Winter Cereal Trust and the Agricultural Research Council. The authors acknowledge Liesl Morey from the ARC-Biometry Unit for assistance in statistical analysis.

**Keywords:** CIMMYT, *Fusarium graminearum*, glasshouse screening, wheat

## REDUCING THE RISK OF SCAB IN SOUTH AFRICAN IRRIGATION WHEAT

CIP De Villiers<sup>1</sup>, N Baloyi<sup>1</sup>, SL Sydenham<sup>1</sup>

<sup>1</sup>Small Grain Institute, Private Bag X 29, Bethlehem, 9700

DeVilliersC@arc.agric.za

### INTRODUCTION

Scab is one of the most destructive diseases of wheat and other small grains. *Fusarium graminearum* (*Gibberella zeae*) is the predominant causal organism on wheat and it has become an increasing concern for producers and researchers within the expanding irrigation areas of South Africa.

### MATERIALS AND METHODS

Over the last year, this programme has imported 12 FHB resistant donors for use in a pre-breeding crossing block and 89 CIMMYT FHB donors. These donors have been validated phenotypically in a field trial at SGI near Bethlehem, where they were planted in a honeycomb design. These donors were inoculated by spray inoculation during flowering with a cocktail of different *Fusarium* isolates. Inoculated heads were covered by plastic bags to increase humidity and were screened 28 days post inoculation (dpi) to test their resistance. Each of the entries were evaluated by using a CIMMYT scale to determine resistance.

### RESULTS AND DISCUSSION

From the 12 FHB resistant donors, five exhibited resistance (R), four displayed moderate resistance (MR), one displayed a moderately susceptible (MS) reaction and two were susceptible (S). From the 89 CIMMYT FHB donors the following reactions were observed, ten displayed R, 17 displayed MR, 18 displayed MS, 26 exhibited S, nine were very susceptible (VS) and of the remaining donors nine did not germinate. Gamenya was used as a susceptible control and Sumai #3 as a resistant control. Imported donors resistance levels need to be validated with local FHB isolates before it can be utilised. These donors will be screened in the glasshouse and field again to confirm resistance since it was tested only for one year.

### CONCLUSIONS

The most environmentally responsible and efficient long-term method for *Fusarium* head blight control is the development of resistant cultivars with host plant resistance. Therefore a pre-breeding project was initiated with the aim to make use of phenotypic and marker-assisted backcross pre-breeding to develop diverse FHB and DON resistant wheat germplasm for the South African wheat industry.

### ACKNOWLEDGEMENTS

This research was funded by the Winter Cereal Trust and the Agricultural Research Council.

**Keywords:** field screening, CIMMYT, scab, USDA



## INTEGRATED USE OF INORGANIC FERTILIZER AND COMPOST FOR SUSTAINABLE MAIZE PRODUCTION IN A LONG-TERM TRIAL

JC Dlamini, D Marais and PS Hammes

*Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0001*

E-mail: jerrydlamini012@gmail.com

### INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop in the world after wheat and rice. As a staple crop to about 1.2 billion of the world population, it is mainly grown under intensive mono-cropping systems of variable fertilizer applications. Such systems often result to drastic yield declines over the years due to lack in capacity to replenish soil nutrients crucial in supporting the growth and development of a successful maize crop. There exists a gap in studies of the integrated use of inorganic fertilizers and compost for sustainable maize production in long-term trials. Thus, this paper aims at highlighting the influence of such integrations on maize yield under a long-term trial.

### MATERIALS AND METHODS

A maize field trial was carried-out at the University of Pretoria's Hatfield experimental farm for three seasons; 2011 - 2014. The design of the experiments was a randomized complete block design (RCBD), with 16 treatments each replicated 4 times. Maize plots were treated with different fertilizer combinations; 0 (control), N, P, K, NP, NK, PK, NPK, W, WN, WP, WK, WNP, WPK and WNPK since 1939. Compost was applied in W plots for three seasons between 2003 and 2005. Harvesting was done by hand in a 5m by 5m plot, and then data expressed in  $t\ ha^{-1}$ . Data was statistically analysed using SAS and significant differences at the 5% probability level was determined using Tukey's HSD test.

### RESULTS AND DISCUSSION

Compost integrated with inorganic fertilizers significantly ( $p>0.05$ ) influenced grain yield for all three seasons. WNP ( $5.89\ t\ ha^{-1}$ ) obtained a better yield in 2011/2012 compared to the rest of the treatments. However, NPK with  $5.5$  and  $5.8\ t\ ha^{-1}$  obtained the best grain yield in 2012/2013 and 2013/2014 seasons respectively. In all three seasons, compost applied onto long-term inorganic fertilizer trial improved maize grain yield performance.

### CONCLUSIONS

Adding compost into inorganic fertilizer mono-cropping systems improves maize grains yields.

### ACKNOWLEDGEMENTS

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**Keywords:** *maize, mono-cropping, long-term trial, fertilizer, yield.*

## PLANT FUNGAL DISEASE RESISTANCE GENES: IMPROVING OUR UNDERSTANDING

C. Dweba., T. Sikhakhane., T. Baloyi, T. Hlongoane and T. Tsilo

ARC-Small Grain Institute, Private Bag X29, Bethlehem 9700  
Dwebac@arc.agric.za

### INTRODUCTION

Fungal diseases in plants play a major role in the continued decline in agricultural production and cause significant economic losses. The management of these diseases involves various technologies such as chemicals, genetics and breeding. Chemical management has received a lot of criticism because of the high costs that are involved as well negative environmental impacts. Genetic control strategies aimed to maintain high outputs have been highlighted by the advances in the study of genetics and genomics, with research currently focused on finding and cloning genes that are involved in plant defence mechanisms. Numerous antifungal genes have been shown to confer resistance to various crop against different fungal disease. The development of transgenic plants, with antifungal genes, offers a promising solution. These genes have been grouped into different categories, depending on the mechanism of resistance: - (i) Pathogenesis-related (PR) proteins which are induced during stress conditions as well as during hypersensitive response. There genes are therefore assumed to play a role in the natural defence systems of plants; (ii) Antifungal proteins which predominantly include chitinase and glucanase enzymes are responsible for the hydrolysis and subsequent destruction of the fungal cell walls; (iii) Phytoalexins are compounds that are encoded for by various genes and have antimicrobial properties that confer resistance to fungal disease; (iv) Plant ribosome-inactivating proteins function with the *N*-glycosidase activity which inactivates ribosomes of foreign bodies. Plant ribosome-inactivating proteins therefore prevent protein synthesis of the pathogen; (v) Resistance genes are the signalling receptors for the pathogen's avirulence genes, stimulating resistance against the pathogen. This review focuses on elucidating plant resistance to various fungal pathogens. Furthermore, the review aims to improve our understanding of resistance across different plant species by looking at the different mechanisms employed by the different genes.

### UNDERSTANDING THE PROBLEM

Fungi constitute the largest number of plant pathogens, with a wide range of fungal diseases identified worldwide. Some examples of fungal diseases include Fusarium Head Blight (FHB) and Stem rust caused by *Fusarium graminearum* and *Puccinia graminis* respectively, these have been known to cause severe outbreaks in the world's wheat. The use of fungicides has had very limited effect as a management strategy leading to the requirement for the development of resistant cultivars to ensure the survival of agricultural crops.

### CONCLUSION AND RECOMMENDATIONS

The use of genetic markers is essential for the development of superior cultivars that can withstand the biotic stresses. Continued search and cloning of new resistance genes and subsequent development of transgenic plants is the direction that researchers should be following.

**Keywords:** Antifungal proteins; Fungal resistance; Genetic engineering; Pathogenesis-related proteins; Plant ribosome-inactivating proteins; Resistance genes

## INTEGRATED WEED MANAGEMENT OPTIONS FOR SMALL SCALE FARMERS IN THE WESTERN CAPE

MI Ferreira<sup>1</sup>, Z Sedeman<sup>1</sup>

<sup>1</sup>Directorate Plant Science, Chief Directorate: Research and Technology Development Services, Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607 South Africa

mikefe@elsenburg.com

### INTRODUCTION

Resistance to agricultural chemicals, production costs, environmental and human health concerns necessitates the development of new control methods. Soil solarisation, smother crops and plant mulches are non-chemical techniques. These practices, in combination with limited herbicide application were tested in an integrated way to evaluate its effectiveness for weed management on small scale farms.

### MATERIALS AND METHODS

Solarised and smother crops plots were arranged in a randomised block design with four replicates in a field trial conducted over two years at George. Following soil solarisation, winter smother crops were planted in mixtures with legumes. Treatments included pure stands of grass crops on soil not previously solarised. All treatments were cut at twelve weeks after planting to form mulches. A shallow cultivation on solarised plots was followed by planting summer smother crops in mixtures with legumes. Student's t-least significant difference was calculated at the 5% level to compare treatment means.

### RESULTS AND DISCUSSION

Results showed that by cutting high biomass producing smother crops at 12 weeks after planting to form a plant mulch, effective weed control was extended by an additional 10 weeks at least and weed population numbers were suppressed significantly by over 90% within two years by black oats treatments. However, an additional intervention had to be made for persistent weeds like nutsedge and purslane, which had to be controlled with herbicide applications after the first year, never to re-emerge, provided the soil remained covered with smother crops or mulches and no disturbance took place.

### CONCLUSIONS

By integrating solarisation, herbicides, cover cropping and mulching and using it in tandem, as part of small scale production practices, weeds may be suppressed effectively with less herbicide, benefitting sustainable agriculture.

**Keywords:** plant mulch, small scale farmers, soil solarisation, smother crops, weed suppression.

## EVALUATION OF TEN BREAD WHEAT CULTIVARS FOR SEEDLING RESISTANCE TO STEM RUST

S Figlan<sup>1</sup>, TG Terefe<sup>1</sup>, HA Shimelis<sup>2</sup>, TJ Tsilo<sup>1</sup>

<sup>1</sup>Agricultural Research Council - Small Grain Institute, Private Bag X22, Bethlehem, 9700, South Africa; <sup>2</sup>African Centre for Crop Improvement, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa

FiglanS@arc.agric.za

### INTRODUCTION

Breeding for resistance is the most economic, sustainable and environmentally friendly approach to minimize losses incurred by fungal diseases such as stem rust of wheat caused by *Puccinia graminis* f. sp. *tritici*. In South Africa, the wheat stem rust poses a major threat to production and productivity due to the emergence of four highly virulent Ug99 variants: TTKSF, TTKSP, PTKST and TTKSF+. The main aim of this study was hence to establish a Nested Association Mapping (NAM) panel using eight new sources of resistance together with two cultivars adapted to South Africa to study stem rust resistance and pursue novel resistance genes/QTLs. The objective was to evaluate the ten bread wheat cultivars for seedling resistance to stem rust disease.

### MATERIALS AND METHODS

Ten bread wheat cultivars, along with McNair used as a susceptible check were obtained from the ARC-Small Grain Institute germplasm bank and tested with three South African races of *Puccinia graminis* f. sp. *tritici* (2SA88, 105 and 106). Five seeds per cultivar were sown in each pot with three replicates (pots) per cultivar. Infection types described by Stakman et al. (1962) were assessed 14 days post inoculation.

### RESULTS AND DISCUSSION

All ten wheat cultivars displayed differential reactions to the stem rust races used. Pasa, Kudu, Ngiri, Popo and Romany showed resistance reactions (0; to 2); Paka, Fahari, Kariega, Gem Morocco and the susceptible check McNair consistently showed susceptible reactions (3- to 4). When screened with molecular markers associated with resistance genes *Sr2*, *Sr24* and *Sr57/Lr34/Yr18*; Romany, Paka, Pasa, Gem and Popo proved to carry both the *Sr2* and *Sr57/Lr34/Yr18* gene complex. None of the ten cultivars harboured *Sr24*. *Sr2* along with *Sr57/Lr34/Yr18* are adult plant resistance genes and have aided in breeding for durable resistance (Sawhney, 1992).

### CONCLUSION

The potential new resistance genes can be exploited and integrated in breeding for resistance in South African wheat cultivars. Due to the contrasting resistance reactions in the NAM panel, further studies to characterise this panel for seedling resistance and adult plant resistance is on-going.

### ACKNOWLEDGMENTS

The National Research Foundation and the Winter Cereal Trust are acknowledged for financial support.

**Keywords:** *Puccinia graminis* f. sp. *tritici*, seedling resistance, stem rust, wheat.

## HERITABILITY ANALYSIS OF NUTRITIONAL COMPOSITION IN COWPEA GENOTYPES [VIGNA UNGUICULATA (L.) WALP.]

AS Gerrano<sup>1</sup>, PO Adebola<sup>1</sup>, WS Jansen van Rensburg<sup>1</sup>

<sup>1</sup>Agricultural Research Council-Vegetable and Ornamental Plant Institute, Private Bag X293, Pretoria 0001, South Africa

agerrano@arc.agric.za

### INTRODUCTION

Cowpea is an underutilized African legume crop widely grown by subsistence farmers. As an underutilized and a potential crop for food and nutritional security, it is an under-researched crop in South Africa. Improvement of nutritional composition of cowpea genotypes requires information of the magnitude of genetic variation present in the available germplasm, interdependence of genetic heritability and genetic advance of various contributing traits of minerals and protein. Therefore, the experiment was carried out with the objective to study the different selection parameters for nutritional composition in different cowpea genotypes.

### MATERIALS AND METHODS

A field experiment was conducted at Roodeplaat Research Farm of the ARC-VOPI (latitude 17° 49'S, longitude 31° 04'E), during the 2012 and 2013 cropping seasons. Young leaves of 25 cowpea genotypes were analysed for total protein and contents of nine mineral elements [calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), and nitrogen (N)]. Nutritional data was analysed by means of ANOVA using Agrobases Generation II (2008) statistical software. Genetic parameters were calculated following Johnson et al. (1955) procedures.

### RESULTS AND DISCUSSION

The analysis of variance showed highly significant ( $p=0.01$ ) differences among the cowpea genotypes for all mineral elements [(Ca, 2.99 mg/Kg<sup>-1</sup>), (Cu, 10.33 mg/Kg<sup>-1</sup>), (Fe, 534.62 mg/Kg<sup>-1</sup>), (Mg, 0.496 mg/Kg<sup>-1</sup>), (Mn, 163.97 mg/Kg<sup>-1</sup>), (Na, 188.18 mg/Kg<sup>-1</sup>), (P, 0.33 mg/Kg<sup>-1</sup>), and (N, 4.38 mg/Kg<sup>-1</sup>)] except (K, 1.14 mg/Kg<sup>-1</sup>) and protein (27.35%) content indicating the existence of high genetic variability among them. The results of the variance components revealed that the phenotypic variance was relatively higher than the genetic variance for all mineral elements and protein content recorded. This indicated that there was possibly a higher environmental influence on genotypes during the growing periods compared to the genetic factor.

### CONCLUSIONS

All characters showed moderate to high heritability values. Furthermore, the genetic advance for the traits showed higher values. These could be used for selection of individual plant from a population in cowpea improvement programme in the country.

**Keywords:** cowpea, genetic advance, heritability, variability

## WHY DIFFERENT EMERGENCE INDEX MODELS?

L. Henning<sup>1</sup>, G.M. Ceronio<sup>1</sup>, A.A. Nel<sup>2</sup>

<sup>1</sup>University of the Free State, PO Box 339, Bloemfontein 9300; <sup>2</sup>ARC-Grain Crops Institute, Private bag X1251, Potchefstroom 2520

HenningL@ufs.ac.za

### INTRODUCTION

Emergence index models that predict emergence are widely used to determine the rate of emergence for both weeds and annual crops. These emergence index models all have the same aim. The objective of this experiment was to compare different emergence index models and determine which is best to determine emergence rate of sunflower seedlings when exposed to high soil temperatures.

### MATERIALS AND METHODS

Data was collected from an experiment conducted in the glasshouses of the Department of Soil, Crop and Climate Science at the University of the Free State. Seven commercially available sunflower cultivars were exposed to four soil temperatures (35, 40, 45 and 50°C). Models from Fakorede & Ojo (1981)<sup>1</sup>, Anfinrud & Schneider (1984)<sup>2</sup> and Nel (1998)<sup>3</sup> were used to compare the emergence of the selected cultivars. An emergence model was also derived from Nel (1998), with the discriminating factor decreased to 5% as the model was determined over nine days and not three days as was the case for Nel (1998). Day three after planting was used as a standard for first emergence.

### RESULTS AND DISCUSSION

Inspection of the models revealed that although the selected models had the same aim the results of the data set used differed. These differences can be explained by the difference in the counting of emergence after planting. The model of Fakorede & Ojo (1981) and Anfinrud & Schneider (1984) was inconsistent when compared to that of Nel (1998) and this experiment. Therefore models 3 and 4 can be considered for emergence index (EI) of sunflower when the seedlings are subjected to stress conditions such as supra-optimal soil temperatures. The EI computed with the model of Nel (1998) gave a 90.5% correlation with the emergence count while the derived model used in this experiment gave a 99.6% correlation with the emergence count.

### CONCLUSIONS

Emergence index computed with the models in question was best explained under supra-optimal temperatures for sunflower by the latest model derived from Nel (1998)<sup>3</sup>. Emergence index (EI) as indicator is essential, but the model used to compute EI should be examined according to inputs and conditions under which these inputs were generated.

### ACKNOWLEDGEMENTS

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**Keywords:** sunflower, soil temperature, cultivar, vigour

## EFFECT OF GLYPHOSATE DOSAGE RATES ON GROWTH AND PHOTOSYNTHESIS OF HERBICIDE TOLERANT MAIZE

C Malan<sup>1</sup>, HB Odendaal<sup>1</sup>, JM Berner<sup>1</sup>, E Hugo<sup>2</sup>

<sup>1</sup>Research Unit for Environmental Sciences and Development, North-West University, Potchefstroom campus, Private bag X6001, Potchefstroom, 2520, South Africa ; <sup>2</sup>Agricultural Research Council - Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520, South Africa.

HugoE@arc.agric.za

### INTRODUCTION

Glyphosate, the most widely used herbicide in agriculture, was first synthesized and tested by J.E. Franz in 1970 (Duke and Powles, 2008). It was introduced as an herbicide to crop production primarily for burn-down of annual weeds and to control problematic perennial weeds. Herbicide tolerant crops (Roundup Ready®) were introduced in 1996 in the USA with the first RR maize planted in South Africa during the 2002/2003 season. The continuous use and maybe late application of glyphosate on RR maize cultivars have led to reports of potential decreases in yields. The aim of this study was to investigate the effect of glyphosate at different dosage rates on the growth and photosynthetic efficiency of herbicide tolerant maize.

### MATERIALS AND METHODS

Five cultivars (DKC73-76R, DKC78-35R, DKC80-30R, KKS4479R and BG5685R) were planted in 4L plastic pots filled with a clay loam soil (35% clay). The trial was laid out in a randomized complete block design with 6 dosage rates including an untreated control for each cultivar tested. Dosage rates included was equivalent to 0.75, 1.3, 1.7, 2.0 and 4.0 litres per ha. Glyphosate (Roundup PowerMax™) was applied with a knapsack sprayer during the fourth leaf growth stage (V4). The trial was maintained in a glasshouse set at 12 h light / 8 h dark at a temperature regime of 30° / 15°C. Chlorophyll fluorescence parameters [PI<sub>(abs)</sub> and PI<sub>(total)</sub>], chlorophyll content (Cl) and plant height were recorded at 7, 14 and 21 days after application (DAA). Dry biomass of roots and shoots was recorded after termination of the trial. Data were subjected to an analysis of variance to compare means at the 5% significance level (Fisher's Protected LSD).

### RESULTS AND DISCUSSION

A significant interaction between cultivars and glyphosate dosage rates was recorded for PI<sub>(abs)</sub> and PI<sub>(total)</sub> at 7, 14 and 21 DAA. At 7 and 21 DAA, the PI<sub>(total)</sub> of DKC80-30R decreased with 19 and 33% when glyphosate was applied at 1.3 l ha<sup>-1</sup>. The PI<sub>(total)</sub> of KKS4479R decreased with 16 and 32% at 14 and 21 DAA, respectively, when glyphosate was applied at 0.75 l ha<sup>-1</sup>. Chlorophyll content was only significant for the cultivar X time interaction, with the Cl lowest at 21 DAA for BG5685RR. Glyphosate had an inhibitory effect on photosynthetic parameters due to the decrease in the performance indices measured. The immobilizing or trapping effect of glyphosate on Fe and Mn, that is responsible for transport of electrons through the cytochrome complex, may play a role (Eker et al 2006). A significant cultivar X dosage rate interaction was recorded for plant height. In terms of stunting the cultivars DKC78-35R and BG5685RR were most affected at all of the dosage rates. Dry mass differed significantly only between cultivars.

### CONCLUSION

Cultivars showed different reactions to glyphosate applications and the inhibitory effect was not persistent over all cultivars. Further field studies are needed to quantify these inhibitory effects to elucidate potential yield reductions of herbicide tolerant cultivars.

**Keywords:** chlorophyll fluorescence; glasshouse; glyphosate; Roundup Ready® maize.

## OBSERVATIONS CONCERNING THE LICHTENBURG SOIL FORM

EO Jacobs<sup>1</sup>

<sup>1</sup>ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria 0001

ernst@arc.agric.za

### INTRODUCTION

The existence of the Lichtenburg soil form (orthic A on red apedal B on hard plinthite B) has been reconfirmed in deep soil pits and road cuttings in the Lichtenburg area. Strong variation in soil depth and observations deeper than the standard soil depth of 1.5 m are shown to be relevant during soil surveys, to soil classification issues and interpretations for crop production. Deeper horizons below the hard plinthite have been observed as an integral component of the soil genesis.

### MATERIAL AND METHODS

The Lichtenburg soil form will be a new addition to the proposed revised soil classification system for South Africa. The hard plinthic B horizon below the red apedal B, as found in deep soil pits, cannot be cut with a spade under moist circumstances as commonly encountered in newly dug pits. However, it can often be broken by hand tools. The material is commonly permeable to water and can be penetrated to some extent by crop plant roots. Road cuttings show examples that when indurated (dried out), the same material becomes extremely hard and can only be disturbed by powerful earth moving machinery. In deep pits a fourth often gleyed and wet horizon has also been observed.

### RESULTS AND DISCUSSION

It has been shown that crop plant roots are able to extract water and find their way through some hard plinthite materials. Serious consideration should therefore be given to how this material ought to be defined and classified and where to distinguish between soft and hard plinthite. The definition of hard plinthite should include the fact that the material cannot be cut with a spade when wet, but may be disrupted by hand tools. Induration, although extensive, is not continuous in all directions and individual fragments of the plinthite can be disrupted by hand tools. The implication of this definition is that root penetration will take place to a greater or lesser degree. The revised definition may also narrow the range of soft plinthic material. The definition of soft plinthite ranges from at least 10% sesquioxide concretions in commonly soft matrix material to a massive bank of indurated hard material that cannot even be cut with a spade under moist conditions, is too wide. Deeper horizons including the commonly encountered gleyed material should be incorporated into the classification too, because that is soil genesis and affects the crop production potential of the soil.

### CONCLUSION

It deserves recommendation to review the definition of hard plinthite by recognizing the range in the degree of induration (hardness) and whether the induration is continuous or not, thus allowing for a certain degree of root penetration and water extraction. Provision should be made in the classification to include deeper horizons in the definition of soil forms since the Lichtenburg soil form has marked differences in crop production potential.

**Keywords:** hard plinthite, Lichtenburg soil form, soil classification, deep soil horizons



## SOIL POINT DATA OF SOUTH AFRICA IN DIGITAL FORMAT

EO Jacobs<sup>1</sup>, HL Weepener<sup>1</sup>

<sup>1</sup>ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria 0001

ernst@arc.agric.za

### INTRODUCTION

An increasing need for soil information on a more detailed scale is the motivation to find ways to make use of existing soil information in a new format. The existing land type information provides insufficient opportunities to supply more detailed information since it was designed to produce 1:250 000 scale maps.

### MATERIAL AND METHODS

Soil point data available in the ARC-ISCW archives may contribute to a more detailed picture of the soil variation in South Africa when used with modern computer technologies and additional environmental factors in digital format.

The Land Type Survey, undertaken between 1973 and 2001 (and finalized in 2012), was executed in the field on a total of 1450 1:50 000 topo sheets. Up to 723 soil observations were made per 1:50 000 sheet. At an estimated average of 400 observations per 1:50 000 sheet, a total of 780 000 observation points can be expected.

### RESULTS AND DISCUSSION

All field maps with observations are in the process of being digitized in order to extract the point information. To date 60 747 points are captured in a shape file. Data available on the maps and in separate profile description reports are captured in the attributes table. Often only one attribute, the soil form is available, but up to 24 soil characteristics (attributes) can be captured.

The results for the KwaZulu-Natal Province have been processed. This field observation (FO) database contains a soil form (according to the 1977 Binomial Soil Classification System) for all observations and in many instances the soil series has also been noted. From the soil series and directly noted clay contents, over 30 000 clay content entries could be created for the study. Effective rooting depth had rarely been noted for these observation sites.

### CONCLUSIONS

A complete digitization is in process to capture all soil observations made during the Land Type Survey in digital format. The results for KwaZulu-Natal show that the FO database can provide additional information for regional modelling exercises such as predictive soil mapping.

There is a wealth of information on soils available in the land type memoirs, but unfortunately it requires extensive alphanumeric database modelling to translate land types to various user requirements in terms of soil potential.

*Keywords:* soil information, digital data processing, soil database

## OBSERVATIONS CONCERNING THE PROPERTIES AND CLASSIFICATION OF DEEP SOIL HORIZONS

EO Jacobs and DP Turner

*ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria 0001*

E-mail: [ernst@arc.agric.za](mailto:ernst@arc.agric.za)

### INTRODUCTION

The recognition of deep soil horizons becomes relevant as observations of deeper rooting depths are now increasingly being made. Crop production systems are increasingly influenced by soil conditions and plant water availability at greater depths. Roots of annual crop plants have been found at up to 2 m depth and moist or wet soil horizons are often present at these depths. The current soil classification system recognizes three diagnostic horizons in its 73 soil forms. Four horizons are recognized in only two soil forms (Lamotte and Concordia) and reference to deeper soil characteristics is made in one additional soil form (Constantia). Observations in deeper soil pits show that additional horizons can be identified that will invariably impact on deep rooted crops and in the hydrological functioning of soils. This paper proposes that the properties of deep soil horizons are recognized in the classification system.

### MATERIAL AND METHODS

Standard soil profile description methods were used in describing deep soil horizons.

### RESULTS AND DISCUSSION

Several profiles are presented to show more than the conventional three diagnostic horizons. The examples were located in the Bergville district of KwaZulu-Natal and the Lichtenburg district of North West Province. In these areas deep soil horizons are routinely identified during soil surveys by agricultural advisors. The challenge is not only to describe these deeper horizons but also to accommodate them in the soil classification system. The challenge is further to standardize the nomenclature, description and classification of profiles that contain more than the currently recognized three diagnostic horizons used to classify soils.

At present the deeper Avalon and Lichtenburg soil forms with wet or gleyed horizons below the plinthite are attracting attention since they are common in the maize producing areas and are under constant investigation by farmers and their support agencies. The availability and characteristics of these deep horizons are highly relevant for crop production and their changing characteristics in terms of moisture deserve recognition and monitoring.

### CONCLUSIONS

It is strongly recommended that deep soil horizons receive recognition in the description and formal classification of soils.

*Keywords:* soil horizons, soil classification

## USING PLANT SAP ANALYSIS "OMNISAP®" TO DETECT DIFFERENT CALCIUM, POTASSIUM AND MANGANESE LEVELS IN MAIZE PLANTS.

WD Jonker<sup>1</sup>, M Mlalazi<sup>1</sup>, V Nolan<sup>1</sup>, S Opperman<sup>1</sup>

<sup>1</sup>Omnia Fertilizer , PO Box 69888, Bryanston 2012 , Republic of South Africa

E-mail: wjonker@omnia.co.za

### Introduction

Plant sap analyses dates back to the 1930's as indicated by Sooneveldt and Voogt (2009). Omnia Fertilizers, a Division of the Omnia Group, have been developing and using "OmniSap®" for the last 17 years in South Africa, Australia and Sub Saharan Africa for early detection of nutrient deficiencies and monitoring plant available nutrients. The aim of the study was firstly, to determine the sensitivity of the OmniSap® analysis across a range of applied nutrient concentrations. Secondly, to determine the influence of change in total plant biomass on plant sap analyses to address the issues raised by de Kreij (1993).

### Materials and Methods

Separate glasshouse pot trials were conducted during 2010 to 2013 to evaluate the sensitivity of OmniSap® analyses for manganese (Mn), calcium (Ca) and potassium (K) content. Trial design was a complete randomized block design with 4 application rates for each nutrient. K and Mn treatments were replicated 5 times and 6 replicates for Ca. Maize (CRN3505) plants were grown in 20 L plastic bags using silica sand and fed hydroponically. Ca treatment concentrations were 47, 95, 190 and 285 mg/L. Treatment concentrations for K were 63, 138, 276 and 552 mg/L and for Mn 128, 257, 514 and 1028 µg/L respectively. Results for total plant biomass and plant sap nutrient levels at the 8 leaf stage will be discussed. Statistical analysis for ANOVA and Fisher's least significant difference test (LSD) was done using STATISTICA version 12.

### Results and discussion

Changes in biomass in the Potassium pot trial were not significant. Differences in plant sap K were significant between all treatments with an increase in sap K content from the 63 mg/L treatment to the 552 mg/L treatment. For the Manganese pot trial there was no significant difference between treatments for total biomass measurements. Differences in plant sap Mn concentrations were significant between all treatments increasing from the 128 µg/L Mn treatment to the 1028 µg/L Mn treatment. For Ca there was a significant increase in total biomass between all treatments tested. Levels in plant sap Ca also increased with increasing Ca applications with the 190 and 285 mg/L treatments being significantly higher than the 47 and 95 mg/L treatments.

### Conclusion

Plant sap analysis, OmniSap®, was able to accurately detect differences imposed by treatment levels for Mn, Ca and K in maize. Changes in total plant biomass did not affect the sensitivity of plant sap analysis to detect different application rates.

### References

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*Keywords:* plant sap analysis , total dry biomass , OmniSap® , maize, nutrient concentrations

**VIABILITY OF OUT OF SEASON ONION PRODUCTION IN MIDDELBURG, ADELAIDE AND CRADOCK (EASTERN CAPE, SOUTH AFRICA) USING DIFFERENT PLANTING MATERIALS AND PLANTING DATES**

**Jordaan M<sup>1</sup>**, Coetzer G<sup>2</sup> and Allemann J<sup>2</sup>

<sup>1</sup> *Eastern Cape Department of Rural Development and Agrarian Reform, Horticultural Research, Döhne Agricultural Development Institute, Private Bag X15, Stutterheim, 4930, South Africa*

<sup>2</sup> *Department of Soil, Crop and Climate Sciences, University of the Free State, P O Box 339, Bloemfontein, 9300, South Africa*

marina.jordaan@drdar.gov.za

**INTRODUCTION**

A field experiment was conducted at Adelaide, Cradock and Middelburg, situated in the Fish River catchment, Eastern Cape, South Africa, to determine the viability of out of season onion production in this area.

**MATERIALS AND METHODS**

The short day onion cultivar, 'Z516', was established with sets (onion bulbs 10-12 mm diameter) and seed on five different planting dates (end of January, middle of February, end of February, middle of March and end of March). A randomized block design with four replications was used. Marketable and unmarketable yields were recorded and the percentage marketable yield of total yield calculated.

**RESULTS AND DISCUSSION**

Results indicate that seed is not suitable for out of season onion production at all 3 locations. Sets produced the highest marketable yields and marketable yield percentage when planted in Adelaide at the end of February (39.68 t ha<sup>-1</sup> (93%)), middle of March 62.60 t ha<sup>-1</sup> (92%) and end of March (50.40 t ha<sup>-1</sup> (89%)) and matured from April to September when onion prices are usually high on the local market.

**CONCLUSION**

Results indicate that out of season onion production is viable in Adelaide on condition that sets of the short day onion cultivar 'Z516' are planted from the end of February to end of March. The low temperature profiles of Cradock and Middelburg, especially during winter (May to September) make these locations unsuitable for out of season onion production.

**Keywords:** bolting, marketable and unmarketable onion yield, planting date, seed, sets

## EFFECT OF DIFFERENT INOCULANTS ON NODULATION OF TWO DIFFERENT SOYBEAN CULTIVARS

CJF Jorge<sup>1</sup>, TC Baloyi<sup>1</sup>, K Ramachela<sup>2</sup>

<sup>1</sup>ARC-Grain Crops Institute, Private Bag X1251, Potchefstroom 2520, South Africa ; <sup>2</sup>Department of Crop Sciences, North West University, Mafikeng, South Africa

Jorgec@arc.agric.za

### INTRODUCTION

Inoculation of legumes is fundamentally important, especially for soil where there is no efficient native strains of Rhizobium. Rhizobium is a soil bacteria that is characterised by their ability to infect root hairs of legumes and induce nodulation. Inoculation of soybean seeds with bacteria of the genus Bradyrhizobium promotes the production in per hectare basis of nodules in leguminous species, thus decrease production costs due to the ability of biological nitrogen fixation (Zill *et al.* 2008). This advantage enables the replacement partial and/or total nitrogen through chemical fertilisers. This study aimed to evaluate the effect of different inoculants on the nodulation and performance of two soybean cultivars.

### MATERIALS AND METHODS

The experiment was conducted during the 2013/14 summer-cropping season at ARC Grain Crops Research Station, Potchefstroom. The treatments consisted of two soybean species namely, PAN1454R and PAN1729R. These cultivars were inoculated with different inoculants registered for soybean. Unamended control plots were also included as standard checks. The cultivar were fertilised at optimum recommended rates for phosphorus (P) and potassium (K), while no nitrogen was added. The sources of P and K were superphosphate and potassium chloride, respectively. Treatments were fitted in a randomised complete block design and replicated four times. Data collected was of total number of nodules and seed yield.

### RESULTS AND DISCUSSION

The effect of inoculant showed significant differences in the number of nodules per plant, while no significant effects was found for cultivar. The higher total number of nodules per plant (44.6) were observed from plants inoculated with hicoat super + extender and minimum (22.3) by Vault Hp. The effect of inoculants did not exert statistically significant effects on soybean seed yields. Significantly higher seed yield was produced with PAN1729R. Generally, higher seed yield across the inoculants was achieved with soygro and vault HP in combination with PAN1729R.

### CONCLUSIONS

The study showed that hicoat super + extender promoted nodulation. Soybean yields were not affected by the type of inoculant applied, but limited to the effects of the cultivar. Comparatively, PAN1729R produced higher yield than PAN1454R regardless of the type of inoculant used.

**Keywords:** Inoculants, leguminous plants, nodulation, seed yield

## FARMERS' PERCEPTIONS OF INSECT PESTS IN THE EASTERN CAPE MAIZE-BASED CROPPING SYSTEMS AND THE EFFECTS OF RESIDUE MANAGEMENT ON INSECT PEST POPULATIONS

TL Kadango<sup>1</sup>, AY Armide,<sup>2</sup> PNS Mkeni<sup>3</sup>

<sup>1</sup>university of fort hare, p. bag x1314, Alice, 5700; <sup>2</sup>university of fort hare, P Bag X1314, Alice, 5700 ; <sup>3</sup>university of fort hare, P Bag X1314, Alice, 5700

201411696@ufh.ac.za

### INTRODUCTION

Indigenous and introduced insect pests are among the major constraints to maize production and productivity. Limited information on farmers' perceptions of these insect pests, their economic significance and the effectiveness of the pest control practices they employ necessitated the need to carry out baseline studies in the Eastern Cape. In this study, we investigated the main current cropping systems and assessed the indigenous knowledge on insect pests and pest management practices under these cropping systems.

### MATERIALS AND METHODS

Semi-informal surveys were carried out in four (4) municipal districts of the Eastern Cape where questionnaires were administered to government extension agents and smallholders farmers actively involved in maize production. The questions were modelled in such a way to enable classification of maize-based cropping systems and to identify the economically important insect pests and their current control practices. Descriptive statistics were used to analyse the data collected.

### RESULTS AND DISCUSSION

The majority of interviewed farmers produce maize as a mono-crop for grain under dryland, with very few producing maize with rotations under irrigation. The major crops included in the rotations are leafy vegetables and potatoes. All the farmers grew genetically modified (GM) maize seeds either round-up ready or with B<sub>1</sub> genes through the government support scheme of the Cropping Programme. Farmers used inorganic fertilisers as supplements to improve soil fertility in their farms. All the farmers retain maize stover in the field after harvesting and they let animals to graze during the off season. The most widely reported pest were stalkborers and cutworms in all the districts. The proportion of farmers reporting the importance of termites, birds, rodents, weeds and weevils as maize pests varied widely. The most common pest control practice is the use of insecticides followed by the use of GM maize seed.

### CONCLUSIONS

It was concluded that Eastern Cape smallholder farmers produce maize as a mono-crop, under dryland mainly for grain purposes. The major maize pests are stalkborers and cutworms in which farmers solely depend on insecticides to control these pests. Farmers need to be trained on alternative pest control practices so as to reduce the reliance on chemicals and practice crop rotations so as to ensure food security.

**Keywords:** maize, pests

## EFFECTS OF DIFFERENT SOIL AMENDMENTS ON SOYBEAN SEEDLING EMERGENCE UNDER CRUSTING SOILS

A Kamota<sup>1</sup>, C Parwada<sup>1</sup>, M Makumucha<sup>1</sup>

<sup>1</sup>Bindura University of Science Education, Bindura, Zimbabwe

agathar.kamota@gmail.com

### INTRODUCTION

Poor crop establishment due to soil crusting is a challenge in semi-arid areas. A field study was conducted in Bruton Smallholder Resettlement Scheme, Zimbabwe to assess the possibility of soil amendments on management of crusted soils and the effect on emergence and quality of seedling growth characteristics.

### MATERIALS AND METHODS

Cattle manure, humus and gypsum were used as amendments that can sustainably manage crusting soils to improve crop stand and subsequent seedling growth. A 3 x 4 factorial experiment was carried out in complete randomised block design and replicated on three different soil types and the blocks were replicated three times on each experimental site. Emergence and seedling growth characteristics were recorded.

### RESULTS AND DISCUSSION

Rhodic nitisols (fine sand clay loam) with a crust thickness of 1mm amended with cattle manure produced the highest emergence of 72.78% and the least was observed on the unamended soils with 22.78% emergence at  $P=0.012$ . Similar trends were observed on Haplic lixisols (fine sand clay loam) (10mm crust) though with the least emergence percentage means. This implies that soil amendments were effective alternatives to ameliorate crusting soils.

### CONCLUSION

Cattle manure and humus are useful in the amelioration of crusting soils to improve seedling emergence and seedling early growth characteristics.

**Keywords:** Soil amendment, soybean emergence, soil crusting

## CALSIUM FERTILIZATION EFFECTS ON POTATO TUBER QUALITY

E Kempen<sup>1</sup>, NJJ Combrink<sup>1</sup>

<sup>1</sup> Department of Agronomy, University of Stellenbosch, Private Bag X1, Matieland 7602  
estellek@sun.ac.za

### INTRODUCTION

The importance of calcium ( $\text{Ca}^{2+}$ ) as plant nutrient for strengthening the cell wall and stabilizing membranes is well known. For potatoes compelling scientific proof exist that  $\text{Ca}^{2+}$  is only transported from the roots on the stolon to the tuber via the xylem along with water resulting in significantly lower  $\text{Ca}^{2+}$  levels in tubers compared to stem tissue.  $\text{Ca}^{2+}$  deficiencies have been linked to an increase in post-harvest susceptibility to pathogens and a decrease in stress tolerance. The aim of this study was to determine if the  $\text{Ca}^{2+}$  application rate will result in an increase in tuber  $\text{Ca}^{2+}$  content and the tubers post-harvest quality.

### MATERIALS AND METHODS

In a factorial trial Plantlets from seven potato cultivars (BP1, Avalance, Mondial, UptoDate, Buffelspoort, Chella and Paramount) were cultivated at five different  $\text{Ca}^{2+}$  levels; 5, 65, 125, 250, 400 and 600 ppm). After a growing period of 12 weeks the  $\text{Ca}^{2+}$  content of leaves and tubers – peel and medulla - were determined as well as visually inspected for defects and the tuber specific gravity measured. A sub sample of the tubers was evaluated for the rot potential of the tubers by inoculating them with bacterial inoculums. The statistical significance of the results was analysed by the t-test ( $p \leq 0.05$ ).

### RESULTS AND DISCUSSION

The  $\text{Ca}^{2+}$  content of leaves and tubers exhibited a good correlation with the  $\text{Ca}^{2+}$  concentration in the nutrient solution for all the cultivars tested. The average leaf  $\text{Ca}^{2+}$  concentration increased from 0.14 % dry weight (DW) at an application of 5ppm Ca to 1.23 % DW at an application rate of 250 ppm Ca. The  $\text{Ca}^{2+}$  concentrations of the tubers, both in medulla and peel (outer 0.5cm) increased with an increase in  $\text{Ca}^{2+}$  application rate up to 400 ppm  $\text{Ca}^{2+}$  demonstrating that additional  $\text{Ca}^{2+}$  application will be beneficial. Tuber specific gravity (SG) was not correlated to tuber tissue  $\text{Ca}^{2+}$  content. Tubers were more susceptible to soft rot pathogens at lower tuber tissue  $\text{Ca}^{2+}$  concentrations even though the increase in resistance was not linearly correlated to an increase in tuber tissue  $\text{Ca}^{2+}$  concentration. A negative relationship between internal brown spot and  $\text{Ca}^{2+}$  concentration of the medulla was observed.

### CONCLUSION

These results indicate that it is possible to significantly increase the potato tuber  $\text{Ca}^{2+}$  content through increasing the application level and that this will have important consequences with regards to the post-harvest quality of potato tubers.

**Keywords:** Calcium, potato, nutrient uptake, tuber quality



## THE EFFECT OF NaCl AND ROOTING-MEDIA ON THE YIELD AND MINERAL COMPOSITION OF ROSE GERANIUM (PELARGONIUM GRAVEOLENS L.)

ZP Khetssha<sup>1</sup>, MM Sedibe<sup>2</sup>

<sup>1</sup>Central University of Technology, Free State; <sup>2</sup>C

zkhetssha@cut.ac.za

### INTRODUCTION

Rose geranium oil is produced commercially worldwide for use in perfumery, medicinal and aromatherapy industries. Leaves, flowers and branches are important parts of the plant because this is where most of the trichomes are found. The yield of rose geranium is affected by mineral composition and environmental factors such as sodium chloride. The objective of the study was to evaluate the effect of NaCl and root-media on the yield and mineral composition of rose geranium.

### MATERIALS AND METHODS

This trial was carried out in a climate controlled greenhouse tunnels at Bloemfontein, campus of the University of the Free State located in the semi-arid area at an altitude of 1395 m above sea-level. The greenhouse temperature was kept at a minimum and maximum of 24 and 26°C, respectively using two axial fans and a wet-wall of the plant house. Treatments were arranged in a split plot experimental design laid out in a randomized complete blocks. Sodium chloride concentrations (1.6, 2.4, 3.2 and 4.0 mS cm<sup>-1</sup>) were allocated to the main plots and root-media (sand and sawdust) to the subplots. To determine the stomatal conductance, a factorial experimental design (4x2x2) was used 4 days before harvest. Treatments for the stomatal conductance were NaCl levels, root-media and time of the day. All treatments were replicated three times. Parameters studied were the number of leaves, plant height, number of branches, foliar fresh mass, leaf area, chlorophyll stomatal conductance and minerals.

### RESULTS AND DISCUSSION

The number of leaves ( $P<0.01$ ), plant height ( $P<0.05$ ), number of branches ( $P<0.05$ ), leaf area ( $P<0.01$ ) and chlorophyll content ( $P<0.05$ ) were significantly reduced at the 4 mS cm<sup>-1</sup> NaCl level. The number of leaves, plants height, number of branches, leaf area, chlorophyll and foliar biomass are ascribed to yield. Increased yield was realised where NaCl concentrations were low, at 1.6, 2.4 and 3.2 mS cm<sup>-1</sup>. Yield of rose geranium was reduced at 4 mS cm<sup>-1</sup> NaCl level and this is associated with the toxicity effect of NaCl in the plant cell. Increased rose geranium yield grown in sawdust is associated with sufficient root-zone moisture, temperature and lower bulk density. The time of the day had a significant effect on stomatal conductance recorded on day-1 ( $P<0.01$ ), day-2 ( $P<0.05$ ), day-3 ( $P<0.01$ ) and day-4 ( $P<0.01$ ). Stomatal opening significantly occurred mostly in the morning when light intensity was relatively low due to better gas exchange and low light fluxes.

Only P ( $P<0.05$ ), K ( $P<0.01$ ), Mg ( $P<0.01$ ), Na ( $P<0.01$ ) and Cl ( $P<0.01$ ) were significantly affected by NaCl in the nutrient solution. The leaf mineral content of P, K and Mg were high at lower NaCl concentration and consequently reduced in high NaCl level. Dissimilar to P, K and Mg; the leaf mineral content of Na and Cl were increased at high NaCl level. Root-media only significantly affected the Na ( $P<0.01$ ) leaf-mineral content. Sodium leaf-mineral content was high in plants grown in sand than in sawdust. Root-media only significantly affected the Na ( $P<0.01$ ) leaf-mineral content. Sodium leaf-mineral content was higher in plants grown in sand than in sawdust.

### CONCLUSION

Water with high NaCl concentration must be avoided for a successful production of rose geranium on soil-less culture. Growers should fertigate rose geranium with nutrient solution that has NaCl concentration of 3.2 mS cm<sup>-1</sup> and lower.

**Keywords:** mineral uptake, NaCl levels, root-media, rose geranium

**EFFECT OF INTEGRATING *TRICHODERMA HARZIANUM* AND POTASSIUM SILICATE TO IMPROVE PLANT GROWTH AND YIELD OF MAIZE IN THE PRESENCE OF *RHIZOCTONIA SOLANI*, THE CAUSAL AGENT OF ROOT ROT**

Kubheka B.P.<sup>1</sup>, Laing M.D.<sup>2</sup> and Yobo K.S.<sup>2</sup>

<sup>1</sup>DRDAR, P/Bag X15, Stutterheim, 4930, <sup>2</sup>UKZN, P/Bag X01, Scottsville 3209

Bongani.Kubheka@drdar.co.za

## **INTRODUCTION**

Maize (*Zea mays* L.) is one of the major crops grown in South Africa. It contributes 13.2% to gross agricultural production but Eastern Cape contributes 0.82% of the total commercial maize production due to many factors, including poor soils, root rot and affordability. Root rot caused by *Rhizoctonia solani* may be controlled by *Trichoderma harzianum* (Marzano *et al.*, 2013). Silicon is an abiotic elicitor which is readily available in the soil. It primes the plants' defense mechanism to enhance resistance to abiotic and biotic stresses (Gonzalo *et al.*, 2013). In this study, therefore, the effect of integrating biological control using *T. harzianum* and priming for resistance using silicon fertilizers were evaluated for their ability to improve crop production in the presence of *R. solani*.

## **MATERIALS AND METHODS**

The field trial was conducted in loamy soils at the Mgwalana Village, Elliot, Eastern Cape, South Africa (31° 28' 0" South, 27° 18' 0" East) in soils with a 54% acid saturation. Micro dosing of dolomitic lime and 2:3:2 (28) fertilizer was used. The seeds were treated as per the requirement of the plot as per the experimental design. The treatments were two formulations of silicon fertilizer, Eco-T® (*T. harzianum*), Eco-T® plus Potassium silicate (liquid formulation) and Eco-T® plus Potassium silicate (solid formulation). All plots were inoculated with *R.solani*. Parameters evaluated were yield, plant height at different stages, dry root weight and other yield components.

## **RESULTS AND DISCUSSIONS**

It was observed that *T. harzianum* performed significantly better as a single treatment in controlling root rot than when applied together with silicon. The results also showed that silicon application performed better as well when applied alone than when applied together with *T. harzianum*. There was no significant difference in performance between the liquid formulation and the slow release formulation. This means that the combination of priming the plant for resistance and biological control of *R. solani* did not improve the control.

## **CONCLUSIONS**

It is therefore concluded that the silicon and *T. harzianum* effectively control root rot when applied individually than in combination.

**Keywords:** Maize, Silicon, biological control

## EFFECTS OF SOIL TILLAGE AND CROPPING SEQUENCE ON MICROBIAL DIVERSITY IN SHALE-DERIVED SOILS OF THE WESTERN CAPE

J Labuschagne<sup>1</sup>, J Habig<sup>2</sup>, H v Zyl<sup>1</sup>, W Langenhoven<sup>1</sup>

<sup>1</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607; <sup>2</sup>Agricultural Research Council-Plant Protection Research Institute, P/Bag X134, Queenswood, Pretoria, 0121

johanl@elsenburg.com

### INTRODUCTION

Knowledge about the influence of management practices on microbes is important to ensure sustainable crop production. It is expected that tillage and crop rotation will influence the microbial community in the root zone of crops. The aim of this study was to develop a better understanding of the effects of tillage practice and cropping sequence on microbial diversity.

### MATERIALS AND METHODS

This long-term tillage/crop rotation trial was started in 2007 on Langgewens near Moorreesburg and Tygerhoek near Riviersonderend. Three cropping systems namely, wheat monoculture (WWWWW), wheat-canola-wheat-lupin (WCWL) and wheat-medic-wheat-medic (WMcWMc) systems were included. Tillage treatments included were; zero tillage (ZT), *soil left undisturbed and planted*, no-till (NT), *soil left undisturbed and then planted with a no-till planter*, minimum-till (MT), *soil scarified to a depth of 100mm to 150mm in March/April and then planted with no-till planter* and conventional-till (CT), *soil scarified in March/April, then ploughed before planting, and planted with the no-till planter*. Five sub-samples up to a depth of 150mm per treatment combination were aseptically collected at the end of August 2011, pooled, and stored at ±5 °C until analysis. Carbon source utilisation profiles were determined by inoculating the soil suspension into Biolog EcoPlates™. Soil microbial diversity was determined using the amount and equitability of 31 carbon sources metabolised as indicators of richness and evenness, respectively.

### RESULTS AND DISCUSSION

Tygerhoek demonstrated a higher overall microbial diversity compared to Langgewens. The highest soil microbial diversity was observed in the WMcWMc sequence (Langgewens and Tygerhoek), whereas the lowest was observed in WWWWW (Langgewens) and LWCW (Tygerhoek). The lowest microbial diversity was observed under CT (Langgewens and Tygerhoek), while the highest was observed under ZT (Langgewens) and MT (Tygerhoek).

### CONCLUSIONS

Soil microbial diversity showed higher sensitivity to cropping sequences, than to tillage treatments. Preliminary results showed that the composition of soil microbial populations was the lowest in the WWWWW cropping sequence and the highest in WMcWMc. Low microbial diversity in the wheat monoculture plots could be the result of specialised microbial populations present, with the ability to utilise wheat root exudates most effectively.

**Keywords:** carbon source utilisation profiles, crop rotation, soil tillage, microbial diversity, soil quality

## THE EFFECTS OF SOIL TILLAGE AND CROPPING SEQUENCE ON ENZYME ACTIVITY IN SHALE-DERIVED SOILS OF THE WESTERN CAPE

J Labuschagne<sup>1</sup>, J Habig<sup>2</sup>, H van Zyl<sup>1</sup>, W Langenhoven<sup>1</sup>

<sup>1</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607; <sup>2</sup>Agricultural Research Council-Plant Protection Research Institute, P/Bag X134, Queenswood, Pretoria, 0121

johanl@elsenburg.com

### INTRODUCTION

Soil enzymes play an important role in organic matter decomposition and nutrient mineralisation in soils. The aim of this study was to develop a better understanding of the effects of tillage practice and cropping sequence on the potential of the soil microbial population to decompose or convert substrates.

### MATERIALS AND METHODS

This trial is being conducted as a component study within a long-term tillage/crop rotation trial started in 2007 on Langgewens near Moorreesburg and Tygerhoek near Riviersonderend. Three cropping systems namely, wheat monoculture (WWWW), wheat-canola-wheat-lupin (WCWL) and wheat-medic-wheat-medic (WMcWMc) systems were included. Tillage treatments were; zero tillage (ZT), *soil left undisturbed and planted with a star-wheel planter*, no-till (NT), *soil left undisturbed until planting and then planted with a tined planter*, minimum-till (MT), *soil scarified to a depth of 100mm to 150mm in March/April and then planted with the no-till planter* and conventional-till (CT), *soil scarified to a depth of 100mm to 150mm in March/April, then ploughed before planting, and planted with the no-till planter*. Five sub-samples to a depth of 150 mm per treatment combination were aseptically collected at the end of August 2011, pooled, air-dried at 40 °C, sieved (2mm), stored at ±5 °C and soil microbial enzyme activity determined. β-glucosidase, acid- and alkaline phosphatase and urease activity were calculated with reference to the applicable calibration curves.

### RESULTS AND DISCUSSION

At both localities, soil microbial communities in the LWCW cropping sequences demonstrated the highest potential to convert carbon (β-glucosidase activity), whereas the WLWC cropping sequence demonstrated the lowest potential to convert phosphorous (acid phosphatase activity). Medic (WMcWMc) cropping sequences demonstrated the highest potential to convert both phosphorous (acid phosphatase activity) and nitrogen (urease activity), the CWLW cropping sequence demonstrated the highest potential to convert phosphorous (acid phosphatase activity), but also the lowest potential to convert nitrogen (urease activity) in both Langgewens and Tygerhoek Trials.

The absence of similarities regarding microbial activities between extreme tillage systems amongst the two localities could be attributed to differences in soil physical-chemical characteristics.

### CONCLUSIONS

Due to the sensitivity of soil microbial communities as biological indicators of a soil's health status, cropping sequences and tillage systems affect soil microbial activity with relation to nutrient cycling.

**Keywords:** crop rotation, soil tillage, soil quality, microbial activity, soil enzyme activities

## ESTIMATION OF MOBILITY FACTORS OF HEAVY METALS IN SOIL PROFILES OF STONE QUARRIES USING LINEAR REGRESSION MODEL

Y. A. Lanre-Iyanda<sup>1</sup>, A. M. Gbadebo<sup>3</sup>, A. G. Taiwo<sup>1</sup> and A. O. Shobo<sup>2</sup>

<sup>1</sup>Department of Science Laboratory Technology, <sup>2</sup>Pharmaceutical Technology Department, Moshood Abiola Polytechnic, Abeokuta, Nigeria. <sup>3</sup>Department of Environmental Toxicology, Federal University of Agriculture, Abeokuta, Nigeria.

mrsIanreiyanda@gmail.com

### INTRODUCTION

Soils overlying mineralised rocks and human activities can result in the production of higher than normal concentrations of elements in the soils. Heavy metals may be bound or sorbed by particular natural substances which may increase or decrease mobility (Hulanicki, 2000).

Mobility factor is an important parameter that is estimated for heavy metals in soil and in presenting the estimated concentrations of heavy metals along vertical profile by an order (Iwegbue, 2007). The use of simplistic linear regression analysis to deduce a mobility factor for heavy metals in soil takes into consideration the immediate natural conditions of soil under study.

### MATERIALS AND METHODS

Soil samples at vertical depths (0-25cm, 25-50cm, 50-75cm and 75-100cm) from North, South, East and West of each of the four quarries and native soil (control) were analysed. Samples were wet digested then AAS analysed. Linear regression equation was used for estimation of metal mobility and forecasting concentration at certain depth level (Manly, 2009).

### RESULTS AND DISCUSSION

Table 1: Summary of mean Metal concentration at various sampling sites and their Mobility factors.

Sampling sites	Mn (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
AGI	150.39±22.91	4.99±0.39	5.06±0.45	3.52±0.52
NTC	199.07±16.27	10.15±2.78	4.79±0.11	3.21±0.60
GP	148.77±28.82	0.66±0.59	3.19±0.27	1.99±0.40
Control	116.26±22.06	1.02±0.36	1.89±0.67	1.78±0.37
Mean	166.08±21.33	5.27±1.25	4.35±0.28	2.91±0.51
Mobility factor	0.97	2.40	0.06	-0.33

The results of linear regression analysis considered the value of slope in the equation for the estimation of mobility factor of heavy metals in the quarry sites. The following average order of mobility factor for the heavy metals Pb (2.40) > Mn (0.97) > Cr (0.06) > Ni (-0.33) was established. This order is not dependent on concentration, which alludes to already established facts that several factors influence mobility of heavy metals.

### CONCLUSION

The mobility factor of Pb indicated that it poses more risk in this environment. Mn concentration is highest in all the quarry sites.

**Keywords:** Heavy metals, Mobility factor, Regression model, Soil profile, Stone quarry,

## METAL CONTENT ASSESSMENT OF FARM VEGETABLES AND FARM SOIL

A. G. Taiwo<sup>1</sup>, Y. A. Lanre-Iyanda<sup>1</sup> and A. A. Alabi<sup>2</sup>

<sup>1</sup>Science Laboratory Technology Department, <sup>2</sup>Hospitality, Leisure and Tourism Department of Moshood Abiola Polytechnic, Abeokuta, Nigeria.

mrsanreiyanda@gmail.com

### INTRODUCTION

The widespread contamination of metals in the last decade has raised public and scientific interest due to their dangerous effects on human health. These metals may contaminate plants, vegetables, fruits and canned foods through air, water and soil during cultivation (Hussain *et al.*, 1995). The accumulation of metals can have middle and long term health risk effect, therefore strict periodical surveillance is therefore mandatory.

### MATERIALS AND METHODS

The various vegetables and soil were collected randomly in replicates from a major farm in Abeokuta metropolis, Ogun State of Nigeria. Samples were wet digested and analysed using Atomic Absorption Spectrophotometer (A.O.A.C. 2000) and the data subjected to statistical analysis of variance using SPSS version 17.0

### RESULTS AND DISCUSSION

Table 1: Mean Metal content in farm vegetables and soil

Sample(mg/Kg)	As	Cu	Ni	Pb	Cd	Fe	Na
Bitter leaf	ND	0.24±0.00	0.54±0.01	0.01±0.00	0.02±0.01	9.73±0.5	4.02±0.05
African Spinach	ND	0.18±0.01	0.59±0.02	0.13±0.01	0.11±0.10	8.69±0.50	12.26±0.50
Water leaf	ND	0.76±0.02	0.44±0.00	8.64±0.03	0.03±0.00	9.05±1.00	9.77±0.04
Jews mallow	0.02±0.00	0.21±0.01	0.62±0.03	11.43±0.50	0.03±0.01	5.80±0.50	5.67±0.03
Basel	0.25±0.01	0.23±0.02	0.63±0.02	0.19±0.01	0.02±0.00	15.22±1.00	6.27±0.02
Farm soil	0.95±0.05	0.30±0.01	0.78±0.03	0.04±0.01	0.01±0.00	38.80±2.00	5.99±0.01
FAO/WHO/CO DEX, 2001 STD	0.2	40	0.2	0.3	0.2	425	20

ND: Not detected, STD: Standard.

The result of metal analysis of the vegetable samples revealed that Ni in all samples as well as, As, Pb and Cd in some samples were above the standard permissible limit. Cd levels in some of the vegetable samples were also above the soil Cd content. This could be as a result of atmospheric deposition of this metal on the vegetables from anthropogenic activities resulting in environmental pollution, as the farm is close to the highway. High levels of metals in vegetables and soils may be of potential health risk especially through edible plant consumption leading to bio-accumulation.

### CONCLUSIONS

Metal levels in some of the vegetables were above the permissible limit and in some cases above the soil metal level. There is the need for continuous monitoring of these farms to ensure food safety for consumers of these vegetables.

**Keywords:** metals, vegetables, soil, health risk concern

## THE EFFECT OF ONCE-OFF TILLAGE ON THE SOIL WATER CONTENT AND RESULTANT CROP RESPONSE OF A SHALE DERIVED SOIL UNDER NO-TILL IN THE SWARTLAND SUB-REGION OF THE WESTERN CAPE

I.R. Leygonie<sup>1</sup>, J. Labuschagne<sup>2</sup>, E. Hoffman<sup>1</sup> and H. Van Zyl<sup>2</sup>

<sup>1</sup>Department Soil Science, University of Stellenbosch, Private Bag X1, Matieland 7602

<sup>2</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607

johanl@elsenburg.com

### INTRODUCTION

Conservation agriculture has become a very popular management practice in the Western Cape. The positive effects of CA are well known, although some negative effects may develop over time. Nutrient stratification, increased bulk density and increased crop residue cover may result in management challenges to ensure optimum crop productivity. These challenges may be addressed through, amongst others, the cultivation of soil. The cultivation of soil may also effect soil water relations. The objective of this study is to determine the effect of once-off tillage on the soil water content and the resultant crop response.

### MATERIALS AND METHODS

The study was conducted as a short term study during 2014 to 2015 at the Langgewens Research Farm near Moorreesburg (33°16'42.33" S; 18°42'11.62" E; 191 m). The experimental design was a randomised complete block with a split-plot treatment design. Three cropping sequences, namely: medic-clover/wheat/medic-clover/wheat (McWmCW), wheat/lupine/wheat/canola (WLWC) and lupine/wheat/canola/wheat (LWCW) were allocated to main plots and replicated four times (The last letter in the sequence represents the crop on the field at the time of data collection). Main plots were subdivided into three sub-plots and allocated to tillage treatments, namely: continuous no-till (NT), soil left undisturbed until planting and then planted with a tined no-till planter, non-inversion tillage (DT), deep tine to a depth of ~400 mm and inversion tillage (MP), soil inverted using mouldboard plough to a depth of ~250 mm. The Diviner 2000 was used to record soil moisture content (100 mm increments) at weekly intervals to depths of between 70 cm and 100 cm using access tubes.

### RESULTS

The water content of all treatment combinations tended to decrease as the season progressed. No definite trend in the effect of NT, MP and DT on the soil water content was observed within the different cropping systems included in the study. The initial (immediately after planting) average profile water content of the McWmCW system (192.57 mm) tended to be higher than WLWC (178.54 mm) and LWCW (107.18 mm). The in season water content of the McWmCW system varied between 110.53-307.88 mm, 68.09-281.56 mm for the LWCW system and 74.55-228.69 mm for the WLWC system. Maximum water content of the canola sequence tended to be lower than the other two sequences included in the study. The highest grain yield of 3802 kg/ha<sup>21</sup> for the LWCW sequence was recorded for DT, 4066 kg/ha<sup>21</sup> for McWmCW where NT was practised and 2131 kg/ha<sup>21</sup> for canola in WLWC which received the MP treatment.

### CONCLUSION

Preliminary results show that water content tends to differ between the tillage treatments and crop rotation systems studied. Inclusion of a second year data (2015) is however needed to formulate final conclusions.

**Keywords:** canola, no-till, plough, rip, wheat

## DETERMINING OPTIMUM CANOLA PLANT DENSITY IN THE WESTERN CAPE: PRELIMINARY STUDY

PJA Lombard<sup>1</sup>, LT Smorenburg<sup>1</sup>, JA Strauss<sup>1</sup>

<sup>1</sup>Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607

pietl@elsenburg.com

### INTRODUCTION

The high costs of canola seed is one of the driving forces why producers plant at reduced rates. This study was launched to determine the optimum canola plant stand and from there determining the optimum seeding rate.

### MATERIALS AND METHODS

Cultivars x density trials were conducted at Riversdale and Tygerhoek in the Southern Cape, as well as Langgewens in the Swartland, during 2012. These trials were repeated in 2013 at Riversdale and Tygerhoek. Each trial consisted of 6 treatments within a complete block design, with 3 replications in 2012 and 4 replications in 2013. Seeding rate was adapted to deliver the required plant density of 25, 50, 75, 100, 125, and 150 plants m<sup>-1</sup>. We assumed a field establishment of 60% for the cultivars AGA Max (2012) and Hyola 575 (2013). At each site the number of plants per m<sup>2</sup> was counted approximately 4 weeks after sowing and again at harvest. The data was then used to determine the optimum plant density and the seeding rate necessary to obtain the optimum plant density.

### RESULTS AND DISCUSSION

In 2012 the germination percentage varied between 81.1% (150 plants m<sup>-1</sup>) and 100% (25 plants m<sup>-1</sup>). During 2013 it varied between 70.1% and 94.5%. The survival rate of plants declined as the seeding density increased. The percentage plants that survived varied between 83.0% and 46.7% in 2012 and 98.3 to 53.2% in 2013. In 2012 the target seeding rate influenced seed yield with 25 plants m<sup>-1</sup> yielding the highest followed by 50-, 75-, 100-, 125- and 150 plants m<sup>-1</sup> (R<sup>2</sup>=0.78). There was no significant yield response in 2013. In a seed yield vs number of surviving plants equation, the seed yield started to plateau at 35-37 plants m<sup>-1</sup> at harvest time.

### CONCLUSIONS

The optimum plant density of canola appears to be 36.48 seeds m<sup>-1</sup>. Suggested seeding rate according to data is calculated at 2.2kg ha<sup>-1</sup> compared to the recommended norm of 3 to 4 kg ha<sup>-1</sup>, which relates to a possible 50% saving in seed costs. The data also indicated that a more comprehensive trial might be necessary to test for differences between more cultivars and genotypes.

**Keywords:** plant survival, seeding rate, yield



DETERMINING OPTIMUM PLANT DENSITY FOR OATS AND TRITICALE FOR HAY PRODUCTION IN THE  
WESTERN CAPE

## DETERMINING OPTIMUM PLANT DENSITY FOR OATS AND TRITICALE FOR HAY PRODUCTION IN THE WESTERN CAPE

PJA Lombard and JA Strauss

Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607

piet@elsenburg.com

### INTRODUCTION

The planting density of oats and triticale varied widely in the rain fed environment of the Western Cape. The reasons for variation in plant density are the price of seed, weed competition and lack of information. The establishment of the optimum plant population is essential to achieve the maximum possible bio-mass yield. The trials were conducted to determine the optimum plant density for optimum yield in oats and triticale.

### MATERIALS AND METHODS

In 2006 SSH 421, SSH 405 (oats), Ibis and Rex (triticale) were planted in a Latin square design with 4 treatments and 4 replications at Elsenburg. In 2007 the trial was repeated with SSH 421 and Ibis in a randomised complete block with 10 treatments and 3 replications. The 4 plant density treatments in 2006 were 150, 200, 250 and 300 seeds  $m^{-2}$ , while in 2007 the plant density treatments had a 25 interval starting at 125 seeds  $m^{-2}$  and ended at 350 seeds  $m^{-2}$ . The number of plants and bio-mass at the milky- and soft dough stage was determined. Data was analysed using SAS ( $P < 0.05$ ).

### RESULTS AND DISCUSSION

In the 2006 trial, the number of ears in the 300 seeds  $m^{-2}$  treatment was significantly more than the 150 seeds  $m^{-2}$  treatment for the oats cultivars. The number of ears of triticale cultivars increase at higher seeding rates but was not significant. The bio-mass of SSH 421 in the 150 seeds  $m^{-2}$  treatment was significant higher than the 250 seeds  $m^{-2}$  treatment, while the bio-mass of Rex was significant higher in the 300 seeds  $m^{-2}$  treatment compared to 150 seeds  $m^{-2}$ . The 2007 trial showed a strong correlation between seeding density and number of seedlings for both oats ( $R^2=0.95$ ) and triticale ( $R^2=0.97$ ). There was a positive correlation between number of ears and bio-mass at milky stage (SSH 421,  $R^2=0.45$  and Ibis  $R^2=0.65$ ).

### CONCLUSION

No optimum plant density for oats is evident for oats in this study. Triticale bio-mass increased with increasing seeding density

**Keywords:** oats, triticale, bio-mass, seeding density

**EFFECT OF BIOCHAR AND PHOSPHORUS FERTILIZER APPLICATION ON SELECTED SOIL CHEMICAL PROPERTIES AND YIELD OF CHICKPEA (*Cicer arietinum*)**

SG Lusiba<sup>1</sup>, JJO Odhiambo<sup>1</sup> and JBO Ogola<sup>2</sup>

<sup>1</sup> Department of Soil Science, <sup>2</sup> Department of Plant Production, University of Venda, Private Bag X5050, Thohoyandou 0950, South Africa  
E-mail: ciphwe.gloria@gmail.com

**INTRODUCTION**

Low soil fertility is a major problem limiting crop yield especially in arid and semi-arid areas. Therefore, the study investigated the effect of biochar and phosphorus (P) fertilizer application on selected soil chemical properties and yield of chickpea grown on clay and a loamy sand soils.

**MATERIALS AND METHODS**

Two field experiments were conducted on a clay and a loamy sand soil at the University of Venda's Experimental Farm, and at the ARC-Institute for Tropical and Subtropical Crops farm in Nelspruit, respectively, during summer 2013/2014. Treatments consisted of a factorial combination of four biochar levels (0, 5, 10 and 20 t ha<sup>-1</sup>) and two P fertilizer levels (0 and 90 kg ha<sup>-1</sup>), arranged in a RCBD and replicated three times. Data was subjected to ANOVA using GLM procedure of Minitab and means were compared using LSD test at (P = 0.05).

**RESULTS AND DISCUSSION**

Biochar application affected total C in both clay and loamy sand soil. The highest values of total C were observed at 10 t ha<sup>-1</sup> and 20 t ha<sup>-1</sup> of biochar application in loamy sand and clay soil, respectively. The increase in total C due to biochar application could be due to the presence of high amount of carbon content in the biochar used. The effect of biochar and P fertilizer application on total N was significant only in clay soil. The lack of response of total N to biochar application in loamy sand soil was probably due to low decomposition and mineralization of biochar in the soil. Biochar application did not have any effect on available P in both soils. However, P fertilizer application increased available P in loamy sand soil but not in clay soil. The effect of biochar and P fertilizer on grain yield and 100 seed weight was not significant in both soils. In contrast, biochar and P fertilizer application increased the number of seeds per pod in clay soil, and number of seed per pod increased with P fertilizer application in loamy sand soil.

**CONCLUSION**

The application of biochar at 20 t ha<sup>-1</sup> and P fertilizer at 90 kg ha<sup>-1</sup> increased both total C and N in clay soil but not in loamy sand soil. However, there was no significant effect of biochar and P fertilizer on grain yield in both soils.

**Keywords:** Carbon content, crop production, 100 seed weight, soil fertility

## NUTRITIONAL VALUE AND MARKETING OF THE PREFERRED INDIGENOUS LEAFY VEGETABLES (ILVs) OF LIMPOPO PROVINCE

MHR Mabala<sup>1</sup>, IK Mariga<sup>2</sup>, MP Mabapa<sup>1</sup>

<sup>1</sup>University of Limpopo, Private Bag x1106, Sovenga, 0727 ; <sup>2</sup>University of Limpopo, Private Bag x1106, Sovenga, 0727

mabalahm@gmail.com

### INTRODUCTION

There are a wide variety of indigenous leafy vegetables (ILVs) found in Africa, which are used for ensuring food security among rural communities. These vegetables also have many nutritional attributes that prevent or cure some diseases. The aim of this study was to identify the most preferred ILVs utilized by rural communities in three districts of Limpopo Province, namely Capricorn, Sekhukhune and Vhembe, determine their nutritional values and study how they are marketed.

### MATERIALS AND METHODS

A survey questionnaire was used to gather information about the preferred ILVs and their marketing value. Fresh samples of these ILVs were collected during the survey. Dried samples of cooked leaf of the preferred ILVs were analysed for mineral nutrient content at the Feed Laboratory of the Department of Agriculture and Environmental Affairs in KwaZulu-Natal Province using standard methods.

### RESULTS AND DISCUSSION

The preferred species identified in the survey included spider plant, cowpea, pumpkin, Amaranth, cucurbit, jute mallow, *Vernonia fastigiata*, tsamma, blackjack, *Cleome monophylla*, nightshade and bitter gourd. The preference of these ILVs may be due to their taste, the level of their availability, their high nutritional value and their medicinal and cultural uses. Farmers identified 10 ILVs in Capricorn, 12 in Sekhukhune and nine in Vhembe district as their mostly preferred. Amaranth was shown to be the most preferred ILV in the three districts with Capricorn having 50%, Sekhukhune 90% and Vhembe 54.7% of the respondents. Most ILVs preferred in Sekhukhune district were similar to the ones preferred in Capricorn district but were different to those for Vhembe district. This may be due to cultural difference as Sekhukhune and Capricorn districts are predominately Pedi speaking while Vhembe district is largely inhabited by Vendas. These vegetables are known to have high nutritional value compared to exotic vegetables. The results ILVs showed that Swiss chard (0.78%) contained low content of calcium compared to devils thorn (3.17%), spider plant (2.24%), spindle pod (3.17%), jute mallow (2.46%) and bitter gourd (1.60%) and also low content of iron (288.4 mg/kg) compared to black jack (563 mg/kg) that contained two times the content. The results ILVs showed that spider plant had high sodium (1222.4 mg/kg) and aluminum (934 mg/kg) content. *V fastigiata* contained high iron (1078 mg/kg) mineral content. Amaranth harvested from Vhembe district had different minerals nutrients compared to the one harvested from Sekhukhune district, these maybe due to the different soil types, age of the crop and climatic factors. Amaranth from Vhembe district had high sodium (759.2 mg/kg), zinc (318 mg/kg), molybdenum (220 mg/kg), iron (669 mg/kg) and aluminum (835 mg/kg) compared to amaranth from Sekhukhune that contained 583.6 mg/kg sodium, 43 mg/kg zinc, 107 molybdenum, 671 mg/kg iron and 613 mg/kg aluminum content. These ILVs are mostly marketed locally by local people.

### CONCLUSION

Blackjack, amaranth, pumpkin, cowpea and spider plant are the most common ILVs sold in the three districts. ILVs play a significant role in the lives of poor people as they can provide nutrients required to keep them healthy and can also be used to generate income for poor households.

**Key words:** indigenous leaf vegetables, marketing, nutritional value

## RESPONSE OF TWO HYDROPONICALLY GROWN TOMATO CULTIVARS TO TRANSPLANTING STAGE AND DIRECT SEEDING

MM Maboko<sup>1</sup>\*, Du Plooy CP

<sup>1</sup>Agricultural Research Council - Vegetable and Ornamental Plant Institute, Private Bag X293, Pretoria, 0001

maboko@arc.agric.za

### INTRODUCTION

Direct seeding of hydroponically grown tomatoes is not a common practice in South Africa, and most growers use transplants. Various studies have been conducted in open field cultivation on direct seeding versus transplants (Leskovar and Cantliffe, 1993; Leskovar and Cantliffe, 1991), but there is limited information for tomatoes grown hydroponically. This study was conducted to determine the yield of two locally produced tomato cultivars as affected by transplant stage and direct seeding.

### MATERIALS AND METHODS

The study was conducted during October 2011 to February 2012 (2011/2012) and repeated in September to February 2013 (2012/2013) at the Agricultural Research Council -Vegetable and Ornamental Plant Institute (ARC-VOPI), Roodeplaas. A temperature controlled plastic tunnel was used, equipped with a pad and fan cooling system. Two indeterminate freshmarket tomato cultivars, FA593 and Linares, were either directly sown in 10 L plastic bags filled with sawdust, or transplanted as seedlings at 2-, 4- and 6-leaf stages. A randomized complete block design with 4 replicates was used. Data were subjected to analysis of variance (ANOVA) using the statistical program *GenStat*® version 11.1. Treatment means were separated using Fisher's protected T-test least significant difference (LSD) at the 5% level of significance.

### RESULTS AND DISCUSSION

The 2011/2012 experiment was terminated early (126 days after transplanting) due to a high infestation of tomato rust mite (*Aculops lycopersici*). In 2011/2012, cultivar FA593 produced significantly higher early and total yield, as well as unmarketable yield, compared to cultivar Linares. Total marketable yield and number of marketable fruit were not significantly affected by cultivar. However, cultivar FA593 produced a higher early yield than Linares. In 2011/2012, directly sown seeds, and seedlings transplanted at the 2- or 4-leaf stages, produced significantly higher early marketable and total yields than seedling transplanted at the 6-leaf stage. Total yield, and total marketable yield, for direct seeded and transplanted tomato were similar. In 2012/2013, sowing seed directly into the sawdust or transplanting seedlings at the 2-leaf stage produced plants that had the highest early number of marketable fruit, and early total and marketable yield. Total yield, or total marketable yield, were not affected by transplant stage or direct seeding.

### CONCLUSIONS

Direct seeded plants, or transplanting seedlings at the 2-leaf stage, will benefit growers by producing tomatoes earlier for the market, while eliminating or reducing transplant shock. Direct seeding or transplanting seedlings at the 2 leaf stage would reduce production costs in hydroponic production systems.

**Keyword:** early yield, market, seedling

P.B. Machipyan<sup>1</sup>, T.P. Mafeo<sup>1</sup>, M.R. Masevhe<sup>1</sup>, N Mathaba<sup>2</sup> and J Mlimi<sup>2</sup>

<sup>1</sup>University of Limpopo, SAES, P/Bag x 1106, Sovenga, 0727

<sup>2</sup>ARC-ITSC, P/Bag x 11208, Nelspruit, 1200

#### **INTRODUCTION**

Cold storage can prolong storage life and quality of avocado because it reduces ethylene production, respiration rate and ripening. However, it can lead to reduced firmness and physiological disorders such as vascular staining, stem-end rot, chilling damage and anthracnose. There is a need for continued development of more viable avocado cultivars with superior characteristics, to enhance competitiveness and profitability in the South African Avocado Industry. In response to these challenges, the Agricultural Research Council-Institute for Tropical and Subtropical Crops (ARC-ITSC) has already bred and selected new superior 'Hass type' avocado selections. Therefore, the aim of this study was to determine the response of these new 'Hass type' avocado selections to the mandatory low temperature required for prolonged storage.

#### **MATERIALS AND METHODS**

Mature new 'Hass type' avocado fruits ("Jalna" and "S-SS2") were harvested from the Burgershall, ARC-ITSC gene block and transported to the ARC-ITSC Post harvest laboratory in Nelspruit for analysis. At the laboratory the fruits were sorted, graded and stored at 5.5°C for up to 28 days. Ten fruits per tree per selection were harvested. The experiment was a factorial, arranged in a completely randomized design (CRD) consisting of 3 boxes with 9 fruits as one of the fruits was destructively used for moisture analysis, replicated three times which makes a total of 27 fruits. After cold storage, fruits were kept at ambient temperature to ripen. During ripening fruits were evaluated for electrical conductivity, firmness, colour change (Lightness, chroma, hue) and respiration rate (CO<sub>2</sub>).

#### **RESULTS AND DISCUSSION**

According to Cutting et al. (1988), during avocado ripening respiration increases, culminating in reduced quality and shelf-life. Selections under investigation showed a decrease in colour parameters (Lightness, chroma, hue), a characteristic of commercial Hass (Cox et al., 2004). "S-SS2" showed enhanced chilling injury, electrolyte leakage, respiration rate but a longer shelf-life and better quality fruits in comparison to "Jalna". Furthermore, "Jalna" had significantly large fruits, increased respiration (CO<sub>2</sub>), and weight loss; and therefore, reduced shelf-life. In conclusion, "S-SS2" appeared to have reduced ripening rate, enhanced firmness and shelf-life, however, its downfall is predominantly chilling damage.

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**Keywords:** Avocado fruit; Days to ripening; "Jalna", "S-SS2" and Hass

**THE EFFECT OF BIOCHAR AND PHOSPHORUS FERTILIZER APPLICATION ON  
PHOTOSYNTHESIS, STOMATAL CONDUCTANCE, AND CHLOROPHYLL CONTENT OF  
CHICKPEA (*CICER ARIETINUM*)**

P.J. Macil<sup>1</sup>, J. B.O Ogola<sup>1</sup>, J. J. O. Odhiambo<sup>2</sup>, S. G. Lusiba<sup>2</sup>

<sup>1</sup>Department of plant production, University of Venda, Private bag X5050, Thohoyandou, 0950, South Africa

<sup>2</sup>Department of soil science, University of Venda, Private bag X5050, Thohoyandou, 0950, South Africa  
ochanda@univen.ac.za

#### **INTRODUCTION**

Incorporation of chickpea into existing cropping systems in the dry environments of Limpopo Province, that are characterised by continuous cropping, with hardly any addition of fertilizer and soil amendments may increase productivity. The study aimed at assessing the effect of biochar and phosphorus (P) fertilizer on some physiological traits of chickpea.

#### **MATERIALS AND METHODS**

A field experiment was conducted at the University of Venda's Experimental Farm in Thohoyandou (23°35'14.0" S and 30°15'50, 3" E and 595m asl), Limpopo, South Africa during the winter of 2014. The treatments consisted of a factorial combination of 2 phosphorous fertilizer rates (0 and 90 kg ha<sup>-1</sup>) and 4 biochar rates (0, 5, 10, and 20 t ha<sup>-1</sup>) arranged in RCBD with 3 replications. Photosynthesis, stomatal conductance, and chlorophyll content were measured at flowering. Data was subjected to ANOVA using Genstat (version 16). Significant differences between treatments were determined at 5% level using the standard error of differences of means.

#### **RESULTS AND DISCUSSION**

The effect of biochar and P fertilizer increased stomatal conductance ( $P < 0.001$ ) and chlorophyll content ( $P < 0.05$ ). In contrast, the effect of biochar and P fertilizer was not significant on net leaf photosynthesis. The non-response of net leaf photosynthesis to biochar could imply that stomatal factors were not limiting to photosynthesis in the current study. The increased stomatal conductance with biochar application could be due to the effect of biochar on soil properties (Steiner et al., 2007). Biochar have improves soil moisture retention, nutrient supply, reduced erosion and leaching of soil nutrients. The response of chlorophyll content to biochar application could be due to effect of biochar on the nutrient status of the plant.

#### **CONCLUSIONS**

Application of biochar and P fertilizer did not affect net leaf photosynthesis but significantly increased stomatal conductance and chlorophyll content. However, it is recommended that more studies should be done before conclusions can be drawn on the effect of biochar and P fertilizer on physiological parameters of chickpea.

**Keywords:** physiological traits, soil fertility

## GROWTH AND YIELD RESPONSES OF BEETROOT TO FERTILISER

CWMP Chauke, VI Ayodele, MB Mahlatji  
University of Limpopo, Private Bag X 1106, Sovenga 0727  
School of Agriculture and Environmental Sciences

mahlatjimb@gmail.com

### INTRODUCTION

Beetroot (*Beta vulgaris* L.) is a traditional and popular vegetable in many parts of the world. Integrated use of organic and inorganic fertilisers can be an effective approach for soil fertility maintenance and improved crop yield. The objective of the study was to assess growth and yield of beetroot in response to sole and combined application of effective microorganisms' enriched compost, broiler manure and mineral fertiliser.

### MATERIALS AND METHODS

The experiment was conducted on the University of Limpopo horticultural skill centre (23° 53' 10" S; 29° 44' 15" E). The experiment was laid out as randomized complete block design (RCBD) with six treatments replicated three times. The treatments were (1) control (no fertiliser application), (2) recommended amount of EM (Ravivi) enriched compost (12.88 kg/4 m<sup>2</sup>), (3) recommended amount of broiler manure (12 kg/ha), (4) recommended amount of inorganic (NPK) fertiliser (2:3:2 (30) at a rate of 150 kg/ha N, 60.83 kg/ha P and 151.25 kg/ha K, this was applied as N from urea at 476.2 g/4 m<sup>2</sup>, P from single superphosphate at 231.79 g/4 m<sup>2</sup> and K from potassium chloride (KCl) at 121 g/4 m<sup>2</sup>, (5) 50 % of recommended amount of inorganic fertiliser + 50 % of recommended amount of poultry manure, (6) 50 % of recommended amount of EM enriched compost + 50 % recommended amount of inorganic fertiliser. Seedlings were transplanted at normal spacing of 1800 cm<sup>2</sup> per plant.

### RESULTS AND DISCUSSION

Beetroot growth and yield increased ( $P \leq 0.05$ ) with fertiliser application. Better stand establishment was found in beetroot plants grown in soils treated with fertiliser materials compared to the control (without fertiliser application). Growth parameters such as plant height and number of leaves were significantly higher in soils treated with EM compost, NPK and broiler manure compared to the control. Yield parameters also showed the same trend. Beetroot leaf production, fresh and dry shoot and root mass were highest in broiler manure treatment, while the significantly lower values were obtained in the control. The values per plant were 10.93 g (dry shoot mass), 49.60 g (dry root mass) compared to 1.57 g and 2.43 g respectively recorded in the control. The highest significant root yield of 3544 g 4 m<sup>2</sup> was found in broiler manure treatment, 2795.7 g 4 m<sup>2</sup> in EM+ NPK, 1929.2 g 4 m<sup>2</sup> in EM compost, 1685.3 g 4 m<sup>2</sup> in broiler manure + NPK, 850 (g 4 m<sup>2</sup> in NPK and 133.2 g 4 m<sup>2</sup> in the control

### CONCLUSION

Broiler manure, EM enriched and inorganic (NPK) fertiliser may be applied solely or in combination for improved growth and yield of beetroot crops.

**Keywords:** broiler manure, Effective microorganisms' enriched compost.



## SUITABLE POTTING MEDIA FOR WEANING *IN VITRO* PROPAGATED *CUCUMIS MYRIOCARPUS* PLANTLETS

MY Maila<sup>1</sup>, PW Mashela<sup>2</sup>, MS Mphosi<sup>1</sup>

<sup>1</sup>Limpopo Agro-Food Technology Station/ <sup>2</sup>Department of Plant Production, Soil Science and Agricultural Engineering, University of Limpopo, Private Bag X1106, Sovenga 0727, South Africa  
yvonne.maila@ul.ca.za

### INTRODUCTION

Plant species from the Cucurbitaceae Family, with various potential economic uses are being considered as alternative crops (Mphahtele et al. 2012), particularly in Sub-Sahara Africa. Empirical information demonstrated that uniform plantlets of indigenous *Cucumis* species to South Africa could be mass-propagated using *in vitro* procedures (Maila et al. 2013). Selection of suitable potting medium is integral to the successful weaning of *in vitro* mass propagation of uniform plants to *ex vitro* conditions. The objective of the study therefore, was to determine suitable potting media for weaning *in vitro* propagated wild cucumber (*Cucumis myriocarpus*) plantlets.

### MATERIALS AND METHODS

Three-month-old healthy plantlets measuring 15-cm long with at least 5 leaves and a well-developed root system were carefully removed from the acclimatising conditions and transplanted into 15-cm-diameter disinfected plastic pots. Pots were filled with four mixtures of potting media, namely, sand + loam (standard), sand + vermiculite, sand + Hygromix and sand + compost, all at 3:1 (v/v). The four treatments were arranged in a randomised complete block design, with 10 replications. Plantlets were irrigated with 250-ml tapwater every other day. At harvest, stem diameter, number of shoots, dry shoot mass, dry root mass and vine length were measured, recorded and subjected to analysis of variance using SAS software.

### RESULTS AND DISCUSSION

Relative to the standard potting medium, sand + compost increased all variables measured in *C. myriocarpus in vitro* produced plantlets. Sand probably improved aeration and drainage, while compost improved retention of moisture and available nutrient elements.

### CONCLUSIONS

In conclusion, sand + compost mixture was considered the most suitable transplanting potting medium for *in vitro* propagated plantlets of *C. myriocarpus*. Sand probably improved aeration

**Keywords:** Adapted crops, food security, mother stock, plant growth regulators.

## ESTIMATING GENETIC DISTANCES OF MAIZE INBRED LINES USING SSR MARKERS

TJ Malala<sup>1</sup>, LA Madubanya<sup>2</sup>, TC Baloyi<sup>2</sup>

<sup>1</sup>Taung Agricultural College, Private BagX532, Taung 8584; <sup>2</sup>ARC-Grain Crops Institute P/Bag X1251, Potchefstroom, 2520

tmalala@nwpg.gov.za

### INTRODUCTION

Identification of parental combination that produces superior hybrids is the most crucial step in any breeding program. Information about germplasm diversity facilitates the effective use of genetic resources in maize breeding program. The genetic relationship among breeding lines can be a useful tool for predicting the relative performance of the hybrid combinations. This can result in cost and time reduction for testing progenies. Of recent past SSR markers has been developed and applied to overcome the constraints associated with pedigree and phenotypic markers and it makes it possible to identify and locate genes controlling complex traits such as yield. The efficiency of the breeding program can be improved if the parental lines are screened and superior crosses are predicted before field evaluations embarked on by breeders. The purpose of this study was to generate the genetic distance information among maize inbred lines for the development of superior hybrids.

### MATERIAL AND METHODS

Genomic DNA was extracted using the CTAB method from 15 inbred lines obtained from the ARC germplasm bank. Lines were selected based on field evaluations of agronomic traits. PCR products were generated using 68 fluorescently labelled SSR primers pairs and separated using the ABI 3130x1 genetic analyser. Electrophoresis results were analysed using Genemapper 4.0 software (Applied Biosystems). Statistical analyses were carried out using Powermarker v3.25 using the Rogers (1972) parameter to determine genetic distances.

### RESULTS AND DISCUSSION

The genetic dissimilarity among maize inbred lines varied from a minimum of 0.144 between A7082Y and I137TN to a maximum of 0.795 between CB199 and CBY275. The distances among these inbred lines are consistent with the inbred lines pedigree data. It is well documented that crosses between unrelated and genetically distant parents show greater hybrid vigour than crosses between closely related parents. It is therefore, expected that the cross between CB199 and CBY275 may be more heterozygous than others while the cross between A7082Y and I137TN is expected to be more homozygous than all others.

### CONCLUSIONS

The information on genetic distances among maize inbred lines is very useful for better management of gene pool and genetic enhancement of inbred lines for maize breeding programs. Highly diverse maize genotypes from this study could be used in further breeding program. Inbred lines showing high genetic distances based on SSR markers should be selected and crossed and F1 hybrids evaluated for their yield and other agronomic traits performance.

**Keywords:** genetic distance, heterozygous, hybrid vigour, SSR markers

## SCREENING FOR MORPHOLOGICAL CHANGES AND DROUGHT TOLERANCE IN SWEETPOTATO MUTANT PLANTS

ME Malebana<sup>1</sup>, SM Laurie<sup>2</sup>, N Chiloane<sup>2</sup>, WM Mphela<sup>2</sup> and ML Mokoena<sup>1</sup>

<sup>1</sup> Limpopo Department of Agriculture, Tsoelike Research Station, Private Bag X1615, Bela Bela, 0480, South Africa; <sup>2</sup> Plant Breeding Division, ARC-VOPI, Pretoria, South Africa

malebanaME@agric.limpopo.gov.za

### INTRODUCTION

Drought tolerant varieties are important for sustainable sweetpotato production in South Africa where the crop is mainly grown under rain-fed conditions. The aim of this study was to screen a generated sweetpotato mutant population for any visible morphological changes and improved drought tolerance in the glasshouse.

### MATERIAL AND METHODS

Putative mutants derived from the cultivar Ndou were cultured and propagated *in vitro* for four generations to obtain stable mutations. At the M<sub>1</sub>V<sub>4</sub> stage, 4 500 plantlets were transplanted for morphological screening. Mutation frequencies were calculated for each phenotypic change observed. Mutant lines (110) with morphological changes were evaluated for drought tolerance in two separate experiments conducted in a glasshouse. Experiment 1 entailed screening for both drought and heat tolerance while Experiment 2 evaluated mutants for drought tolerance only. Both experiments were planted in a CRD with three replicates in plastic boxes. Plants were watered for 14 days and thereafter subjected to water stress until 70% of plants were severely wilted or dead. Data were collected on survival rate as well as days to severe wilting or death. The ANOVA was run using Genstat 15.1 at P=0.05 and the Fisher's protected LSD test was used to group treatments as sensitive, intermediate or tolerant to drought stress.

### RESULTS AND DISCUSSION

A total of 144 plantlets (3.6%) with visible phenotypic changes when compared to Ndou were identified. Changes observed included changes in leaf shape, chlorophyll variegation, leaf colour, vine twining and root flesh colour. Root flesh colour changes observed during sectioning of roots ranged from dark yellow, cream with light orange spots and light orange to yellowish cream with dark orange spots covering most of the flesh. A root flesh colour mutation frequency of 1.18% was obtained. Results from Experiment 1 of drought evaluation identified 13 mutant lines (M2, M3, M5, M23, M26, M31, M32, M33, M37, M45, M63, M64 and M70) with potentially improved tolerance to drought and heat stress compared to Ndou. In Experiment 2, no mutant lines with significantly improved drought tolerance compared to Ndou were identified.

### CONCLUSIONS

The study identified 144 mutant lines with phenotypic changes (including root flesh colour) and 13 mutant lines with potentially improved tolerance to drought and heat stress compared to Ndou. Identified mutant lines will be included in field trials for further evaluation of drought tolerance and other agronomic traits to confirm these results.

### ACKNOWLEDGEMENTS

International Atomic Energy Agency (IAEA) for funding the research project.

**Keywords:** flesh colour, gamma ray, induced mutation, *Ipomoea batatas*

## EFFECT OF EFFECTIVE MICROORGANISMS ENRICHED COMPOST, BROILER MANURE AND INORGANIC FERTILISER APPLICATION ON GROWTH AND YIELD OF MUSTARD SPINACH

MS Mohale, VI Ayodele and TW Maluleka  
University of Limpopo  
School of Agricultural and Environmental sciences

tiyiselani662@gmail.com

### INTRODUCTION

Mustard spinach (*Brassica juncea*) is a leafy vegetable that is characterised by large number of broad oblong shaped leaves in the lower layers. It can be grown on well drained soils. There is limited knowledge on the potential role of effective micro-organisms enriched compost, broiler manure and inorganic fertiliser application on growth and yield of the crop. This study aimed at assessing the effect of sole and combined application of broiler manure, effective micro-organisms enriched compost and NPK fertilisers on growth and yield of mustard spinach.

### MATERIALS AND METHODS

The study was conducted during the 2013/ 2014 growing seasons at University of Limpopo horticultural skill centre, Limpopo province, South Africa. The experiment was arranged in a randomised complete block design, with three replication and six treatments. The assigned treatments were, (a) Control (without any organic and inorganic fertilisers), (b) recommended amount of effective microorganisms enriched compost of (12 kg/ha), (c) recommended amount of broiler (12 kg/ha), (d) recommended inorganic fertilisers NPK (2:3:2(30) at a rate of 100 N, 85 P and 200 K. This was applied as N from urea, P from superphosphate and K from potassium chloride (KCL), (e) 50 % recommended amount of effective microorganisms enrich compost and 50 % inorganic fertilisers, (f) recommended amount of broiler manure and 50 % recommended amount of inorganic fertilisers. Data collected were: plant height, number of shoots, plant vigour, and plant stand establishment, fresh and dry shoot mass.

### RESULTS AND DISCUSSION

Growth of mustard spinach varied with fertiliser application. Results obtained showed that significantly highest plant height of 26.27 cm was obtained in sole broiler manure treatment and lowest value of 16.50 cm was recorded in control without fertiliser application. For parameters such as plant vigour, the highest value of 0.62 at six weeks after transplanting (WAT) was obtained in NPK treatment and lowest mean of 0.38 was found in combined effective microorganisms compost and NPK treatment 6 WAT. However, the reverse was the case at 16 WAT. In general, plants grown in broiler manure treatment had the highest fresh leaf mass of 150 g compared to 70 g in the control and also highest dry shoots and marketable yield.

### CONCLUSION

Mustard spinach performed better in broiler manure treated soils than other fertiliser materials. Further study should be conducted on rate, time and combinations frequency of application of these materials for optimum mustard spinach product.

**Keywords:** Broiler manure, effective micro-organisms enriched compost, NPK fertilisers, yield.

## EVALUATION OF THREE COMMERCIAL COMPOSTS USED BY SMALL-SCALE FARMERS IN LIMPOPO PROVINCE, SOUTH AFRICA

L Mamanyuha<sup>1</sup>, FR Kutu<sup>2</sup>, ME Moshia<sup>3</sup>, KA Tshikolomo<sup>4</sup>

<sup>1</sup>University of Limpopo, Turfloop Campus, Department of Plant Production, Soil Science and Agricultural Engineering, Private Bag X1106, Sovenga 0727; <sup>2</sup>North West University, Mafikeng Campus, Department of Crop Science, Faculty of Agriculture, Science and Technology, Private Bag x2046, Mmabatho 2735; <sup>3</sup>Tshwane University of Technology, Pretoria Campus, Department of Crop Science, Private Bag x 680, Pretoria 0001; <sup>4</sup>Limpopo Department of Agriculture, Branch: Agricultural Advisory Services, Private Bag X9487, Polokwane 0700

mamanyuhal@yahoo.com

### INTRODUCTION

South African soils mostly those of the Limpopo Province, are low in organic matter due to the possible negative effect of climate that favours rapid decomposition of organic matter and poor farmers management practices that do not promote sufficient return of organic materials to the soil. Application of organic fertilizers such as composts has a potential to enrich the soil with organic matter, which has a significant influence on the improvement of soil physical and chemical properties. The study intended to provide detailed information to farmers on useful plant nutrient quality indices for selecting suitable high quality compost/s for possible use on their crop fields.

### MATERIALS AND METHODS

The materials used were a soil sample obtained from top 20cm soil depth and compost from three different areas (Capricorn (CAP), Vhembe (VHE) and Mopani (MOP)) for incubation (comparison of potential rates of mineralization in soils from multiple sources by maintaining homogenous experimental conditions) study. Experimental design for incubation was 3 x 6 factorial replicated 3 times for Nitrogen (N) and Phosphorus (P) mineralization. Treatments were 3 composts & 6 sampling dates (7, 14, 21, 28, 35 and 42 days after incubation (DAI)). The compost was analysed for pH, Electrical Conductivity (EC), total N, P and K, and Organic Matter (OM), C:N and C:P ratios while the incubation was analysed for N and P.

### RESULTS AND DISCUSSION

The study revealed that pH and EC were within recommended range while OM was less for all composts. The composts had different quantities of total N, P and K. Composts from CAP and MOP had less total N and P than recommended, that from VHE had these nutrients within recommended range. The quantity of total K was within recommended range for all composts. Compost from MOP District had more plant available organic N and is therefore a better N source than those from CAP and VHE Districts; Composts from CAP and VHE Districts had more extractable P and are better P sources than that from MOP.

### CONCLUSION

Consequently, the use of the composts from the three sources can lead to increased crop production and reduced hunger in rural poor communities.

**Keywords:** Compost quality, Incubation study, N and P mineralization, organic fertilizer

**RHIZOME SIZE AND PLANTING DEPTH ON GROWTH AND YIELD OF AFRICAN GINGER  
(*Siphonochilus aethiopicus*)**

P.H. Maphothoma<sup>1</sup>, G. Prinsloo<sup>2</sup>, R. Kleynhans<sup>3</sup>, C.P. du Plooy<sup>1</sup> and H. Araya<sup>1</sup>

<sup>1</sup>ARC-VOPI, Private bag X293, Pretoria, 0001. Tel 012 808 8000, Fax 012 808 1811,

PhomoloM@arc.agric.za

**INTRODUCTION**

African ginger (*Siphonochilus aethiopicus*) is one of the most important and most popular of all the 38 indigenous species that have been commercialized to some extent. Propagation and cultivation are the only interventions that can ensure a sustainable supply of quality material for the growing commercial market whilst simultaneously contributing towards the conservation of natural populations and making plant material available to the informal market. The effects of rhizome size and planting depth on growth and yield of African ginger were evaluated in order to address the gap in cultivation practices and to relieve the pressure on wild harvested material.

**MATERIALS AND METHODS**

The planting depth experiment was conducted at Brits experimental farm, South Africa at an altitude of 1085 m with an annual rainfall of 620 – 630 mm per annum. The treatment design was a 3 x 5 factorial with three different rhizome sizes, small (20-35 g), medium (35 -50 g), large (>50 g) and five planting depths (4 cm, 8 cm, 12 cm, 16 and 20 cm), replicated three times. The parameters recorded include number of shoots and leaves per plant, plant height and chlorophyll content of the leaves. Yield in terms of fresh mass per plant, fresh root mass and number of rhizomes per plant were recorded during harvesting.

**RESULTS AND DISCUSSION**

A significant difference in leaf number, plant height and number of shoots was observed between the three rhizome sizes where large rhizomes produced increased number of leaves, shoots and plant height. Rhizome weight and multiplication rate increased with an increase in rhizome size. Planting depth did not have any significant influence on the height of the plants. Moreover, planting depth and rhizome size had no interaction effect. Leaf chlorophyll content differed significantly throughout the growing period at all intervals of chlorophyll data collection, however, there was no significant difference in leaf chlorophyll content among three rhizome sizes. Significantly greater number of rhizomes were produced by plants cultivated at the depths of 4, 8, and 12 cm.

**CONCLUSION**

Large rhizomes and 4 cm planting depth showed the best performance in terms of number of shoots, leaves, rhizome yield and multiplication rate per hectare while small rhizomes and planting depths of 20 cm gave reduced in yield. Our findings indicate that rhizome size and planting depth individually affect the growth and yield of African ginger during cultivation.

**ACKNOWLEDGEMENTS**

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**Keywords:** African ginger, rhizome size, planting depth, growth, yield

## EFFECT OF LIQUID MAXIFLO AND TRYKOSIDE ON YIELD OF TOMATO

<sup>1</sup>Mashamba NR and <sup>2</sup>Pretorius JC

<sup>1</sup>Agricultural Research Council-Institute for Industrial Crops, Private Bag x 82075, Rustenburg, 0300

<sup>2</sup>University of the Free State, Faculty of Natural and Agricultural sciences, Mashambar@arc.agric.za

### INTRODUCTION

Tomato (*Lycopersicon*) belongs to the plant family Solanaceae, is a native of tropical America and is also classified as an annual under the plant group with a hemispherical type of root system (McCullum & Ware, 1975). Trichoderma species (fungus) form the basis of the product Trykoside and Azospirillum (bacterium) the base of Maxiflo. These are used to control bacterial and fungal disease. Therefore, the objective of this study was to determine if Maxiflo and Trykoside could increase the yield of tomatoes.

### MATERIALS AND METHODS

The trial was conducted at the experimental farm of the Department of Soil, Crop and Climate Sciences of the University of the Free State, near Kenilworth in the Bloemfontein district, during the 2003 growing season. A randomized complete block design (RCBD) consisting of six different treatments were used and each treatment was replicated five times. Tomato seedlings cultivar (Nemoneta) were transplanted in a row spacing of 35 cm and between row spacing of 150 cm, which represent a plant population of approximately 12 500 plants per hectare. Number of fruits on seven plants per plot (16.8 m<sup>2</sup>) was counted and the weight determined in kg plot<sup>-1</sup> after sorting fruits into categories of small, medium and large. Insects and diseases were controlled. Tomatoes were harvested by hand once a week over an eighteen week period. Data collected was analysed using NCSS 2000 statistical programme while Tukey's least significance difference procedure was applied to separate means (P<0.05).

### RESULTS AND DISCUSSION

Although, no significant differences between application treatments was observed in terms of either fruit size or total yield, application treatments tended to reduce the total yield compared to the untreated control. Both Maxiflo and Trykoside improved the number of medium and large size fruits during harvest periods. In light of the results from the study and other reports, the possibility exists that the Maxiflo and Trykoside concentrations used in this study might not have been optimal and needs to be verified in a follow-up study.

### CONCLUSION

Maxiflo and Trykoside had no significant effect of fruit yield of tomatoes, although it was in contradiction with other author's findings. The trial should be should repeated with more optimum doses.

**Keywords:** Tomato, yield; Maxiflo and Trykoside

## MAIZE GRAIN YIELD ASSESSMENT UNDER THREE LEVELS OF NITROGEN FERTILIZATION IN A DRYLAND FARMING SYSTEM

S MASHEGO<sup>1</sup>, B.M. PETJA<sup>1</sup>, R.G LEKALAKALA<sup>1</sup>, W.G MUSHADU<sup>1</sup>

<sup>1</sup>Limpopo Dept. of Agric., Directorate of Research Services, P/Bag X9487, Polokwane 0700;

suzan.mashego6@gmail.com

### INTRODUCTION

Low crop yield and poor soil fertility are problems that farmers at Ha-Lambani identified as limiting factors to maize production. Small-scale farmers have limited access to agricultural inputs. Fertilizers are mostly a priority on farming budget. Nitrogen (N) is required in comparatively larger amounts than other nutrient elements on maize production. The study was designed to assess yield differences of maize grain under three N fertilization levels in a dryland farming system.

### MATERIALS AND METHODS

The study is part of a broader initiative on defining the interplay between market access, crop and livestock technologies. It looks at investment risks in water-and market-scarce environments that lead to technology adoption by farm families, enabling them to enhance food security and income through efficient nutrient and water use. A field experiment was conducted at Ha-Lambani of the Limpopo province. Three levels of N were assessed that is, 0, 29 and 58 kg N/ha on a planted maize. The N levels were based on the farmer's regular practices. Some farmers do not fertilize their soil, while other fertilise based on levels that are at their disposals. The experiment was laid in a randomized complete block design, replicated three times during the 2013 cropping season.

### RESULTS AND DISCUSSION

The maize grain yield of 1585 and 1543 kg/ha, where 29 and 58 Kg N/ha were applied, respectively, was observed to be significantly higher ( $P<0.05$ ), than 1049 kg/ha of 0 kg N/ha. No significance difference was observed in grain yield between the 29 and 58 Kg N/ha levels. Optimum maize yield is dependent of N availability particularly after the 6<sup>th</sup> leaf developmental growth stage.

### CONCLUSION

The 29 N/ha level shows potential for optimum maize yield considering the access and costs of fertilizers by the small-scale farmers. The study is ongoing.

**Keywords:** fertilization, grain yield, maize production, nitrogen rate



## GENETIC DIVERSITY ANALYSIS IN BOTTLE GOURD (*Lagenaria siceraria*) LANDRACES USING MORPHO-AGRONOMICAL TRAITS

J Mashilo<sup>1,2</sup>, H Shimelis<sup>3</sup> & AO Odindo<sup>2</sup>

<sup>1</sup>Crop Science Discipline, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa; <sup>2</sup>Limpopo Department of Agriculture - Tlokoeng Research Station, Private Bag X1615, Bela-Bela, 0480, South Africa; <sup>3</sup>African Centre for Crop Improvement (ACCI), University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa

jacobmashilo@yahoo.com

### INTRODUCTION

Bottle gourd (*Lagenaria siceraria*) is an important but neglected and under researched crop in South Africa. In the country, small-holder farmers grow unimproved landraces which exhibit great morphological diversity. Genotypic and phenotypic characterization of the variability present among the landraces is helpful to identify useful genotypes for breeding and systematic conservation. The objective of this study was to characterize the genetic variability present amongst bottle gourd landraces grown by smallholder farmers in the Limpopo Province of South Africa using qualitative and quantitative morpho-agronomical traits.

### MATERIALS AND METHODS

Thirty six landrace collection of bottle gourd were phenotyped at Tlokoeng Research Station, Bela-Bela, during the 2014 growing season. A field experiment was laid out in a 6 x 6 a-lattice design with two replications. Data on 32 qualitative and 28 quantitative traits were collected following the descriptors of Morimoto *et al.* (2005) and Yetisir *et al.* (2008). Qualitative data were subjected to analyses using the following procedures: Kruskal-Wallis non-parametric test, correlation, principal component and cluster analyses. Quantitative data were subjected to analysis of variance of lattice procedure followed by mean separation using the Least Significance Difference test procedure at the 5% level of significance.

### RESULTS AND DISCUSSION

Significant ( $P < 0.05$ ) differences were observed amongst bottle gourd landraces with regards to some qualitative traits indicating the presence of phenotypic variability. Further, significant ( $P < 0.05$ ) differences were observed to several quantitative traits. The number of fruits per plant significantly correlated with number of nodes on main stem ( $r = 0.75$ ), plant height ( $r = 0.67$ ), number of male flowers ( $r = 0.67$ ), number of aborted fruits ( $r = 0.87$ ), and number of branches ( $r = 0.76$ ). Number of seeds per fruit also significantly correlated with fruit mass ( $r = 0.84$ ). Principal component analysis (PCA) on qualitative and quantitative traits identified eight and seven principal components (PCs) which accounted for 78% and 87% of total variation respectively. PC1 and PC2 contributed to most of the total variation for qualitative at 22.9 and 11.8% and quantitative at 39.6 and 13.1%, respectively. Principal component biplot and cluster analyses grouped landraces based on their genetic similarities. Consequently, unique genotypes were identified including BG-25, BG-67, BG-12, BG-13 and BG-09 showing suitable qualitative and quantitative morpho-agronomical traits.

### CONCLUSIONS

This study showed that genetic variability is present amongst bottle gourd landraces from the Limpopo Province useful for bottle gourd improvement in South Africa.

### ACKNOWLEDGEMENTS

The University of KwaZulu-Natal and the National Research Foundation (SA) are acknowledged for financial support.

**Keywords:** Bottle gourd, genetic diversity, landrace, principal component analysis, qualitative traits, quantitative traits

## COMPARISON OF SMALLHOLDER COFFEE FARMING PRACTICES IN NKOZI SUB COUNTY

L Kyeyune<sup>1</sup>, S Kojo<sup>1</sup> and LA Metho<sup>1</sup>

<sup>1</sup>Tshwane University of Technology, Department of Crop Science  
lkyeyune@yahoo.co.uk

### INTRODUCTION

Benefits derived from improved coffee farming practices (ICP) resulted in an improved new cultivar, optimum weeding frequency, pests and disease resistance which outweighed traditional coffee farming practices (ITK). Application of modern research technology / practices resulted in higher coffee yield (> 40%) and in corresponding higher economic income to the farmers. These results confirm past research findings by Mango and Hebinck, 2004. However, the rate of adoption of ICP is low (less than 15%) and indications are that gender differences (male and female coffee farmers) may be affecting adoption rate and responsible for the lack of adoption of new technology (ICP). More females are aligned to the traditional coffee farming practices (ITK) because of ease of handling. Also dominance of females in coffee farming may also be attributed to the fact that most men perceive farming as a women's chore. The main aim of this study was to provide an understanding of coffee farming practices and their characteristics from a smallholder perspective.

### MATERIALS AND METHODS

Our study was conducted in Buseese and Nakibanga parishes in Nkozi. The research process comprised of a pilot Study, documentation, data analysis and recommendations. The methodology used to gather data involved quantitative and qualitative approaches. A sample of seventy farmers was obtained through a stratified sampling method.

### RESULTS AND DISCUSSION

Variables	Traditional	New	Mixed	Variables	Traditional	New	Mixed
<b>Gender</b>				<b>Price of coffee</b>			
Male	20%	11%	9%	>1000shs	34%	13%	20%
Female	27%	13%	20%	1000shs+	13%	11%	9%
<b>Bean size</b>				<b>Land</b>			
Small	41%	1%	0%	Less than1ha	47%	24%	29%
Large	1%	10%	0%	1ha+	0%	0%	0%
Average	4%	13%	30%				

Table1. Showing Socio-Economic and Production Variables of Farmers

Our results indicate that of the female participants that were interviewed, 27% took part in the traditional coffee farming system. 13% practiced the new coffee farming system while 20% practiced the mixed coffee farming system. More females are aligned to the traditional coffee farming practice because of the benefits such as intercropping and ease in handling. Intercropping of coffee with other crops like beans, maize helped female farmers meet their household needs as "bread winners" of many households. The dominance of females in coffee farming may also be attributed to the fact that most men perceive farming as a women's chore.

### CONCLUSIONS

Data indicates, the study did not focus on female farmers who are essentially more involved in coffee farming. Most household decisions are influenced by males who also own the land. Hence, any change or adoption of technology is a gender matter. Subsequently, males make household decisions and not women. This probably explains why the acceptance of improved coffee farming practices (ICP) is not being embraced as quickly, yet research findings indicate improved coffee farming practices as superior to traditional coffee farming practices.

**Key words:** smallholder farming, traditional coffee farming and new coffee farming

## CALCIUM AND NITRATE NUTRITION IMPROVE WATER USE EFFICIENCY OF MAIZE UNDER WATER DEFICIT CONDITIONS

M Mlalazi<sup>1</sup>, L Ehlers<sup>1</sup>, MH Ngoetjana<sup>1</sup>, RM A'Bear<sup>1</sup> and JJ Bornman<sup>1</sup>

<sup>1</sup>Omnia Fertilizer, a division of Omnia Group (Pty) Ltd, PO Box 69888, Bryanston 2021

mmlalazi@omnia.co.za

### INTRODUCTION

Drought and water scarcity affect the productivity of maize. Plants that are exposed to drought stress suffer from oxidative damage, catalysed by reactive oxygen species (ROS). Increasing evidence suggests that the application of nitrate ( $\text{NO}_3^-$ ) and calcium ( $\text{Ca}^{2+}$ ) to water-stressed plants decreases the production of ROS and increases water use efficiency (WUE). A greenhouse study was conducted to determine the effect of  $\text{Ca}^{2+}$  and  $\text{NO}_3^-$  on the WUE of maize grown under optimum and deficit water conditions.

### MATERIALS AND METHODS

Maize was grown in 10l plastic pots placed on a rotating table in a greenhouse facility of Omnia Fertilizer near Sasolburg. The pots were filled with a sandy loam soil and the plants were subjected to two moisture regimes namely, well irrigated (kept at 90% of plant available water (PAW)) and low water availability (kept at 40% of PAW). Urea, ammonium nitrate solution, limestone ammonium nitrate and calcium nitrate were used as treatments, replicated five times and arranged in a completely randomised design. The maize was top-dressed with treatments at 2 and 4 weeks after emergence (WAE). Leaf chlorophyll content were measured at different intervals throughout the trial. Water use efficiency (WUE) ( $\text{g pot}^{-1} \text{L}^{-1}$ ) was calculated as the dry root mass, dry shoot mass and total biomass produced per litre of water added to each pot. The data was statistically analysed with STATISTICA (Version 12).

### RESULTS AND DISCUSSION

The total biomass production of maize under water deficit conditions was significantly ( $P < 0.01$ ) increased when top-dressed with  $\text{Ca}^{2+}$  and  $\text{NO}_3^-$  containing fertilizers compared to that of urea. Ammonium nitrate solution, limestone ammonium nitrate and calcium nitrate significantly ( $P < 0.01$ ) increased the WUE, expressed as total biomass produced per pot ( $\text{g pot}^{-1} \text{L}^{-1}$ ) by 16%, 53% and 74% respectively, when compared to urea. There was also a positive correlation ( $P < 0.01$ ) shown between  $\text{Ca}^{2+}$  uptake ( $R^2=0.78$ ) and WUE.

### CONCLUSION

Fertilizers containing nitrates or a combination of nitrates and calcium were shown to increase the WUE of maize produced under water deficit conditions when compared to urea.

**Keywords:** calcium nitrate, LAN, drought stress, limestone ammonium nitrate

## RESPONSE OF NEWLY DEVELOPED MANDARIN CITRUS SELECTIONS TO ETHYLENE DE-GREENING AND COLD STERILIZATION

K Mmako<sup>1</sup>, T.P. Mafeo<sup>1</sup>, M.R. Masevhe<sup>1</sup>, N Mathaba<sup>2</sup> and J Mlimi<sup>2</sup>

<sup>1</sup>University of Limpopo-SAES, P/Bag X1106, Sovenga, 0727

<sup>2</sup>ARC-ITSC, P/Bag X11208, Nelspruit, 1200

### INTRODUCTION

The manifestation of chilling injury after withdrawal from cold storage reduces the marketability of citrus fruit. Furthermore, ethylene de-greening contributes to chilling-sensitivity of citrus fruit (Tietel *et al.*, 2010). The response of the newly bred ARC-ITSC selections, namely; Sonet, I22, M37, B24, Nova ARC and Nova to pre-requisite sub-zero cold sterilization is not documented. The aim of this research was to evaluate response of these newly developed mandarin selections to ethylene de-greening and cold sterilization.

### MATERIALS AND METHODS

'Mandarin' fruit were collected from the ARC-ITSC in Addo (Eastern Cape). After harvesting, some fruits were de-greened while others were untreated, packed and transported to the Postharvest Laboratory at ARC-ITSC in Nelspruit. Fruits were re-packed into smaller boxes, which contained 15 fruits per box with three replicates per treatment for cold storage (-0.5°C). After 28 days cold storage fruits were evaluated for weight loss, firmness, colour (L, Chroma and hue), TSS, acid and chilling injury (CI).

### RESULTS AND DISCUSSIONS

Degreening had no effect on chilling susceptibility of the new mandarin selections, except M37, which showed significantly higher external chilling damage than the other selections after cold sterilization. Furthermore, after cold storage, both degreened and untreated mandarin fruit showed an improvement in colour as measured by L, Chroma and hue, and such findings were in line with the behaviour of other citrus commercial cultivars (Sdiri *et al.*, 2012). A significant change in weight loss was detected after 28 days of cold storage. Furthermore, in all cases the fruits lost firmness during storage with no significant changes in TSS, TA and Brix, as reported by (Tietel *et al.*, 2010).

### ACKNOWLEDGEMENTS

The authors are greatly indebted to AgriSeta for their financial support and Mr. J. Mlimi for the technical assistance.

**Keywords:** Mandarin fruit (*Citrus reticulata*); Ethylene de-greening; Cold sterilization; Chilling injury; Firmness; Colour; Membrane damage

**ASSESSMENT OF GENETIC RELATEDNESS AMONG SOUTH AFRICAN SORGHUM  
GENOTYPES USING AGRO-MORPHOLOGICAL TRAITS**

MA Mofokeng<sup>1</sup>, HA Shimelis<sup>1</sup>, P Tongoona<sup>1</sup>, MD Laing<sup>1</sup>

<sup>1</sup>African Centre for Crop Improvement, School of Agricultural, Earth and Environmental Sciences,  
University of KwaZulu-Natal, Private Bag X 01, Scottsville 3209, South Africa

alinamofokeng9@gmail.com

**INTRODUCTION**

Genetic diversity assessment in sorghum is essential for strategic breeding and conservation. The objective of this study was to assess the presence of genetic relatedness among 98 South African sorghum genotypes using phenotypic markers.

**MATERIALS AND METHODS**

Ninety eight sorghum accessions collected from the Department of Agriculture Forestry and Fisheries, the African Centre for Crop Improvement and the Agricultural Research Council-Grain Crops Institute were phenotyped at two sites: Makhathini Flats in KwaZulu-Natal and Burgershall in Mpumalanga, in 2012. Trials were laid out using an alpha lattice design with three replications. Data on nine quantitative and six qualitative traits were collected using the standard key descriptor lists of IBPGR/ICRISAT (1993). Data collected were subjected to principal component analysis (PCA), hierarchical cluster analysis, and multivariate analysis. A dendrogram was constructed using the Unweighted Pair Group Method with Arithmetic Mean.

**RESULTS AND DISCUSSION**

The principal component analysis revealed three important PCs that contributed 88.9% to the total variation observed among the genotypes across locations. PC1, PC2 and PC3 contributed to 46.69, 30.74, and 11.45% of the total variation, respectively. The dendrogram revealed three main clusters. The grouping of the sorghum genotypes was not linked to the site of collection. Unique genotypes such as MP 4277, FS 4909, and LP 4303 were identified.

**CONCLUSION**

There was great genetic diversity among the studied South African sorghum genotypes. The clustering of sorghum lines was not based on the source of the lines. The information collected through the study will be useful for future breeding and germplasm conservation.

**ACKNOWLEDGEMENTS**

The Alliance of a Green Revolution in Africa, the Agricultural Research Council and University of KwaZulu-Natal are sincerely thanked for financial support.

**Keywords:** Genotype, phenotypic markers, principal component analysis, sorghum

## EFFECT OF AMMONIUM SULPHATE (AMS) ON THE EFFICACY OF GLUFOSINATE AMMONIUM

BP Molefe<sup>1</sup>, PJ Pieterse<sup>1</sup>

<sup>1</sup>Department of Agronomy, Stellenbosch University, P/Bag X1, Matieland 7602

bontfeng@sun.ac.za

### INTRODUCTION

Ammonium sulphate (AMS) is a fertilizer commonly used as an adjuvant in crop protection. An adjuvant is any substance that modifies the herbicidal activity or spray characteristics when added to a spray tank (Pacanoski 2010). Addition of AMS enhanced the activity of glufosinate ammonium (GA) and glyphosate on weed control (Pline et al 2000). However, there is limited information on the effect of AMS on GA efficacy. The objective of the study was to determine if AMS could increase the efficacy of GA on ryegrass (*Lolium* spp.) and other weed populations.

### MATERIALS AND METHODS

Glasshouse and field trials were conducted at Stellenbosch University's Welgevallen experimental farm. Four ryegrass populations (one commercial cultivar (*Lolium multiflorum* cv Agri Hilton) and three suspected resistant weedy types (*Lolium* spp.) were used in the glasshouse experiment. The four ryegrass populations were each subjected to a 7 x 2 factorial with seven rates (0, 0.75, 1.5, 3, 4.5, 6 and 7.5 L ha<sup>-1</sup> of GA) and two treatments (with and without AMS) laid out in a randomised complete block design with three replicates. The field trial consisted of a 2 x 5 factorial with two treatments (with and without AMS) and five rates (0, 2.5, 5, 7.5 and 10 L ha<sup>-1</sup> of GA) in a randomized complete block design with four replicates. The percentage control in both the glasshouse and field trials were determined six weeks after spraying. Data was subjected to analysis of variance (ANOVA) using the Statistica 12 program/software.

### RESULTS AND DISCUSSION

Ryegrass populations varied in their response to GA and GA plus AMS. In the glasshouse trial, in two of the populations (commercial and suspected resistant population 2) AMS significantly increased GA efficacy at specific critical levels but not above or under the levels. AMS had no effect on GA efficacy on the other two suspected resistant populations. Field results did not show a consistent positive effect of AMS on GA efficacy.

### CONCLUSION

Addition of AMS to GA did not consistently improve GA efficacy under field conditions. Application of AMS with GA showed a significant effect on the control of two ryegrass populations at specific dosage rates in the glasshouse but had no effect in the case of the other two populations. Based on results from this study, it is therefore inconclusive whether addition of AMS to GA increase efficacy of GA.

**Keywords:** adjuvant, ammonium sulphate, glufosinate ammonium efficacy, ryegrass

## EVALUATION OF SELECTED MAIZE HYBRIDS UNDER LOW NITROGEN ENVIRONMENTS FOR GRAIN YIELD.

L.L. Molefe<sup>1</sup>, E.N. Ndou<sup>1</sup> and K.Mashingaidze<sup>1</sup>

<sup>1</sup>Agricultural Research Council - Grain Crops Institute, Private bag X1251, Potchefstroom, 2520.

molefel@arc.agric.za

### INTRODUCTION

African maize farmers are faced with challenge of nutrient starved soils and inability to purchase nitrogen fertilizers. They therefore do not apply recommended fertilizer dose which results in yield reduction (Banziger *et al*, 2000). The main objective of this study was to determine yield of selected hybrids planted on low soil nitrogen.

### MATERIALS AND METHODS

Twenty four white maize hybrids and six checks were planted at KwaZulu-Natal Province (KZN) in three different locations (Cedara, MB6 & MB8) under low nitrogen soils during 2013/2014. Low soil nitrogen was achieved by planting without any application of nitrogenous fertilizer. Irrigation and other fertilizers were applied at recommended application rate. Trial were planted following a (0.1) alpha lattice design with three replications. After harvesting, grain weight and moisture were taken using measuring scale and grain moisture meter to determine grain yield. Data were subjected to analyses using GenStat 15<sup>th</sup> edition for windows.

### RESULTS AND DISCUSSION

Grain yield ranged from 2.7 to 4.3 t/ha with mean of 3.3t/ha at Cedara, at MB6 yield ranged from 2.1 to 4.8t/ha with mean of 2.6t/ha; and at MB8 yield ranged from 1.7 to 4.6t/ha with mean of 3.0t/ha. At Cedara TB2-11/12-37 yielded higher than other hybrids including checks while at MB6 TB2-11/12-58 yielded higher. Hybrid TB2-11/12-43 and TB2-11/12-37 yielded above 4t/ha in two locations while TB2-11/12-64 at 4t/ha in two locations. In overall high yielding hybrids across locations were TB2-11/12-43 with 4.1t/ha followed by TB2-11/12-40 with 4.0t/ha. In top 10 of the ranks across locations there is only two checks ranking sixth and ninth.

### CONCLUSIONS

Results shows that there are hybrids yielding higher than commercial checks under low nitrogen environments. Therefore need to test the selected hybrids from the breeding pipeline is worthy to make an informed breeding selection decision.

**Keywords:** low soil nitrogen, Yield.

## EFFECT OF ZINC FERTILIZER RATES AND METHODS OF APPLICATION ON NUTRIENTS PARTITIONING IN COWPEA PLANTS GROWN UNDER VARIABLE CONDITIONS

MS Moswatsi<sup>1</sup>, FR Kutu<sup>2</sup>, TP Mafeo<sup>1</sup>

<sup>1</sup>University of Limpopo, school of agriculture and environmental science, P/Bag X1106, Sovenga 0727; <sup>2</sup>North West University, Mafikeng campus, P/Bag X 2046, Mmabatho 2735

maboresele@gmail.com

### INTRODUCTION

The problem of poor nutrition and micronutrient deficiency particularly zinc, is a global concern. The situation is exacerbated by the high prices of micronutrients-rich foods and exotic leafy vegetables available locally, thereby leading to malnutrition. Widespread zinc on crop lands constitutes a major limiting factor in the production of zinc-rich food and vegetable crops. Zinc and phosphorus however, have a synergistic effect on growing crops in the field. This study aims to assess the impact of rates and methods of zinc fertiliser application on nutrients partitioning in different cowpea plant parts under dryland and supplementary irrigation.

### MATERIALS AND METHODS

Trials were planted at Ukulima farm near Modimolle under supplementary irrigation, and at the University of Limpopo experimental farm, Syferkuil under rain-fed conditions. The trial was laid out in a split plot arrangement fitted into a RCBD at both sites with four replicates. Treatments consisted of six rates (0, 5, 10, 15, 20 and 25 kg/ha ZnSO<sub>4</sub>) and white seeded cowpea variety ARC-GCI-CP-6. Yield data were subjected to analysis of variance using Statistix 8.1 Software. Where treatments were shown, means were separated using Tukey's test at probability level of 5%.

### RESULTS AND DISCUSSION

Results obtained from this study showed that the zinc concentration in leaves was significantly ( $P < 0.001$ ) affected by method of application under rainfed condition. Under rainfed condition, foliar application resulted in higher leaf Zn content (43.9 mg kg<sup>-1</sup>) than soil application (23.2 mg kg<sup>-1</sup>). Furthermore, foliar application had no significant effect on total P, Fe and Zn uptake in green pods compared to soil application. However, foliar application of zinc gave 28.9% increase in green pod Zn content compared to 24.1% when soil applied relative to un-amended control under supplementary conditions. The same trend was observed under rainfed conditions where foliar application resulted in 35.3% increase in in green pod zinc concentration as compared to 33.0% when soil applied. The mineral contents of the different cowpea plant parts did not differ significantly across the two trial sites.

### CONCLUSIONS

Foliar application improved the zinc concentration in cowpea leaves and green pods. Zinc concentration green pod was relatively higher under supplementary irrigation than rainfed condition.

**Keywords:** Cowpea, micronutrients, nutrients partitioning; plant nutrition.



**EVALUATION OF QUALITY OF FIELD GROWN TOMATO VARIETIES (*Lycopersicon esculentum* Mill) GROWN IN HIGH TUNNEL AT THULAMELA (Vhembe District)**

Mothapo M,<sup>1</sup> Thovhogi F.,<sup>1</sup> Ramphinwa, M.L.,<sup>1</sup> Prof G.R.A Mchau<sup>1</sup>  
University of Venda, Department of Horticultural Sciences, Private bag X5050,  
Thohoyandou, 0950

mmaanea@univen.ac.za

**INTRODUCTION**

Tomato (*Lycopersicon esculentum* Mill) is one of the most important summer vegetable crops in the Vhembe district. Growing tomato during the rainy season triggers several problems, such as diseases and pests, which lead to a high input cost. The main objective of the study was to investigate the quality of field grown tomatoes grown in a plastic tunnel.

**MATERIAL AND METHODS**

The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications. The four cultivars that was used were 'Money Maker', 'Roma VFN', 'Rodade' and 'Floradade'. Measurements taken during the experiment were number of fruits per plant, fruit weight per plant, individual fruit weight, flowering period, and marketable yield. Analysis of variance was compared at 0.05 probability using general linear model (GLM) procedures of SPSS. Treatment means were compared using the Least Significance Difference (LSD) procedures at probability of 5% (Steel & Torrie, 1980).

**RESULTS AND DISCUSSION**

A significant difference was recorded in plant height among the four varieties grown under tunnel structure at three weeks after transplanting. It ranged from (65.5) to (140.5 cm). Money Maker had the tallest plants at (140.5 cm) and the shortest plants showed in Roma VFN at (65.5). It was found that days to flowering, days to harvest, fruit weight per plant, number of fruits per plant and individual fruit weight was significantly different among the four cultivars.

**CONCLUSION**

Yield ability is closely linked with the genetic background of different varieties, environmental condition and cultural practices. Further research is needed to evaluate other tomato varieties for high tunnel production in Vhembe district. Economic comparison should be made between open field and high tunnels including prices received during various growing seasons. Additional crops should be evaluated for their suitability in Vhembe district.

**Keywords:** tomato, rainy season, maturity, fruit quality

## EFFECT OF TUBER SIZE AND PLANTING DEPTH ON GROWTH, YIELD AND QUALITY OF POTATO VARIETY BP1

ORS Mtengwa<sup>1</sup>, A Shayanowako<sup>2</sup>, R Mangani<sup>2</sup>, U Mazarura<sup>3</sup>

<sup>1</sup>University of Venda P. bag x5050, Thohoyandou, Limpopo Province, South Africa, <sup>2</sup>Africa University Box 1320, Mutare, Zimbabwe and <sup>3</sup>University of Zimbabwe Crop Science Department, P. O. Box MP 176 Mt Pleasant, Harare, Zimbabwe

onai.mtengwa@univen.ac.za

### INTRODUCTION

Potato production in developing countries has been affected by scarcity and poor quality seed tuber material. When seed is acquired, farmers are never certain of the production potential of the seed therefore it is important to determine a standard seed size and planting depth that guarantees an optimum yield performance. This study sought to establish the effect of seed tuber size and planting depth on growth and yield of the potato variety BP1.

### MATERIALS AND METHODS

BP1 was evaluated for its response to depth of planting and seed size in a 3x3 factorial experiment laid out in a randomized complete block design. The two factors seed size and planting depth had 3 levels. Tubers of size small<75g, 75g< medium<120g, 120g =large were planted at depths of 8cm, 15cm, 20cm. Plots used were 4.0 x 4.0 m and plants were spaced at 0.9 m x 0.30 giving 30 plants per plot. The study was done at Africa University farm, Mutare, Zimbabwe, 18°53'70, 3°S: 32°36'27.9°E at 1.131m above sea level. The site had a clay loamy soil. Average annual rainfall ranges from 750-1200mm. The average maximum temperature ranges from 18 °C (July) to 32°C October.

### RESULTS AND DISCUSSION

Results revealed that tuber yield and tuber density significantly increased ( $p<0.05$ ) with an increase in the size of the seed tuber category. Planting depth had no influence had no significant influence on yield and tuber density per plant. No statistical difference were noted between the interaction of seed tuber size and planting depth ( $p<0.05$ ). The size of seed tuber had a significant effect on the size of harvested tubers. The size of the harvested tubers significantly differed among small, medium and oversized ( $p<0.05$ ) but there was no difference observed with respect to large tubers ( $p>0.05$ ). Seed size and planting depth had no significant effect to influence the size of the harvested tubers.

### CONCLUSION

This study showed that both seed size and planting depth had a considerable influence on yield and quality determinants of tubers. There was an increase in the rate of emergence with an increase in the size of the seed tuber. Seed size had an effect on the number of leaves and stems per plant.

Keywords: Potato, Planting Key Words Depth, Seed size, growth, yield

## PRODUCTION STRATEGIES AND POSTHARVEST PROTOCOL FOR GREAT QUALITY BABY SPINACH: THE EFFECT OF POST-HARVEST STORAGE AND TIME ON QUALITY

Mudau A.R.<sup>1</sup>, Soundy P.<sup>2</sup>, Ngezimana W.<sup>1</sup>, Araya H.T.<sup>3</sup> and Mudau F.N.<sup>1</sup>

<sup>1</sup>Department of Agriculture and Animal Health, College of Agriculture and Environmental Sciences, University of South Africa, Private Bag X6, Florida, 1710, South Africa.

<sup>2</sup>Department of Crop Sciences, Tshwane University of Technology, Private Bag X680 Pretoria, 0001.

<sup>3</sup>Agriculture Research Council-Vegetable and Ornamental Plant Institute, Private Bag X293, Pretoria, 0001.

### INTRODUCTION

Baby spinach (*Spinacia oleracea* L.) possesses high biological and nutritional value. It is a great source of minerals and vitamins. The biological value (flavonoids) content in spinach is high and includes compounds that are not commonly found in other vegetables. This study was conducted to investigate the influence of post-harvest storage temperature and time on the quality of baby spinach.

### MATERIALS AND METHODS

At 36 days after planting, baby spinach leaves were harvested and subsequently stored at 4°C and 22°C for 0, 2, 4, 6, 8, 10, and 12 days. Chemical analysis include mineral and trace elements), total phenols, flavonoids, carotenoids and antioxidant activity were evaluated.

### RESULTS AND DISCUSSION

The results showed quality deteriorate of baby spinach as the storage time progresses and temperature increases. Composition of magnesium, zinc and iron declined after 8 days of storage at 4°C whilst at 22°C, they declined after 2 days of storage. Three parameters namely; magnesium, zinc and iron resembled similar trend since the significantly higher carotenoids were found up to 6 days in storage time 4°C, whilst at 22°C the level of carotenoid declined after only 2 days. Total phenolic compounds decrease gradually in samples stored at 4°C. However, samples stored at 22°C decreased rapidly after 4 days of storage. Both total antioxidant activities and Vitamin C content showed a similar trend, as the content remained at constant level at 4°C and decreased after 6 days, whereas, the total antioxidant activities and vitamin C stored at 22°C decreased immediately after 2 days. The concentration of variables held at 4°C are higher than in those held at 22°C, especially before 6 days, can be linked with the metabolic rate as it is well known that metabolic processes are generally slower at lower temperature.

### CONCLUSION

Cooler temperatures have a better effect on the storage quality of baby spinach.

**Keywords:** Baby spinach, post-harvest, storage temperature, storage time

## EVALUATION OF POSTHARVEST STORAGE TEMPERATURE AND SHELF-LIFE OF NEWLY DEVELOPED 'FUERTE-TYPE' AVOCADO SELECTIONS

M Munzhedzi<sup>1</sup>, TP Mafeo<sup>1</sup>, MR Masevhe<sup>1</sup>, N Mathaba<sup>2</sup>, J Mlimi<sup>2</sup>

<sup>1</sup>University of Limpopo, SAES, P/Bag X1106, Sovenga, 0727; <sup>2</sup>ARC-ITSC, P/Bag X11208, Nelspruit, 1200

mmunzhedzi@gmail.com

### INTRODUCTION

In avocado, cold storage preserves and prolongs quality during shipping to long distance markets. However, low temperature storage might result in development of various physiological disorders (Woolf *et al.*, 2005). Currently, European countries are the main markets, however, for the industry to remain competitive it must continue to search new high paying markets. Furthermore, countries of the same production season such Peru, Chile and Australia continue to pose competition to the industry by breeding superior selections and shipping at the same time as South Africa (Vorster, 2004). To mitigate these challenges, new cultivars with superior characteristics need to be bred. The Agricultural Research Council-Institute of Tropical and Subtropical Crops (ARC-ITSC) developed new avocado selections namely, BL1058, ITSC Selection, Calshad and Wurtz. However, information about the response of these selections to a mandatory cold storage temperature is not documented.

### METHODS AND MATERIALS

Mature new 'Fuerte-type' selections avocado fruit were harvested from a single gene block at ARC-ITSC Burgershall research farm in Hazyview and transported to the ARC-ITSC postharvest laboratory. At the laboratory, fruit were sorted, weighed, packed and stored at 5.5°C for up to 28 days. The experiment comprised five treatments viz., ITSC selection, Calshad, BL1058 and Wurtz and a control (normal Fuerte) laid out in a completely randomized factorial design with 3 replicates. After cold storage, fruit were kept at ambient temperature to ripen. During ripening fruit were evaluated for electrolyte leakage, weight loss, firmness, colour change (L, chroma, hue, a&b), carbon dioxide production, physiological disorders (chilling injury, vascular staining) and postharvest diseases (anthracnose, stem end rot).

### RESULTS AND DISCUSSION

During ripening the tested 'Fuerte-type' avocado selections (ITSC selection, Calshad, BL1058 and Wurtz) maintained colour parameters (L, chroma and hue). After cold storage, 'Calshad' and 'ITSC selection' showed lower fruit weight loss, respiration rate, electrolyte leakage, and ripening percentage which correlated with no external chilling symptoms. An increase in weight loss, respiration rate, ripening percentage and electrolyte leakage was observed in 'Wurtz' and 'BL1058'. Higher rate of metabolism in 'Wurtz' and 'BL1058' correlated with the onset and later manifestation of chilling symptoms (Ferreiro, 2007). In conclusion, 'Wurtz' and 'BL1058' were not susceptible to external chilling symptoms at the mandatory cold storage temperature and had a longer shelf-life. Therefore these selections can be recommended for registration.

### ACKNOWLEDGEMENTS

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**Keywords:** Avocado ITSC Selections; Calshad; BL1058; Wurtz; Fuerte-type

## VERIFICATION OF A CORRECT SOIL SAMPLING DEPTH FOR SUGARCANE IN THE SOUTH EASTERN LOWVELD OF ZIMBABWE.

B. Matibiri<sup>1</sup>, M.D.S. Nzima<sup>1</sup> and L.T. Mupondi<sup>1</sup>

<sup>1</sup>Zimbabwe Sugar Association Experiment Station, P.B. 7006, Chiredzi.

Tmupondi@zsaes.org.zw

### INTRODUCTION

Correct sampling of soils is the most important step in any nutrient/soil amendment management program. For most field crops the correct sampling depth is 20 cm. Unlike other crops, sugarcane roots take up most of their nutrients to a depth of 30 cm. In order to provide the correct recommendations on fertilisers, the sampling depth of soil is very critical. The general objective of this experiment was to determine the correct sampling depth among sugarcane fields irrigated using furrows systems.

### MATERIALS AND METHODS

The experiment was done at the Zimbabwe Sugar Association Experiment Station [ZSAES], in the South Eastern Lowveld of Zimbabwe. Soil samples were taken from Field K2 Sable Block which was irrigated using furrows systems. Four sampling depths were used; 0 - 20, 0 - 30, 30 - 60 and 60 - 90 cm. Soil samples were analyzed for available P, K, Ca, Mg and Na. pH was determined potentiometrically in a 1:5 (soil: 0.01 M calcium chloride solution). Soil conductivity was also determined potentiometrically in a 1:5 (soil: deionised water) mixture. Genstat Release 4.24 (Lawes Agricultural Trust, 2008) was used to analyse the variance of the data (ANOVA) and means were separated using the least significant differences (LSD) at  $p < 0.05$ .

### RESULTS AND DISCUSSION

pH and Ca concentration were not affected by sampling depth. Electrical conductivity of the soil was highest at the 0 - 20 cm depth and decreased with sampling depth. The observed trends could be attributed to crop uptake and leaching of bases. Sampling at 0 - 20 cm depth gave significantly higher P compared to the 0 - 30cm depth. Concentrations of both P and K decreased with sampling depth although there was more K than P. Potassium is easily leached from organic materials at the soil surface because it is not organically bound to plant tissues. Great quantities of K were taken up by plants and/or were leached. These losses could explain the decrease of K with depth. On the other hand P is largely immobile and does not move down the profile but is concentrated on the top most layer of the soil. The concentrations of both Mg and Na increased with sampling depth. Results suggested that sampling at the 0 - 20 cm depth may result in an under estimation of fertiliser requirements for the sugarcane crop by overestimating the available nutrients.

### CONCLUSION

The correct sampling depth for furrow irrigated sugarcane soils in Zimbabwe is 0 - 30 cm because the 0 - 20 cm depth tended to overestimate the available nutrients in the soil.

**Keywords:** amendment, nutrients, pH, sampling technique

**FUNGICIDAL EFFICACY OF PLANT EXTRACTS ON LATE BLIGHT DISEASE CAUSED BY  
*Phytophthora infestans* IN IRISH POTATO (*Solanum tuberosum*.L)**

University of Fort Hare, Department of Agronomy  
T. Muzeza, E. Ngadze, M. Handiseni , C. Mutengwa

muzeza.tsitsi@gmail.com

**INTRODUCTION**

Late blight (*Phytophthora infestans*) is one of the main disease affecting Irish potatoes during vegetative growth. A cheap and environmentally friendly method such as the use of plant extracts would be an ideal alternative in managing *P. Infestans*.

**MATERIAL AND METHODS**

An experiment was carried out to investigate the efficacy of plant extracts on late blight disease and air-dried samples of seven plant extracts, *Allium sativum*, *Lantana camara*, *Datura stramonium*, *Azadirachtin indica*, *Capsicum annuum*.L, *Zingiber officinale* and *Brassica juncea* were used. Aqueous extracts of these plant extracts were evaluated against *P. infestans* *in-vitro* and field experiment. The *in-vitro* experiment was designed as a Complete Randomized Design (CRD) with one factor comprising of seven plant extracts at three levels, which were the three different concentrations; 10%, 15% and 20%. In the field experiment only five screened plant extracts from the *in-vitro* experiment were used. The field experiment was a split plot design comprising of two potato cultivars as the main plot and five plant extracts being the sub-plot.

**RESULTS AND DISCUSSION**

Results from the *in-vitro* experiment showed that *A. sativum* and *C. annuum* reduced mycelium growth at 10% concentration, ( $P<0.001$ ). The five plant extracts that were used in the field experiment and included 5 different concentrations of each. The results from field experiment showed that plant extracts reduced incidence and severity of late blight disease ( $p<0.05$ ). Results showed that *A. sativum* and *C. annuum* were the best plant extracts that recorded a 25% and 50% reduction in disease incidence and severity of late blight disease in field respectively. Results also indicated that the yields of potato tubers were corresponding with reduction in disease incidence and severity of late blight disease.

**CONCLUSION**

The present study has indicated that different plant extracts have an effect in the control of late blight disease caused by *P. infestans*. The potential of natural products for late blight management can promote and reduce inputs and improve sustainability of potato production.

**Keywords:** *Phytophthora infestans* , Irish potatoe , plant extracts

## NITROGEN AND PHOSPHORUS RELEASE POTENTIAL OF LATRINE DEHYDRATION AND PASTEURIZATION (LaDePa)

Z Mzayi<sup>1,2</sup> and Dr P Chiveng<sup>2</sup>

<sup>1</sup>Döhne Agricultural development Institute, Private bag X 15, Stutterheim, 4930; <sup>2</sup>School of Agricultural, Earth & Environmental Sciences, UKZN, P Bag X 01, Scottsville, 3209

Mzaiyazizo@yahoo.com

### INTRODUCTION

The one way removal of nutrients from the soil without return has led to a huge nutrient loss and other problems facing agriculture today. The current system of handling human excrement is a biggest contributor as it redirects waste to drainage pipes and closed pits away from the agro-ecosystem. Natural ecosystems function as a closed system, therefore a step towards sustainable agro-ecosystems function includes recycling of human excrement into forms that are easier to handle and safer to use in agriculture. A study was done at UKZN using LaDePa pellets, a product made from human faeces produced by the EThekweni municipality to assess nutrient release pattern in soils and its potential as an agricultural amendment.

### MATERIALS AND METHODS

Three soils of contrasting physico-chemical properties were used, Inanda(Ia), Sepane(Se) and Catref(Cf). Two sets of incubations were setup for 70days from 1 March 2013- 9 May 2013, one to measure Nitrogen (N) and Phosphorus (P) and the other for Carbon Dioxide (CO<sub>2</sub>) emissions at 25°C and 60% water holding capacity. Extractable P was determined by molybdenum blue method and NH<sub>4</sub>-N was determined by the evaporation distillation method followed by titration with 0.02M HCl. CO<sub>2</sub> emission determined using a carbon dioxide gas analyzer and CO<sub>2</sub> quantified using the following equation:

$$\text{net ppmCO}_2 = \left( \frac{x_{\mu\text{LCO}_2}}{100 \text{ mL}_{\text{air}}} \times (m\text{l})V_{\text{headspace}} \times \frac{100}{(g)_{\text{m}_{\text{soil}}}} \right) \times \frac{60}{20} \text{h} \dots \text{Equation 1}$$

### RESULTS AND DISCUSSION

The effects of adding LaDePa are observed in the first 14days and equilibrates after. Microbial activity is highest in Ia>Se>Cf, P followed an opposite trend with Cf>Se>Ia and NH<sub>4</sub>-N was highest in Se>Ia>Cf.

### CONCLUSIONS

Properties of soils affect the nutrient release patterns and strength of LaDePa resulting in different dissolving properties in different soils. Overall LaDePa can be used in nutrient low soils as an amendment to supply N and P in available form and improve microbial activity of the soil. LaDePa made from human faeces returns to the soil the nutrients lost in a dignified form easy to store, handle and apply by the local farmer.

**Keywords:** LaDePa, nutrients

## PERFORMANCE OF ELITE MAIZE HYBRIDS UNDER TWO CONSTRAINING ENVIRONMENTS IN LIMPOPO PROVINCE

EN Ndou<sup>1</sup>, K Mashingaidze<sup>1</sup>, DR Masindeni<sup>2</sup> and N Mailula<sup>2</sup>

<sup>1</sup>Agricultural Research Council - Grain Crop Institute, Private Bag 1251, Potchefstroom 2520

<sup>2</sup>Limpopo Department of Agriculture, Private Bag X9487, Polokwane, 0700

ndoue@arc.agric.za

### INTRODUCTION

Maize is produced in a wide range of environments and its production is mostly hampered by drought and low fertile soils, more especially nitrogen. The situation of drought becomes dire to small holder farmers since they can afford irrigation systems and fertilizers and most of their fields are in water scares areas and marginal soils. To address this problem, Agricultural Research Council has a programme on breeding new maize varieties that will be tolerant drought and low nitrogen. Therefore, the aim of the study was to evaluate the performance of advanced maize hybrids for drought tolerance and low nitrogen under smallholder's farmer fields.

### MATERIALS AND METHODS

Twenty five white experimental hybrids and five checks were evaluated under farmer's field in Giyani, Mokopane, Moletjie, and Nebo, Limpopo Province. The trails design followed was alpha lattice (0.1) design with three replications. The trials were planted under rain fed conditions (random drought) and lower nitrogen levels. Normal agronomic practices were followed to manage the trials in all locations. However, under lower nitrogen levels, no nitrogen fertilizer was applied during the growing stages except in at planting time where it was applied as a compound fertilizer (2:3:2) following poor small holder farmers practices. Grain yield data was collected and subjected to analysis of variance (ANOVA) using SAS software programme.

### RESULTS AND DISCUSSION

Grain yield varied per location and per environments. On average, under random drought environments the grain yield varied between 3.46 - 4.87 t/ha. In low nitrogen environment the average grain yield ranged between 2.27 – 4.67 t/ha. The combined average yield across the environments averaged between 3.20 – 4.27 t/ha. There were significant differences among hybrids and between environments and sites ( $p < 0.05$ ) for grain yield with an overall heritability of 63%. Most of the new elite hybrids had outperformed the checks, except WE3127 and WE3128 two new drought tolerant hybrids that were released by ARC. These hybrids had performed consistently across the different environments and sites. More hybrids from the study will be considered for cultivar release, because of their tolerance to random drought and lower nitrogen.

### CONCLUSIONS

Hybrids performance shows potential for high yields under farmer's field and thus increasing yields for smallholder farmers even in marginal soils and during drought periods.

**Keywords:** random drought, grain yield, low nitrogen, breeding, tolerance



## THE VIABILITY AND POTENTIAL OF SMALLHOLDER SWEET POTATO ENTERPRISES AS A FOOD SECURITY MEASURE IN RURAL COMMUNITIES OF SOUTH AFRICA

P. Ndou\*, K. Mashego, B. Taruvinga & C.P. du Plooy  
*Agricultural Research Council – Rooderplaas, Vegetable and Ornamental Plant Institute (ARC-VOPI),  
Private Bag X293, Pretoria 0001, South Africa. Email:*

*NdouP@arc.agric.za*

### INTRODUCTION

Issues of food security, hunger and poverty, and ways of addressing them, continue to be of great concern in South Africa. Whilst the country produces enough food (save for wheat) to feed its population, about 25% of the population is food insecure, and between 40% and 50% of people living in South Africa is at risk of hunger (Mistry, 2014; van der Berg, 2006). The challenge of food insecurity is intensified by increases in food prices especially in staple foods like wheat, maize and rice (Abdu-Raheem and Worth, 2011). In order to establish food security, it is generally acknowledged that the welfare of the poor people should be improved. One way towards improving the living standards of the rural people is through agriculture production and marketing (Abdu-Raheem and Worth, 2011). This paper presents the argument that establishing sweet potato enterprises among smallholder farmers significantly reduces food insecurity in rural communities of South Africa

### MATERIALS AND METHODS

Sweet potatoes were chosen because they can be easily produced by smallholder farmers, as their production is low risk, requires less management and yet high yielding. After harvesting, they can be stored for some time without getting spoilt. Also, sweet potatoes have an array of health benefits, including as a source of carbohydrates, vitamins, minerals and dietary fiber (Laurie, 2004). A market survey was conducted between August 2013 and December 2014 in six provinces of South Africa, where face to face interviews were conducted with the aid of a questionnaire. The main aim of the survey was to collect data related to markets, pricing and conditions that are required from farmers in order to allow them to supply markets. In order to determine profitability of sweet potato enterprises, enterprise budgets and Return on Investment were drawn based on ARC-VOPI trials, where input and output records of the trials were utilized.

### RESULTS AND DISCUSSION

An income, above variable costs, of R47107.84 is expected from one hectare of sweet potato production. In terms of markets, sweet potatoes are sold from two broad markets viz formal and informal markets, and both markets are willing to get supplies from smallholder farmers.

### CONCLUSION

Investing in sweet potato production is a profitable venture and can potentially improve food security among rural poor in South Africa. Smallholder farmers can utilize both formal and informal markets for selling sweet potatoes. In supplying formal markets, farmers need to produce relatively large amounts and should produce high quality products in order to stand competition. Informal markets are flexible in terms of quality and can be easily accessed by smallholder farmers.

**Keywords:** Food security, sweet potatoes, smallholder farming, profit, market

**SCLEROCARYA BIRREA (MARULA) SEEDLING PERFORMANCE USING DIFFERENT FERTILIZERS AND PLANTING METHODS IN THE LIMPOPO PROVINCE**

R Nematikanga<sup>1</sup>, MM Mofokeng<sup>2</sup>, SR Sasa<sup>1</sup> and R Kleynhans<sup>2</sup>  
1 Limpopo Department of Agriculture, Private Bag X9487,  
Polokwane, 0700  
2 Agricultural Research Council Roodeplaat Vegetable and Ornamental Institute,  
Private Bag X293, Pretoria, 0001

NematikangaR@agric.limpopo.gov.za

**INTRODUCTION**

Even though research has been conducted and published on germination of *Sclerocarya birrea* seeds, marula, (Nerd and Mizrahi, 1993; Akinnifesi et al., 2007) the accessibility of information on seed germination of marula at community level is still a challenge. The objectives of the study were to evaluate the efficient most planting method for producing marula seedlings and investigate the performance of marula seedlings using different fertilizers.

**MATERIALS AND METHODS**

Marula seeds collected at Makonde Village were stored at room temperature for a year to overcome the reported dormancy period (Black, 1989). The experiment consisted of a latin square with four replications. The CRD experiment was conducted with three planting methods (direct seed sowing M1, seedlings transplanting M2 and vegetative propagation M3 replicated four times at a spacing of 10x10m amounting to 100 trees ha<sup>-1</sup> and irrigated daily with 600ml of water until roots developed. The CRD experiment was conducted with four levels of soil fertilizer types 3:2:1(30) NPK (F2), compost (F3), kraal manure (F4) and control (F1=soil). All data was analysed using SAS.

**RESULTS AND DISCUSSION**

*Sclerocarya birrea* seedlings fertilized with 3:2:1(30) NPK (F2), compost (F3), kraal manure (F4) significantly ( $P = 0.05$ ) enhanced growth and yield of the crop whereas the unfertilized seedlings (F1) were stunted and of poor colour. The transplanted seedlings adapted well to the four levels of soil fertilizer types 3:2:1(30) NPK (F2), compost (F3), kraal manure (F4) and control (F1=soil) by growing quickly and seedlings were green and healthy. There were no significant differences between the transplanted seedlings and the vegetative planting methods during stand establishment and seedling growth.

**CONCLUSIONS**

Domestication of *S. birrea* trees is easily achievable (Nerd and Mizrahi, 1993) and communities should no longer experience shortages. For faster growth and quicker harvesting of marula fruits, cuttings performed better than the direct seed and transplanting planting methods.

**ACKNOWLEDGEMENTS**

We are grateful to the Agricultural Research Council (ARC-VOPI) and Department of Science and Technology for their financial support as well as the farmers and the Limpopo Department of Agriculture officials for their assistance in the study.

**Keywords:** indigenous knowledge systems, crop production

## SPIDER PLANT YIELD AND WATER PRODUCTIVITY AS AFFECTED BY IRRIGATION AND NITROGEN LEVELS

T.S Nembudane<sup>1</sup>, E.H Tesfamariam<sup>1</sup> and Y.G Beletse<sup>2</sup>

University of Pretoria, Private Bag X20, Hatfield 0028; Agricultural Research Council-Roodeplaat,  
Private Bag X79, Pretoria 0001

snebudane@yahoo.com

### INTRODUCTION

Spider plant (*Cleome gynandra* L.) is one of the indigenous leafy vegetables commonly consumed in the rural parts of South Africa. Despite this, there is little information on the effect of water and nitrogen availability at different stages of crop growth on the yield and nutritional quality of the crop. The aim of this study was to investigate the response of spider plant leaf yield and water productivity to a range of water and nitrogen regimes.

### MATERIALS AND METHODS

A controlled field experiment was conducted under a rainout shelter at the ARC-VOPI, Roodeplaat, South Africa. Irrigation and N application treatments were laid out as a 3×4 factorial designed in RCBD with three replications. Three irrigation levels namely: irrigating to field capacity (FC); irrigating to 80% of the plant available water (80%PAW) and irrigating to 60% of the plant available water (60%PAW) and four N application rates (0, 50, 100 and 150 kg N ha<sup>-1</sup>). Leaf fresh (LFM) and dry mass (LDM) was determined on leaf samples collected from the middle rows in each plot. Water productivity (WP) in fresh and dry mass basis was calculated as the ratio of spider plant edible leaf yield to the actual evapotranspiration (kg m<sup>-3</sup>).

### RESULTS AND DISCUSSION

Nitrogen application significantly increased ( $P \leq 0.05$ ) spider plant LFM and LDM. Thus higher LFM (8.9 Mg ha<sup>-1</sup> in 2013; 5.0 Mg ha<sup>-1</sup> in 2013/14) and LDM (1.4 Mg ha<sup>-1</sup> and 0.9 Mg ha<sup>-1</sup> in 2013/14) were harvested from the highest N application rate of 150 kg ha<sup>-1</sup>. Irrigation treatments influenced spider plant LFM and LDM but not significantly. However, N application and irrigation significantly influenced WP. WP was low in N fertilizer limited treatments irrespective of the irrigation treatment. High WP<sub>fresh</sub> was attained in moderate irrigation treatment (0.79 kg m<sup>-3</sup> in 2013; 0.91 kg m<sup>-3</sup> in 2013/14) and N application rate of 50 kg ha<sup>-1</sup>.

### CONCLUSIONS

Spider plant LFM and LDM production is sensitive to N application but less sensitive to water stress of up to 60% of the plant available water. Water productivity of spider plant is dictated by plant N availability.

### ACKNOWLEDGEMENTS

ARC-VOPI, WRC and NRF

**Keywords:** spider plant, water productivity, leaf fresh and dry mass.

## THE POTENTIAL OF ACID MINE DRAINAGE (AMD) WATER FOR USE TO GROW POTATO (SOLANUM TUBEROSUM) IN GAUTENG PROVINCE, SOUTH AFRICA

M.V Nemutanzhela<sup>1</sup>, K.J Siyoko<sup>1</sup>, D.M Modise<sup>1</sup>, D Visser<sup>2</sup>

<sup>1</sup>UNISA; <sup>2</sup>ARC-VOPI

raletmv@unisa.ac.za

### Introduction

Agriculture is one of the sectors that utilizes a vast quantity of water for production of food (Ankomah, 2001). The scarcity of this resource combined with global warming is a huge threat to sustained food security in South Africa. As irrigation water is used to supply the water requirements of a wide variety of plants, under widely varying degrees of intensification, with a range of different distribution and application systems, to a wide range of soils over all climatic ranges in South Africa, a wide spectrum of problems may be encountered where water does not meet these demands. In order to circumvent food insecurity, the South African agricultural community needs to recycle the available water and engage themselves with climate smart agriculture systems to diminishing the threat to food security. Acid Mine Drainage is available water in the Gauteng region and can be considered for crop production for the purpose of sustaining South African agriculture and food security.

### Materials and Methods

The study entailed 5 plots laid out in a completely randomized block design with 5 treatments and 30 replicates. Potato (*Solanum tuberosum*) crops were grown for 120 days in a greenhouse and were irrigated with normal water (control) and Acid Mine Drainage (AMD) mixed with Fly Ash (FA) at differing ratios 1:1, 1:2, 1:3, and 100% AMD. The aim of the study was to determine if AMD water treated with FA would have an effect on the growth and quality of potato tubers. Irrigation scheduling for all treatments was done based on soil water tension readings using an irrometer (Model 30 – KTCD - NL). Physiological plant growth parameters were measured over a period of 28 days. These included stomatal conductance recordings using a leaf porometer (Model SC – 1); chlorophyll content readings by means of a Chlorophyll Content Meter (CCM-200 Opti-Sciences) and stem growth data using a digital caliper (Model DC – 515). GenStat 64-bit Release 15.1, and Least significant differences of means (5% level) was used to separate the means.

### Results and discussion

Results indicated that the potato irrigated with differing ratios of AMD water and treated with FA resulted in an increase in the chlorophyll content and stem diameter compared to the crops irrigated with normal tap water. The means of abaxial and adaxial stomata conductance data for potato irrigated with AMD mixed with FA were higher than the crops that were irrigated with normal tap water. This difference in stomatal conductance data between the treatments indicated that CO<sub>2</sub> optimization for plant growth was significantly higher in the potato irrigated with AMD mixed with FA compared to the treatment with tap water.

### Conclusion

On the premise that the abundant AMD water in Gauteng Province, can be used as an alternative source of irrigation water when ameliorated with FA; other quality parameters as a result of the treatments will be discussed in detail.

**Keywords:** Potato, acid mine drainage (AMD), fly ash (FA), stomata conductance, carbon dioxide (CO<sub>2</sub>), chlorophyll content meter (CCM)

## MULTI-MYCOTOXIN ANALYSIS OF FOOD CROP SAMPLES FROM RURAL NORTHERN SOUTH AFRICA

T.C de Rijk<sup>1</sup>, M Hove<sup>1</sup>, P Mngqawa<sup>2</sup>, SH Ngobeni<sup>2</sup>, DR Katerere<sup>2</sup>

<sup>1</sup>Rikilt, Institute of Food Safety, 6700 AE Wageningen, Netherlands; <sup>2</sup>

sngubeni62@gmail.com

### INTRODUCTION

Mycotoxins are a major food borne risk factor in the etiology of various diseases in humans and animals. As maize is a staple food in South Africa and mycotoxin contamination is common, reliable and regular monitoring data are needed as a first step to policy formulation and intervention studies. The aim of this study was to investigate the incidence of mycotoxin contamination in staple crops collected from smallholder farmers in the Limpopo and Mpumalanga provinces of the Republic of South Africa.

### MATERIALS AND METHODS

In laboratory the samples were divided into three groups: white maize samples (n=21), yellow maize samples (n=36), mixed samples (n=17), mainly peanuts (n=3) and beans (n=10). The validated analytical method consisted of an extraction of finely ground sample material and injection of the extract into an AB Sciex QTRAP5500 LC-MSMS. Mycotoxins were identified based on retention time and ion ratio.

### RESULTS

Six samples of yellow maize exceeded the RSA maximum limit of AFB1 of 5 µg/kg in food, with levels up to 0.133 mg/kg (0.148 mg/kg AFB total). White maize and mixed samples did not contain aflatoxins above the LOQ (table 1). No guidelines or maximum limits for fumonisins are set in RSA. Therefore the EU guideline of 1.0 mg/kg (sum of FumB1 and Fum B2, EC/1881/2006) was used. Seven samples of yellow maize and two samples of white maize exceeded the EU guideline, with levels ranging from 1.0 to 12.2 mg/kg. The rural population of Limpopo province may be at risk of the adverse effects of exposure to fumonisins through maize consumption. Individual smallholder farmers may be at risk to exposure of large amounts of aflatoxins. Crops from Mpumalanga province showed little contamination with either fumonisin or aflatoxins but high prevalence of beavericin, zearalenon, deoxynivalenol and ochratoxin A.

### CONCLUSIONS

This is the first comprehensive report of multi-mycotoxin occurrence in northern RSA and follow up studies are required which will inform policy and guideline design. In addition, exposure studies are also required.

**Keywords:** Mycotoxins, aflatoxins, fumonisins, maize

## ENHANCING SWISS CHARD PRODUCTION THROUGH FOLIAR APPLICATION OF ORGANIC GROWER

MR Ngwepe<sup>1</sup>, JK Huma<sup>1</sup>, M Mashaphu<sup>1</sup>, MP Malemela<sup>1</sup> and ML Mokoena<sup>1</sup>  
<sup>1</sup>Limpopo Department of Agriculture, Tlokoeng ADC, Private Bag X1615, Bela-Bela 0480

ngwepemr@gmail.com

### INTRODUCTION

Swiss chard (*Beta vulgaris* L.) is regarded as a heavy feeder of nutrient elements and is recommended for slightly fertile soils when grown in open fields. Improved yield and quality of this leafy vegetable is attributed to its efficient use of water and nutrient elements. Through continuous leaf harvesting, nutrient elements are constantly removed, leading to lower leaf yield. Therefore, enhancing Swiss chard production through the application of fertilizer is important as this will lead to increased leaf yield over its growing period. The objective of this study was to determine the potential effects of Organic Grower (made from Guano) on the leaf yield of three Swiss chard.

### MATERIALS AND METHODS

The field trial was planted at Tlokoeng ADC, approximately 4 km south east of Bela-Bela, Waterberg District, Limpopo Province. The trial was conducted as a 3 X 3 factorial experiment, which included three Swiss chard cultivars and three levels of organic grower, replicated three times. The Swiss chard varieties used were: Ford Hook Giant, Star 1801 and Green Wave. Organic Grower (OG) was applied at three different dilution levels: 0% (OG), 50% (OG) and 100% (OG) of the recommended product labelling. Direct seeding method was used, with two seeds sown per hole but later thinned to one plant. The liquid fertilizer was applied 14 days before first harvest and immediately after first harvest. Data was analysed with Genstat 14.0 and treatment means were separated using Fisher's LSD test at P = 0.05.

### RESULTS AND DISCUSSION

The application of OG significantly affected different yield parameters of Swiss chard. There were significant differences amongst different applications of OG on the total fresh mass, leaf mass and petiole mass. The cultivars had 67% higher total fresh mass when receiving high dilution levels compared to lowest dilution levels. The cultivar Green Wave was significantly different from both Star 1801 and Ford Hook Giant with regard to petiole length, and number of leaves harvested. Ford Hook Giant produced 25 and 33% higher total fresh mass compared to Star 1801 and Green Wave, respectively.

### CONCLUSION

The results indicated that OG has the potential of increasing the total fresh mass of Swiss chard cultivars. Therefore, the study will be repeated to further validate these findings.

**Keywords:** Guano, *Beta vulgaris*, cultivars, yield

## APPLICATIONS OF MICROSATELLITE MARKERS IN HONEYBUSH

M Niemandt<sup>1,2</sup>, R Roodt-Wilding<sup>1</sup>, K Tobutt<sup>2</sup> and C Bester<sup>2</sup>

<sup>1</sup>Department of Genetics, Stellenbosch University, Private bag X1, Matieland, 7602

<sup>2</sup>Cultivar Development, ARC Infruitec-Nietvoorbij, Private Bag X5026, Stellenbosch 7599

niemandtm@arc.agric.za

### INTRODUCTION

Honeybush tea is made from various *Cyclopia* species which are endemic to the Fynbos biome of South Africa and has become increasingly popular as a result of its proposed health properties. Despite its commercial importance, no genetic markers have yet been developed for any of the *Cyclopia* species. This study aims to develop microsatellite markers for *Cyclopia* species for applications in plant breeding practices such as DNA fingerprinting of honeybush accessions. An assessment of the genetic diversity of honeybush in the form of population structure and distribution will be conducted to assist breeding programmes and conservation efforts.

### MATERIALS AND METHODS

Sampling of three *Cyclopia* species (*C. subternata*, *C. genistoides* and *C. longifolia*) was done. A DNA extraction protocol based on the CTAB method was optimised specifically for honeybush, to ensure that all phenolic compounds are removed. Twenty seven microsatellite markers were developed which will be used in the study to DNA fingerprint the ARC honeybush accessions and assess the genetic diversity of the populations. The microsatellite markers will also be cross-amplified to *C. genistoides* and *C. longifolia*, which would minimise the cost associated with the development of microsatellite loci for each species. Several of the unlabelled microsatellite primers were tested using a touchdown PCR protocol and run on a 2% agarose gel.

### PRELIMINARY RESULTS

Beta-mercaptoethanol and polyvinylpyrrolidone (PVP) were found to remove the phenolic compounds during DNA extractions and it was determined that young and intermediate leaves yielded higher quality DNA than when old leaves were used. Samples with NanoDrop values that varied between 1.8 and 2.1 were chosen, since pure DNA has a value of 1.8. The microsatellite markers that were tested (Cys10, Cys20 and Cys25) amplified in all three honeybush species. The correct band sizes were visualised on the gel and the next steps will include PCR amplification with fluorescently labelled primers and further population genetic analysis.

### CONCLUSION

When the microsatellite markers for *Cyclopia* species are successfully developed, it will be a useful tool to apply in the breeding programme for identification of accessions and to determine gene flow and genetic diversity.

### ACKNOWLEDGEMENTS

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**Keywords:** *Cyclopia*, DNA fingerprinting, genetic diversity, honeybush tea, microsatellites.

## **MAIZE GRAIN YIELD RESPONSE INTERCROP WITH TWO PIGEONPEA VARIETIES UNDER DRYLAND CONDITIONS**

FH Nndwambi, TR Nkosi, M Ngwepe

University of Limpopo, School of Agriculture and Environmental Sciences, Private Bag x1106, Sovenga, 0727, South Africa

nndwambif@gmail.com

### **INTRODUCTION**

Many farmers intercrop grain legumes with maize primarily to produce more food, but also to maintain soil fertility (Waddington, 1997). Most small scale farmers in Limpopo province often intercrop maize with groundnut, Bambara groundnut, and cowpea. However, record on the performance of maize and pigeon pea intercropping system under dryland conditions of South Africa is scanty.

### **METHODOLOGY**

Field experiments were conducted in the 2013/14 growing season at University of Limpopo Experimental farm and Ga-Molepo. Maize (PAN6479) was planted as sole crop and also intercropped with the VP-002 and 00040 pigeon pea varieties in a randomized complete block design with 4 replicates. Maize and pigeon pea were sown at populations of 44445 and 111111 plants ha<sup>-1</sup>, respectively. Yield data were subjected to ANOVA while treatment means were separated at 5% probability level. The trials evaluated intercrop yield advantage in terms of LER.

### **RESULTS AND DISCUSSION**

Intercropping enhanced maize grain yield over sole maize at Syferkuil and at Ga-Molepo. For example, maize+VP-002 and maize+00040 had 55.3% and 63.8 % higher grain yield compared to sole maize, respectively. In addition, the calculated total land equivalent ratio (LER) in both locations for two crops gave high and positive value which suggests favourable grain yield advantage for maize/pigeon pea intercrop.

### **CONCLUSIONS**

From the results obtained, it can be concluded that it is advantageous to intercrop pigeon pea with maize.

*Keywords:* Grain yield, Intercrop, LER



## FINE MAPPING AND CHARACTERIZATION OF FUNGAL DISEASE RESISTANCE GENES IN GRAIN SORGHUM (SORGHUM BICOLOR)

Z. Noqobo<sup>1</sup>, L.M.J. Maubane<sup>1</sup>, D.J.G. Rees<sup>1</sup>  
<sup>1</sup>ARC, Private Bag X5, Onderstepoort, 0110

noqoboz@arc.agric.za

### INTRODUCTION

Foliar sorghum diseases such as anthracnose, northern corn leaf blight and rust can significantly reduce sorghum yield and quality; and the use of resistant cultivars is the most effective control method. Surveys were conducted across 5 provinces of South Africa to determine the occurrence and distribution of diseases in sorghum during the 2013/14 growing season.

### MATERIALS AND METHODS

Surveys were conducted at the maturity stage of the crop development. Average incidence (%) of the diseases was obtained from a sample of 100 plants, selected using simple random sampling technique from each farm. A 1-9 scale was used to determine diseases severity. Samples of the leaves showing disease symptoms were collected from each farm and fungal pathogens were isolated. The isolates will be identified using microscopy and next generation sequencing techniques. A population of 189 F9 recombinant inbred lines (RILs) and the ARC sorghum germplasm of 200 cultivars will be used to identify resistant lines to the identified pathogens affecting leaves. The sorghum lines (RILs) that showed disease resistance in the field and the greenhouse will be sequenced and analysed.

### RESULTS AND DISCUSSIONS

Differences in diseases incidence and severity were identified on different farms. Two diseases, Northern corn leaf blight and anthracnose, were identified as the most common. The isolates were grouped into morphotypical groups, based on colour, shape and texture. The species will be identified using morphological characterization and DNA sequencing.

### CONCLUSIONS

Since sorghum is poorly studied in South Africa this work will determine the prevalence, incidence, severity and distribution of sorghum diseases therefore contribute to a better understanding of the diseases and effective management.

**Keywords:** characterization, sequencing, survey

## EFFICACY OF STICKY TRAP DESIGN ON ATTRACTION OF TOMATO FLYING INSECTS IN AN OPEN FIELD

B Nzanza <sup>1,2</sup>, S Ntekati <sup>1</sup>, K. P Malatji <sup>2</sup> and P. Novela

<sup>1</sup>University of Limpopo, Department of Plant Production, Soil Science and Agricultural Engineering, Private Bag X 1106, Sovenga, 0727, South Africa

<sup>2</sup>Natuurboerdery Research Centre, ZZ2 Bertie van Zyl, P. O Box 19, Mooketsi, 0825, South Africa

preciousnovela@gmail.com

### INTRODUCTION

Sticky traps have been widely used to monitor both harmful and beneficial insects, in wild and cultivated crops, world-wide. Traps based on the response of insects to color are used in integrated pest management programmes (Atakan and Canhial, 2004). Mitchell et al., (1989) mentioned that visual stimuli tend to overcome normally strong attraction response to a powerful olfactory stimulant like a sex pheromone. Moreover, McLaughlin et al. (1975) found that, traps of low spectral reflectance were more effective in capturing *Trichoplusia ni* (Hubner) and *Pseudoplusia includens* (Walker). The aim of this study was to demonstrate the effect of trap color on the attractiveness of tomato key pests (thrips, aphids, whitefly and leaf miner).

### MATERIALS AND METHOD

The study was conducted at ZZ2 farm during summer season of 2014. The experiment was laid out as randomized complete block design with six replicates. Treatments consisted of seven different colored sticky cards viz. (i) yellow (ii) yellow + yellow (iii) yellow + blue, (iv) yellow + black (v) blue (vi) blue + blue and (v) pyramid. Blue cards treatments were mounted with a western flower thrip (W.F.T.) pherolure. Traps were placed 30 cm above the plant canopy and placement was adjusted as the plant grows. Number of Aphid, thrips, leaf miner and whiteflies captured were counted on weekly basis throughout the production season. Data was subjected to ANOVA while treatment means were separated at 5% probability level.

### RESULTS AND DISCUSSION

Yellow + black sticky cards combination was more efficient on capturing whitefly, leaf miner and aphids throughout the season. Blue cards were not effective on attracting whiteflies, leaf miner and aphids regardless of the design used. There was no statistical difference observed on number of thrips counted on all sticky traps of different colored and design. However, Blue + blue sticky traps captured the highest population of thrips with mean number 70.8 with the pyramid being the least with mean number 21.7.

### CONCLUSION

The use of yellow + black sticky cards for monitoring tomato flying insects was found to be more effective than double side sticky traps. Further studies will be conducted in different locations to confirm if 3D sticky cards of yellow + black combination are more effective than double side sticky cards.

**Keywords:** Trap color, Trap design, Thrips, Aphids, Whitefly, Leaf miner.

## BREEDING FOR RESISTANCE TO WHEAT LEAF RUST IN

### SOUTH AFRICA: REVIEW

P. Ntshakaza<sup>1,2</sup>, H. Shimelis<sup>2</sup>, T. Terefe<sup>1</sup> and T.J. Tsilo<sup>1</sup>

<sup>1</sup>ARC- Small Grain Institute, Private Bag X29, Bethlehem, 9700, South Africa

<sup>2</sup> African Center for Crop Improvement, University of KwaZulu-Natal, Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa

ntshakazap@arc.agric.za

#### INTRODUCTION

Leaf rust, caused by the fungus *Puccinia triticina* Eriks is one of the most important diseases of wheat worldwide. It is regularly found in the wheat growing areas of South Africa such as Western Cape, Free State and KwaZulu-Natal. In the early 1980's severe leaf rust epidemics occurred in the country inflicting significant yield losses which raised the need for more attention on the disease. Leaf rust pathotypes are genetically diverse and are characterised by observing their avirulence to virulence profiles on differential sets. During 1983-1985, Pretorius et al. (1987) identified nine pathotypes with varying virulence levels and four more were detected during 1986 and 1987. Notably pathotype 3SA140 showed virulence to *Lr26* which was rendering effective leaf rust resistance amongst South African grown wheat. In 1988, new pathotypes such as 3SA137, 3SA141 and 3SA142 were described. No new pathotypes were observed since 1988 until 3SA144 with virulence to *Lr32* was detected in 2005. New pathotypes, 3SA145 (CCPS) and 3SA146 (MCDS) with virulence to *Lr12+13+37* were identified in 2009 and 2010, respectively. In 2010, pathotype 3SA147 (FBPT) was found and was observed to be a foreign introduction into South Africa. The objective of this review is to offer an overview of leaf rust resistance breeding in South Africa.

#### MATERIALS AND METHODS

The emergence of new pathotypes has led to the continuous search for new genes with durable resistance to leaf rust. Several leaf rust genes such as *Lr12*, *13*, *19*, *32*, *36*, *37*, *41* and *53* have been used as sources of resistance. However, the ability of wheat rusts to continuously mutate and overcome resistance has rendered all these genes ineffective against some leaf rust pathotypes occurring worldwide. The genes *Lr1*, *Lr10*, *Lr13*, *Lr17b*, *Lr19*, *Lr27*, *Lr31*, *Lr34*, *Lr39*, *Lr41*, *Lr46*, *Lr53*, *Lr56* and *LrK* are currently used in the pre-breeding programme at the Agricultural Research Council- Small Grain Institute. The process of marker assisted selection is used in breeding programmes to select for individuals with resistance which can be used as sources of resistance for gene pyramiding.

#### RESULTS AND DISCUSSION

The genes *Lr34*, *Lr46* and *Lr67* are pathotype non-specific genes which can be used in combination with the other genes to offer slow rusting and durable resistance in the field. *Lr19*, resistant to all known South African leaf rust races is also associated with high yield, making it an important gene for wheat breeding against leaf rust. Genes such as *Lr36*, *Lr39*, *Lr41*, *Lr53*, *Lr54* and *Lr59* confer some level of resistance to a wide range of South African leaf rust pathotypes and can therefore be used in gene pyramiding.

#### CONCLUSION

Gene pyramiding can enhance host resistance to leaf rust by incorporating durable and slow rusting genes together and/or into lines that possess other essential traits such as high yield and quality.

**Keywords:** Leaf rust, *Lr* genes, *Puccinia triticina*, resistance breeding, wheat.

**A SURVEY OF YIELD LOSS IN MAIZE DUE TO A *Spodoptera exempta* OUTBREAK: A CASE STUDY OF CHRIS HANI AND ALFRED NZO DISTRICT MUNICIPALITIES IN THE EASTERN CAPE**

B Ntwana<sup>1</sup>, NP Mtumtum<sup>2</sup>& NL Skenjana<sup>1</sup>

<sup>1</sup>Döhne Agricultural development Institute, Private bag X 15, Stutterheim, 4930; <sup>2</sup>Department of Agriculture and Rural Development, Private bag X 9059, Pietermaritzburg, 3200.

Babalwa.Ntwana@drdar.gov.za

## INTRODUCTION

*Spodoptera exempta* is a migratory insect that occurs periodically as a pest in South Africa causing large scale damages to crops and pastures. Recently an outbreak of *S. exempta* occurred in the Eastern Cape Province and it was first reported in the Chris Hani District. Field crops especially maize and pastures were infested. As a result of this outbreak, an estimation of yield loss on maize was done in all the affected regions.

## MATERIALS AND METHODS

To estimate yield loss resulting from *S. exempta*, two locations were selected in Chris Hani and four in Alfred Nzo. Surveys were conducted during the first week of May 2013. Current maize yields were estimated using the yield component method:

$$\frac{\text{No. of cobs} \times \text{No. of kernels} \times 0.25}{1000}$$

In order to estimate the yield loss due to African armyworm, the actual losses needed to be measured. Therefore crop loss was obtained by using the following formula:

$$\frac{\text{Potential yield} - \text{Actual yield}}{\text{Potential yield}}$$

## RESULTS AND DISCUSSION

In Chris Hani district, only one of the surveyed locations revealed yield loss due to *S. exempta* damage. In the other location, there was no evidence of damage by the pest but the expected yield was low. The low yield estimation was attributed to plant death from low temperatures (frost) as maize was at a grain filling stage. In Alfred Nzo district, yield loss due to *S. exempta* could only be established for one location. The damage was severe and it was estimated to be 100 % as the pest caused 100 % defoliation. Low yields were also estimated for the three other areas but they were not as a result of pest damage but were due to agronomic practices such as planting date, cultivar choice and plant population.

## CONCLUSIONS

*S. exempta* can be destructive and infestation can result to total loss of a maize crop if it is not controlled timeously as shown by results. In order to avoid damage to crops, it is recommended that the pest be managed timeously. Agronomic practices such as early planting should be followed as they can have an effect on yield loss.

**Keywords:** Damage, *S. exempta*, surveys, yield loss

## ASSESSMENT OF SHIKIMATE LEVELS IN CONYZA BONARIENSIS FOR CONFIRMATION OF GLYPHOSATE RESISTANCE

MN Okumu<sup>1</sup>, BJ Vorster<sup>1</sup>, CF Reinhardt<sup>1</sup>

<sup>1</sup>Department of Plant Production and Soil Science, University of Pretoria, Private Bag X20 Hatfield, Pretoria, 0028, South Africa

u13315049@tuks.co.za

### INTRODUCTION

Glyphosate is extensively used as a non-selective, broad-spectrum and post-emergence herbicide in modern agriculture. Its mode of action is by competitive inhibition of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme which is responsible for the biosynthesis of aromatic amino acids, hormones and other plant metabolites. Inhibition of EPSPS enzyme also causes build-up of precursors of the shikimic acid pathway, notably, shikimate. Accumulation of shikimate, therefore, is indicative of the activity of glyphosate in relation to EPSPS enzyme. Hairy fleabane, *Conyza bonariensis*, is known to have evolved resistance to glyphosate in many parts of the world, including crop fields, orchards and vineyards in the Western Cape region. Objectives were: (1) to confirm resistance or susceptibility to glyphosate in four *C. bonariensis* populations; and (2) to examine the accumulation of shikimate in both glyphosate-resistant and glyphosate-susceptible plants.

### MATERIALS AND METHODS

Two populations of glyphosate-resistant hairy fleabane from Swellendam and Piketberg and two glyphosate-susceptible populations from George and Piketberg were established in the greenhouse at the university's experimental farm. At 4-6 leaf stage, plants were sprayed with glyphosate (Roundup Turbo) at 0 and 2 L/ha, sampled at 0, 2, 4, 6 and 8 DAT and kept at -80°C. The frozen tissue was ground in liquid nitrogen and 100 mg weighed out into Eppendorf tubes. Extraction was done in 0.25 N HCl, followed by vortexing, sonication and centrifuging. The supernatant was taken out and directly used for analysis by HPLC. Shikimate levels were analysed with SAS statistical package and means separated using Tukey's test

### RESULTS AND DISCUSSION

There was a significant interaction effect in location x dosage x DAT ( $P = 0.0001$ ). Shikimate content increased in all the populations from 2 to 6 DAT and continued to increase in susceptible (S) populations but dropped at 8 DAT in resistant (R) populations. Significant shikimate levels ( $P=0.05$ ) were observed from 6 DAT in both R and S biotypes. These results are in line with previous reports by other researchers that shikimate accumulates in both S and R biotypes but decreases with time in R biotypes.

### CONCLUSION

It would be expected that glyphosate-resistant biotypes would have significantly lower amounts of shikimate compared to susceptible ones, or close to that in untreated controls. However, in our study, there was a significant increase in shikimate levels in both S and R accessions. Shikimate accumulation analysis suggests that a glyphosate-insensitive EPSPS enzyme is not the sole mechanism of resistance of *Conyza bonariensis* to glyphosate. More work is underway to unveil other mechanisms of resistance of this weed to glyphosate.

**Keywords:** Weed resistance, hairy fleabane, HPLC

## MONITORING SOIL WATER CONTENT FOR DRIP IRRIGATED SUGARCANE WITH CAPACITANCE PROBES

FC Olivier, A Singels and A Paraskevopoulos

*South African Sugarcane Research Institute, Private Bag X02, Mount Edgecombe 4300*

Francois.Olivier@sugar.org.za

### INTRODUCTION

Large increases in the cost of electricity and increasing demand for limited water resources have stimulated renewed interest in irrigation scheduling as means to use water more efficiently. Although adoption of precise irrigation scheduling has been slow, the use of capacitance probes has recently gained popularity in the sugar industry. This has prompted researchers to focus their attention on irrigation scheduling tools based on this new technology. The objectives of *this* study were to: 1) evaluate the accuracy, reliability and convenience of use of capacitance probes from two different manufacturers; and 2) gain a better understanding of soil water dynamics in drip irrigated sugarcane fields.

### MATERIALS AND METHODS

Capacitance probes of manufacturer A and B were installed in a surface drip irrigated sugarcane field of a third ratoon crop of cultivar N49. Irrigations were applied when weather-based estimations of soil water deficit reached 10 mm. The soil was a shallow (0.63 m) sandy clay loam of the Glenrosa form. One A and one B probe was installed in the centre of a 0.6 m dual cane row next to the drip line and 0.15 m from the emitter. A and B probes were also installed in the centre of the 1.4 m inter-row section. Probes were calibrated using neutron water meter measurements of volumetric soil water content (SWC).

### RESULTS AND DISCUSSION

Over the growing season both probe types gave a reasonably accurate reflection of changes in SWC for both the row and inter-row ( $R^2 = 0.74$  and  $0.80$  for probe A and B respectively). Data from probes A and B compared well ( $R^2 = 0.83$ ) and no seasonal drift was observed. SWC in the inter-row was on average 7% or 11 mm lower than in the row and only responded to rainfall events and not to irrigation applications. Data transfer occurred through radio to local desktop PC or cellular network to an internet server, and both methods were reliable. Data and graphics were easily accessible either through desktop software or internet browser.

### CONCLUSIONS

Both types of probes were accurate, reliable and easy to use. Although calibration is required for research purposes, factory calibrated probe output is very useful for practical irrigation scheduling when correctly installed and interpreted. It is recommended that probes are placed in the cane row under the dripper line for optimal scheduling.

**Keywords:** irrigation scheduling, capacitance probe, neutron water meter, drip irrigation, calibration.

## CREATING AN OPTIMIZED EXPRESSION PLATFORM FOR BIOFARMING WITH TOBACCO

P Pillay<sup>1</sup>, BJ Vorster<sup>2</sup>, KJ Kunert<sup>1</sup>

<sup>1</sup>Department of Plant Science, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Private Bag X20, Hatfield, 0028, South Africa; <sup>2</sup>Department of Plant Production and Soil Science, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, 0002, South Africa

priyen.pillay@fabi.up.ac.za; kraven.priyen@gmail.com

### INTRODUCTION

With the recent worldwide outbreak of the Ebola virus, plant-based vaccines produced by Biopharming have received much attention for their efficacy in combating disease outbreaks. Pharming is a portmanteau on farming and pharmaceutical. Pharming is also known as biopharming. Whole plant systems offer a valuable platform for the production of recombinant proteins. However, recombinant protein yield can be limited due to degradation by endogenous plant proteases, either during the production or the extraction phase. Identification of specific proteases induced during the process of agro-infiltration-mediated transient expression of recombinant proteins in tobacco leaves could provide protease targets that could be inhibited to increase total recombinant protein yield.

### MATERIALS AND METHODS

In this study we used two model proteins, P1 (a structural protein from the foot-and-mouth disease virus) and GOR (glutathione reductase from derived from *Escherichia coli*) to identify genes induced during transient expression of these proteins in leaves of *Nicotiana benthamiana*. Transcriptome profiles were generated through RNAseq of RNA harvested three days after agro-infiltration. Transcript assembly and annotation were performed using the Galaxy pipeline against the reference genomes of both *N. benthamiana* as well as *N. tabacum*. Differential gene expression was evaluated using Cufflinks and Cuffdiff against the transcriptomes of un-infiltrated plants as well as plants infiltrated with empty plasmids.

### RESULTS AND DISCUSSION

Thus far, a total of 441 genes were found to be differentially expressed in plants infiltrated with P1 and 609 in plants infiltrated with GOR compared to un-infiltrated plants. Currently, we are busy analysing the results to identify overlapping and unique genes expressed as a consequence of recombinant protein expression as well as specific proteases from various functional classes induced under these conditions.

### CONCLUSION

Future work will focus on silencing selected proteases and evaluating the effect on recombinant protein yield.

**Keywords:** Biofarming, Tobacco, foot-and-mouth disease (FMDV)

## INCREASING VEGETABLE RESEARCH INVESTMENTS TO ENSURE LONG-TERM SUSTAINABILITY OF VEGETABLE PRODUCTION

M Rancho<sup>1</sup>, F Liebenberg<sup>2</sup>, J Kirsten<sup>2</sup>

<sup>1</sup>Agricultural Research Council, 1134 Park Street Hatfield Pretoria 0083, South Africa;

<sup>2</sup> Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa

RanchoM@arc.agric.za

### INTRODUCTION

Public investment in agricultural research in South Africa has been declining in inflation adjusted terms over the years. This is a concern given the important role that agricultural research plays in the agricultural industry and the economy. With increasing input prices and decreasing land available for agricultural production, the role of agricultural research in developing better inputs and technologies becomes even more important for ensuring the long-term sustainability of agricultural production. Given that there is tight competition for public funds, to increase public investments in agricultural research requires providing evidence of the benefits derived from agricultural research. Studies have been conducted in South Africa evaluating the economic returns to agricultural research. These studies have been conducted at national, enterprise, institute, crop and project levels across various agricultural industries. With the exception of sweet potato research, no study has evaluated the economic returns to vegetable research investments in South Africa. This study therefore aimed to estimate the economic returns to public vegetable research investments.

### MATERIALS AND METHODS

Secondary data obtained from the Department of Agriculture, Forestry and Fisheries (DAFF) for the period 1980 to 2012 was used. Research investment data was obtained from the Agricultural Research Council-Vegetable and Ornamental Plant Institute (ARC-VOPI) for the period 1980-2012. Other data sources included the South African Weather Service and the Organization of Economic Co-operation and Development (OECD).

The study used a Cobb-Douglas production function with a second order Almond polynomial.

### RESULTS AND DISCUSSION

The economic rate of return to vegetable research was estimated at 39.68%. This rate of return suggests that for every R100 increase in vegetable research investments, the vegetable industry gains R39. The result also indicates an underinvestment in vegetable research.

### CONCLUSIONS

The rate of return implies more potential benefits could be derived by increasing vegetable research investments. Increasing vegetable research investments would allow for research into a broader spectrum of vegetables which will ensure the long term sustainability of vegetable production.

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**Keywords:** Rate of return, vegetable research investments



## EFFECTS OF BT MAIZE ON ENZYME ACTIVITY AND RHIZOSPHERIC MICROBIAL COMMUNITIES

DAB Van Wyk<sup>1</sup>, R Adeleke<sup>2</sup>, OHJ Rhode<sup>3</sup>, CC Bezuidenhout<sup>1</sup>

<sup>1</sup>School of Biological Sciences, North-West University, Potchefstroom 2520, South Africa; <sup>2</sup>Agricultural Research Council-Institute for Soil Climate and Water, Private Bag X79, Pretoria, 0001, South Africa ; <sup>3</sup>Agricultural Research Council-Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520, South Africa

rhodeo@arc.agric.za

### INTRODUCTION

Transgenic Bt maize was one of the most quickly commercialised genetically modified crops all over the world. It has been genetically modified to express the Cry1Ab gene from *Bacillus thuringiensis* (Bt) and produce an insecticidal toxin. These toxin are released into soil via root exudates, pollen, and plant residues and may affect the health of soil and microbial communities. Thus the aim of the study was to investigate the potential effects of Bt-maize on soil enzymes and microbial communities.

### MATERIAL AND METHODS

A total of 30 Bt and 30 non-Bt maize rhizosphere soil samples at 0-15 cm depths were collected from two localities in the North West Province. These localities comprised of fields under irrigation and dryland conventional cultivation where Bt maize had been planted at least for 3 consecutive years. Transgenic Bt maize expressing the Cry1Ab protein (event MON 810) and a near-isogenic non-Bt line were used for study. Soil samples were analysed for enzyme activities that included acid phosphatase,  $\beta$ -glucosidase and urease. An analysis of variance (ANOVA) was performed to study the effects of Bt-maize cultivation on selected soil enzyme activities. Rhizosphere communities were also studied using PCR-denaturing gradient gel electrophoresis (DGGE). Based on DGGE profiles the Shannon-Weaver index of diversity ( $H'$ ) was used to determine the diversity of microbial communities present in Bt and non-Bt maize soil.

### RESULTS AND DISCUSSION

In dryland conditions significantly lower acid phosphatase and glucosidase activities were detected under Bt maize cultivation compared to soils under non-Bt maize production. Irrigated fields showed higher acid phosphatase activities in soils under non-Bt maize cultivation as compared to Bt maize. DGGE results showed no great variation amongst Bt and non-Bt maize banding profiles. The Shannon-Weaver indices demonstrated a greater bacterial diversity associated with irrigated fields under non-Bt maize cultivation.

### CONCLUSIONS

Initial results indicated that cultivation practices might have an influence on rhizospheric soil enzymatic properties. Amongst Bt maize fields under irrigation and dryland conditions there was no difference in bacterial and fungal diversity.

**Keywords:** Bt and non-Bt maize, microbial diversity, soil enzymes

## RESPONSE OF SOIL MICROBIAL ENZYMES IN MAIZE RHIZOSPHERE TO SELECTED CHEMICAL FERTILISER MIXTURES

OHJ Rhode<sup>1</sup>, AA Nel<sup>1</sup>

<sup>1</sup>Agricultural Research Council-Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520

rhodeo@arc.agric.za

### INTRODUCTION

Fertiliser use in modern agriculture has become essential for secure food production globally. The adoption of applying NPK fertilisers in maize production had a significant effect in food production. Nutrition and production of crops cannot be understood by only focussing on fertilisers or the soil, but it is essential to also investigate its biology. As such, the aim of the study was to assess the effect of various chemical fertilisers on the soil microbial enzyme activity and grain yield in South African maize production.

### MATERIALS AND METHODS

A maize field trial was conducted in Potchefstroom at ARC Grain Crops Institute Research Station under no-till conditions. Treatments consisted of six fertiliser combinations that were selected based on a prior potting experiment, according to combinations which performed best with regards to microbial activity and plant biomass production. These treatments comprised of (1) control without any fertilisers (NPK) applied, (2) ammonium solution, (3) ammonium sulphate and potassium sulphate, (4) ammonium sulphate and potassium sulphate and mono-ammonium phosphate (MAP), (5) limestone ammonium nitrate (LAN) and potassium sulphate and (6) superphosphate and potassium sulphate. Recommended optimal application rates calculated for a plant population of 20 000 plants ha<sup>-1</sup> were applied. Fertilisers were applied as follows: N at 95 kg ha<sup>-1</sup>, P at 12 kg ha<sup>-1</sup> and K at 8 kg ha<sup>-1</sup>. A randomised complete block design was used and replicated four times. Rhizosphere soil samples collected at day 90 were subjected to microbiological tests that included enzyme assays viz.  $\beta$ -glucosidase, phosphatase and urease. An analyses of variance (ANOVA) was performed to determine significant effects of fertiliser combination on these enzyme activities and grain yield.

### RESULTS AND DISCUSSION

Fertiliser type combinations had no significant effect on  $\beta$ -glucosidase and phosphatase activities. However, urease activity in the ammonium solution treatment was significantly higher compared to LAN and potassium sulphate fertiliser combinations. Application of LAN /potassium sulphate and ammonium sulphate fertiliser combinations gave significantly higher maize yields compared to the sole application of ammonium solution.

### CONCLUSION

The results showed that only urease activity was significantly more responsive to the fertiliser treatments. Soil microbial enzymatic activities and grain yield was affected by chemical fertiliser mixture interaction.

**Keywords:** enzymatic activity, maize, NPK, soil microbes

## HARVESTING FREQUENCY OF TWO AMARANTH SPECIES UNDER DIFFERENT WATERING REGIMES DURING THE HOT SEASON IN SOUTHERN MOZAMBIQUE

JEMM Ribeiro<sup>1,2</sup>, PJ Pieterse<sup>1</sup> and SI Famba<sup>2</sup>

<sup>1</sup>Dept of Agronomy, Stellenbosch University, Private Bag X1, Matieland 7602; <sup>2</sup>Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University, Mozambique

jemmribeiro@tvcabo.co.mz

### INTRODUCTION

The South of Mozambique is characterized by a dry semi-arid climate. Drought tolerant crops with high nutritional value, such as amaranths, may play an important role to improve the nutritional status of rural communities in the area. In Mozambique, the amaranth species are not widely cultivated but they are protected and collected regularly in the forest and in cultivated fields. The frequency of leaf cutting and the time period that plants can tolerate water deficit, without a significant reduction in yield, are important parameters that may be managed to increase the number of leaves and shoots, and leaf yield. This study was planned to assess the effect of different harvesting frequencies on amaranth production under different watering regimes.

### MATERIAL AND METHODS

A field trial was conducted in Maputo city between 15 January and 24 March 2014. The treatments consisted of two species of amaranths, three watering regimes and two levels of leaves harvesting frequencies, in a randomised complete block experimental design with a 2x3x2 factorial arrangement. The amaranths species used were the *A. hybridus* and *A. tricolor*, the three levels of watering regimes included, (i) irrigated at 80% of available water (AW), (ii) irrigated at 50% AW, (iii) rainfed, and the two levels of leaf harvesting frequencies were, (i) every two and (ii) every three weeks. The soil water content at 0-20 and 20-40 cm was measured using a Time Domain Reflectometer (TDR) HydroSense II. Leaf and side shoot numbers, leaf area, as well as leaf yield were determined at each harvest.

### RESULTS AND DISCUSSION

The total amount of water recorded (irrigation plus rainfall) during the trial period for different water level treatments of 80% AW, 50% AW and rainfed cropping, were 632.5 mm, 536.7 mm and 497.6 mm respectively. The leaf yield was affected by the interaction of water regime and species. Though, the leaf yield of *A. hybridus* was not affected by water regime. No significant effect was observed on leaf number. The side-shoots number was affected by harvesting frequency and the leaf area was affected by all the three factors (water, harvest frequency and species).

### CONCLUSIONS

This study shows that the *A. hybridus* is a promising crop under rainfed conditions in the dry semi-arid climate of southern Mozambique.

**Keywords:** harvesting frequencies, water treatments.

## USING MIDDAY STEM XYLEM WATER POTENTIAL TO OPTIMIZE IRRIGATION NORMS FOR MACADAMIA – PRELIMINARY RESULTS

NJR Roets<sup>1</sup> and SP Schoeman<sup>2</sup>

<sup>1</sup>ARC – Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit, 1200; <sup>2</sup>Soetkalmoes Consultation, P.O. Box 44, Schagen, 1206

nico@arc.agric.za

### INTRODUCTION

Plant-based measurements are used to determine water requirements and irrigation norms for tree crops. Midday stem xylem water potential (SXWP) was shown to be a reliable indicator as it was highly correlated with other physiological parameters as well as yield and fruit size. The aim of the current study was to determine if midday SXWP can be used to calibrate current soil-based measurements for irrigation scheduling in macadamia.

### MATERIALS AND METHODS

The trial was carried out in the Nelspruit area on 6-year-old macadamia trees of the cultivar HAES 695 ('Beaumont') planted at a density of 350 trees/ha on a sandy soil. For the physiological measurements, five trees were selected and four leaves per tree were measured for photosynthetic rate, transpiration rate, stomatal conductance (ADC Bioscientific LCpro-SD IRG analyser) and SXWP (PMS Instrument pressure chamber). These measurements were taken at midday. In addition, diurnal SXWP measurements were also carried out and soil water content determined. Photosynthetic rate, transpiration rate, stomatal conductance and soil water content were correlated with midday SXWP.

### RESULTS AND DISCUSSION

In order to be used as an indicator to calibrate irrigation norms, midday SXWP must correlate significantly with the physiological parameters measured and be stable at midday. Midday SXWP correlated highly significantly with stomatal conductance ( $r^2 = 0.90$ ) and significantly with transpiration rate ( $r^2 = 0.66$ ) and soil water content ( $r^2 = 0.69$ ). These results further showed that optimal transpiration and stomatal conductance is at SXWP of approximately -0.4 MPa, which was selected as a preliminary optimal norm. No significant correlation could be found with photosynthetic rate ( $r^2 = 0.02$ ). Diurnal data showed that SXWP stabilized from approximately 10 am until 2 pm.

### CONCLUSION

The high correlations obtained between midday SXWP and transpiration, stomatal conductance and soil water content and the fact that SXWP stabilized during midday, qualify this parameter to be used as a physiological indicator to optimize the irrigation norms of macadamia.

**Keywords:** Photosynthesis, stomatal conductance, transpiration, stem xylem water potential

**YIELD AND QUALITY RESPONSE OF HYDROPONICALLY GROWN ROSE GERANIUM  
(*Pelargonium graveolens* L.) TO SHADING AND MOISTURE STRESS**

MM Sedibe

Central University of Technology, Free State, Private Bag x20539, Bloemfontein 9300

msedibe@cut.ac.za

**INTRODUCTION**

Most greenhouse growers in South Africa use lime or removable paints to reduce radiation in greenhouses and in plastic tunnels due to the high natural radiation levels. More expensive structures with light reflecting screens (nets) are also used to reduce light intensity for high-income crops (Combrink, 2005). Although, rose geranium plants grow well under full sunlight in summer, lower light intensities may be beneficial to improve plant growth and yield. Relatively high radiation levels occur in South Africa during summer months, and some hydroponically grown crops may need shading for optimum production. The aim of this study was to evaluate yield and quality response of rose geranium to shading and moisture stress.

**MATERIALS AND METHODS**

A split plot layout was assigned in randomized complete block experimental design. Treatment of 0%, 20%, 40%, 60% and 80% shading were allocated to the main plots, while subplots were exposed to two moisture stress levels (0 and -0.15 MPa of osmotic pressure).

**RESULTS AND DISCUSSION**

The results show that rose geranium performs well when grown under 40% shade, where the number of branches, foliar fresh and dry mass, branch:height ratio as well as the oil yield peaked. Proline content was significantly higher at a low level of shading, where high levels of radiation were found, and where moisture stress was applied, moisture stress did not, however, affect any of the quality parameters measured for rose geranium oil. Most of the chemical substances produced at 40% shading level were at acceptable levels for good oil quality.

**CONCLUSIONS**

Plant height, number of branches, foliar mass, the ratios of branches to plant height, oil yield and oil quality parameters were affected by both shading and moisture stress. Proline gave a clear indication when stress conditions occurred. Rose geranium should not be subjected to moisture stress or high light intensities. Rose geranium need to be grown under shade in summer.

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**Keywords:** Proline, radiation, rose geranium, shading.

## USING CUCURBITACIN B LEVEL IN *CUCUMIS AFRICANUS* FOR ESTABLISHING THE HARVESTING TIME

KG Shadung<sup>1</sup>, PW Mashela<sup>2</sup>, MS Mphosi<sup>1</sup>, LV Mulaudzi<sup>3</sup>, I Ncube<sup>4</sup>

<sup>1</sup>Limpopo Agro-Food Technology Station, <sup>2</sup>Department of Plant Production, Soil Science and Agricultural Engineering, <sup>3</sup>Department of Chemistry, <sup>4</sup>Department of Biochemistry, Microbiology and Biotechnology, University of Limpopo, Private Bag X1106, Sovenga 0727, South Africa.  
kagiso.shadung@ul.ac.za

### INTRODUCTION

Wild watermelon (*Cucumis africanus*) in the Cucurbitaceae Family, is known for its cucurbitacins, used in ethnomedicines, ethnopesticides, ethnonematicides and nematode-resistant rootstocks. Generally, the concentration of secondary metabolites in organs are depended on the developmental stage of the organ in each they are compartmentalised. In terms of the level of cucurbitacins in fruits, the harvesting time is not documented. The objective of this study was to determine whether harvesting time of *C. africanus* fruit will have an influence on concentrations of cucurbitacin B.

### MATERIAL AND METHODS

A field trial was initiated at the University of Limpopo, South Africa. At two-leaf stage, seedlings were hardened off for 5 days and transplanted, with irrigation being once every other day. Treatments, viz., 60, 67, 74, 81, 89, 96, 103 and 110 harvesting days after transplanting, were arranged in randomised complete block design, with 12 replications. Eight fruits of *C. africanus* were harvested weekly, cut into pieces, dried at 52°C for 72 h in an air-forced oven and ground in a Wiley mill to pass through a 1-mm-pore sieve. For extraction, 4 g dried crude extracts of fruit were mixed with 50 ml methanol and dichloromethane each and allowed to run for 4 h on a waterbath at 40 °C at 45 rpm (Rotary Evaporator). After extraction, sub-samples were homogenised by reducing the volume to 30 ml and then 1 ml centrifuged at 4500 rpm for 10 minutes before filtering through 0.22 µm-pore filter (Miller, Sigma). Concentrations of cucurbitacin B were quantified using the gradient HPLC Prominence 20.

### RESULTS AND DISCUSSION

Harvesting time contributed 73% total treatment variation in cucurbitacin B concentration, with the depended (y-axis) and independent (x-axis) variables having had significant ( $P \leq 0.05$ ) quadratic relationships. The quadratic relationship model explained 79% of the observed variation in cucurbitacin B. Using the optimisation relationship ( $x = -b_1/2b_2$ ) from the quadratic equation, cucurbitacin B was optimised at 5.24 weeks after first harvest.

### CONCLUSION

This study showed that *C. africanus* fruit have optimum cucurbitacin B concentration at 5.24 weeks after first harvest and should therefore not be left lying in the field after this period.

### ACKNOWLEDGEMENT

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*Keywords:* Cucurbitacin, extraction, phytonematicides, nematodes

## SCREENING OF SINGLE CROSS MAIZE (ZEA MAYS L.) HYBRIDS FOR DROUGHT TOLERANCE

S Shandu<sup>1</sup>, P Makhumbila<sup>1</sup>, K Mashingaidze<sup>1</sup>, EN Ndou<sup>1</sup>, L Sere<sup>1</sup>

<sup>1</sup>ARC-Grain Crop Institute, Private Bag 1251, Potchefstroom 2520

ShanduS@arc.agric.za

### INTRODUCTION

Maize is a largely consumed staple crop in Sub-Saharan Africa. Drought is a major abiotic factor limiting maize production. To mitigate the effect; developing and delivering drought tolerant varieties to farmers is the principal key. The objective of the study was to evaluate maize single cross hybrids for drought tolerance.

### MATERIALS AND METHODS

Advanced Maize inbred lines were crossed to a single tester to generate single cross hybrids. A total of 56 single cross hybrids were generated and evaluated at three locations, namely; Potchefstroom, Taung and Cedara under two environments (optimal and random drought). The experiment consisted of 56 single cross hybrids and four checks. The trial was laid out in a (0, 1) alpha lattice design with two replicates. The data was analysed using GenStat 17<sup>th</sup> edition, Least Significance Differences (LSD<sub>0.05</sub>) were used to compare differences between treatments.

### RESULTS AND DISCUSSION

There were significant differences ( $P < 0.005$ ) between environments, sites and hybrids in terms of grain yield. Under optimal environment, Cedara had the highest grain yield (14.4 tons/ha) than Potchefstroom (7.4 tons/ha). The highest grain yield under random drought was recorded at Taung (5.0 tons/ha) than Potchefstroom (3.8 tons/ha). Among the hybrids evaluated, one hybrid ranked consistently across sites and environments. Heritability was medium under both optimal (0.45) and random drought (0.4), implying that inheritance of tolerance to drought is equal under both environments. Therefore, selection process is effective under both random drought and optimal environments.

### CONCLUSIONS

Eight single cross hybrids were identified superior for drought tolerance. These selected single cross hybrids will be subjected to further evaluations in multiple locations and environments before being considered for release. The most superior hybrids will then be released for drought tolerance.

**Keywords:** grain yield, heritability

## IMPROVEMENT OF INTEGRATED PLANT HOST RESISTANCE TO PESTS IN AGRICULTURALLY IMPORTANT CROPS: A REVIEW

TN Sikhakhane<sup>1</sup>, CC Dweba<sup>1</sup>, T Hlongoane<sup>1</sup>, T Baloyi<sup>1</sup>, A. Jankielsohn<sup>1</sup> and TJ Tsilo<sup>1</sup>  
<sup>1</sup>ARC - Small Grain Institute, Private Bag X29, Bethlehem, 9700, South Africa  
tn.mboma@gmail.com

### INTRODUCTION

Various insect species are major pests in agriculture and many have been mainly controlled through the use of insecticides. Alternative means of insect control are needed because of environmental concerns and negative effects of pesticides on beneficial organisms such as pollinators, decomposers and insect predators. Host plant resistance is one of the most effective forms of insect control and offers a very good alternative. Numerous plant-derived resistance (R) genes have already been characterized and are being efficiently used in crop improvement research programs, for example the tobacco *Mi-1.2* gene cloned into tomato against aphids and nematodes. Benefits of using the plant-derived genes in resistance breeding programs include the efficient reduction of pest population growth, minimal damage to the host plant, zero input of pesticides from the farmers and most importantly the environment friendly nature of such crops. Since the introduction of genes conferring pest resistance from wild species into commercial genotypes by classical breeding methods is a tedious process, genetic engineering techniques, using high-throughput molecular tools, have become routine in several laboratories and provides an opportunity to modify and improve selected genotypes for important agronomic traits, such as insect pest resistance, within a short period of time. The aim of this review is to document the importance of increasing the scope of mapped and sequenced plant-derived genes in different agriculturally important crops. This will aid in increasing the yield and quality of such crops.

### PROBLEM IDENTIFICATION

The majority of plant-derived insect resistance genes that have been mapped, have not yet been sequenced, as is with several wheat *Dn* genes against the Russian wheat aphid (Tolmay *et al.* 2007; Nkongolo *et al.* 1991).

### CONCLUSION AND RECOMMENDATIONS

Since most of the plant-derived insect resistance gene sequences are still not fully known, it is important to understand and improve the functional mechanism of resistance genes across different species by collecting adequate reference sequences from resistant hosts in order to use as models for resistance. This will aid in the development of molecular markers and enhance marker-assisted breeding in order to introduce resistance traits into a wider range of economically important agricultural crops.

**Keywords:** cloning, high-throughput molecular tools, insect pest resistance, integrated pest management (IPM)



## CHEMICAL INSECTICIDE USE AND HANDLING BY SOME RURAL FARMERS IN THE EASTERN CAPE: A CASE STUDY OF MAIZE PRODUCING FARMERS

NL Skenjana<sup>1</sup> & A Afolayan<sup>2</sup>

<sup>1</sup>Döhne Agricultural development Institute, Private bag X 15, Stutterheim, 4930; <sup>2</sup>Department of Botany, Faculty of Science and Agriculture, Private bag x 1314, Fort Hare University, Alice, 5700

Nolitha.Skenjana@drdar.gov.za

### INTRODUCTION

Majority of small-scale farmers use chemical insecticides to manage pests of maize in the Eastern Cape Province (Skenjana, 2014; Odeyemi *et al.*, 2006). Their use, handling and application of these chemicals has not been recorded, hence this study

### MATERIALS AND METHODS

A total of 217 small-scale maize producing farmers were interviewed using semi-structured but detailed questionnaires during July – November 2012, focussing mainly on methods employed by farmers to manage insect pests of maize. Information on the details regarding the chemical insecticides used such as the name of the product, preparation methods employed, mode of application, intervals between applications and where the product was applied on maize plant was collected. Data collected were analysed using descriptive statistical methods.

### RESULTS AND DISCUSSION

Eleven (11) chemical insecticides were mentioned by participants, and were further classified according to their active ingredients and chemical action groups. The most cited chemical ingredient was carbaryl, from the carbamate family. When further ranked according to the World Health Organisation (WHO) classification of hazardous chemicals (WHO, 2010), it was found that 2 chemical insecticides were highly hazardous, 7 moderately hazardous and 2 slightly hazardous. Four insecticides (i.e. carbaryl, carbaryl/permethrin, mercaptothion and cypermethrin) mentioned in the study areas, had also been previously reported as chemicals used by maize farmers in rural areas of KwaZulu-Natal (Sibiya *et al.*, 2013). Only 7.7 % of farmers indicated preparing insecticides according to the instructions on the label. The majority were either mixing insecticides with other insecticides, mixing insecticides with substances such as detergents and powdered laundry soaps or with plant extracts. Most insecticides were prepared and applied without the use of protective clothing and majority of farmers were using bare hands to apply insecticides on plants. The findings in this study are not unique as Plianbangchang *et al.* (2009) had reported the same in studies conducted Thailand and Jørs *et al.* (2006) in Bolivia.

### CONCLUSIONS

The study indicates that most farmers neglected the recommended preparation and application procedures of chemical insecticides. Proper training should be provided so as to provide awareness on the potential hazards of chemical insecticides to their health and the environment.

**Keywords:** chemical insecticides, handling, farmers, hazard

## EFFECT OF ONCE-OFF TILLAGE ON CUMULATIVE CO<sub>2</sub> EMISSION IN LUCERNE/CASH CROP SYSTEMS

JDV Smith<sup>1</sup>, J Labuschagne<sup>1</sup>, W Langenhoven<sup>1</sup>

<sup>1</sup>Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607

jacquess@elsenburg.com

### INTRODUCTION

Scientifically tested information on the effects of different tillage management strategies before planting no-till cash crops, following long-term permanent pastures, is not available. Natural stratification of macronutrients and soil organic carbon (SOC) in surface layers of no-till systems is a well-known phenomenon. Applying a once-off tillage operation should "break up" typical stratification but the long-term consequences regarding its effect on soil quality is rather controversial. Since SOC is strongly correlated with soil quality and productivity, the aim of this study was to investigate if significant short-term carbon (C) losses (CO<sub>2</sub> emission) occur following once-off tillage.

### MATERIAL AND METHODS

This study was conducted at the Tygerhoek Research Farm (Riversonderend, Overberg). Three tillage treatments were investigated on a loamy sand Klapmuts soil form: no-tillage (Ausplow, NT); non-inversion tillage (deep tine ~ 400 mm) (DT) and inversion tillage (mouldboard plough) (MP). Tillage was done early May before wheat was planted after a 12-year lucerne stand. Cumulative CO<sub>2</sub> respiration (28 days) was estimated twice during season using Soda-lime method. First trial was carried out 4 weeks after tillage treatments (June/July) and the second trial followed in September/October. Before tillage, total SOC and nutrient content were determined in 5 depth increments (0-5; 5-10; 10-20; 20-30; 30-40cm).

### RESULTS AND DISCUSSION

Cumulative CO<sub>2</sub> emissions in the June/July period were significantly higher for DT while for NT and MP it was similar. Low soil temperatures constrain microbial activity and therefore it is expected that increased soil microbial decomposition is located mostly in the surface layer where temperature is least limiting. Deep tine, not inverting the high SOC surface layer, further enhanced CO<sub>2</sub> emissions as it aerates the surface soil extensively. With MP, similar emissions compared to NT were recorded although soil was most likely more aerated. The highly SOC stratified soil that was inverted, could have resulted in lowering the SOC content in surface layer which lead to lower microbial activity and CO<sub>2</sub> emission compared to DT. In the September/October period, CO<sub>2</sub> emission increased for NT and MP but decreased for DT. No significant differences between treatments were found but MP was marginally higher. More favourable soil conditions e.g. higher temperatures in deeper layers could have allowed higher microbial activity throughout soil profile. This means SOC that was inverted with MP is probably now more utilized by microbes. Carbon emissions due to physical nature (aeration) are also now less noticeable in this period. The increase observed for NT and MP is thus mainly of biological nature while the decrease observed for DT is attributed to a more "steady" physical state of the soil.

### CONCLUSIONS

Preliminary results suggest that natural stratification of macronutrients and SOC in long-term pasture systems can be successfully amended through a once-off MP operation. Short-term losses of SOC with the MP were similar to NT, indicating no significant short-term loss in soil quality. Higher C losses can be expected with DT but it remains a viable option to amend physical limitations (e.g. compacted soil layer). More data is however required to make final recommendations.

**Keywords:** Carbon stratification, CO<sub>2</sub> emission, once-off tillage

## SCREENING FOR POSSIBLE COVER CROPS IN THE WESTERN CAPE

LT Smorenburg<sup>1</sup>, PJA Lombard<sup>1</sup>, JA Strauss<sup>1</sup>

<sup>1</sup>Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607

lisas@elsenburg.com

### INTRODUCTION

Soil improvement benefits from cover crops are well documented within conservation agriculture; although the concept is relatively new in the Western Cape grain producing region. The aim of this study was to identify single crops and mixtures of crops to use as cover crops within existing crop rotations.

### MATERIALS AND METHODS

A screening trial was conducted at Riversdale in the Western Cape during 2013 and 2014. In 2014 a second trial was planted in the Caledon district. The following crops were used in the study: rye, black oats, vetch, bitter lupines, field peas, mustard, serradella and barley. The trials consisted of eight crops and 12 mixes, with up to three different crops in a single mix. It was planted in a randomised complete block with 3 replications. The bio-mass was determined before seed-set in September. The trials were terminated following the biomass data was obtained and material left on the soil as residue cover. Statistical analysis was done using SAS. The ANOVA and t-test was used to determine differences at the 95% confidence level.

### RESULTS AND DISCUSSION

In 2013 a single crop and two mixes showed the highest bio-mass production, namely. These were field peas (10.37 ton ha<sup>-1</sup>), black oats x serradella (8.65 ton ha<sup>-1</sup>) and barley x vetch mix (8.38 ton ha<sup>-1</sup>). In 2014 at Riversdale the highest bio-mass producers were black oats x vetch (11.23 ton ha<sup>-1</sup>), black oats x serradella x field peas (10.6 ton ha<sup>-1</sup>) and rye (10.52 ton ha<sup>-1</sup>). At Langhoogte (Caledon) the best producers were black oats (13.72 ton ha<sup>-1</sup>), rye (12.02 ton ha<sup>-1</sup>) and rye x serradella (10.49 ton ha<sup>-1</sup>). In the combined data the best overall producer were black oats, rye and the mix of black oats x vetch. It was expected that the grass crops would show the highest bio-mass production, but from the overall results of the trials it appears that combinations of grass and legume crops also performed well. The results also indicated that any legume crop works well when shown in a mix with rye.

### CONCLUSIONS

As a single crop black oats might be the best option high bio-mass production, but mixes with rye and legumes may be the best for soil health. The trial indicated that the choice of crop or mixes might differ from area to area

**Keywords:** bio-mass, conservation agriculture

## CASH CROP YIELD RESPONSES TO SHORT CROP ROTATION SYSTEMS

JA STRAUSS & W LANGENHOVEN

<sup>1</sup>Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607

johannst@elsenburg.com

### INTRODUCTION

The southern Cape production region has been dominated by long rotation cropping sequences, consisting of 5 to 6 years of lucerne pasture followed by a cash crop sequence. Shortened crop and/or pasture rotations were introduced through a long-term conservation agriculture trial. The aim of this study was to look at the yield responses of wheat, barley and canola within these shortened rotations.

### MATERIALS AND METHODS

Crop yields of wheat, barley and canola were determined for a period of 5 years (2009 to 2013). The trial consisted of pasture/crop rotation designs; PPC, PPCC, PCPC and two pure cash crop rotation designs, CCCC and CCCCCC (where P = pasture and C = cash crop), with different crops in each design resulting in different rotation systems. The random block design has 2 replicates. Wheat was produced in 13 systems with 16 different crop sequences; barley was produced in 4 systems with 5 different crop sequences and canola in 4 unique systems. The trial has been running continuously since 2002. Data was analysed using SAS. The ANOVA and t-tests were used to determine statistical differences between years, systems and sequences.

### RESULTS AND DISCUSSION

Yield in the two cereal crops showed similar trends in annual production with 2009, 2010 and 2013 showing significantly lower production than 2011 and 2012. This differed in canola production, which showed 3 clearly distinct groupings with 2011 showing significantly higher production than all other years. In wheat the pasture/canola/pasture/wheat system showed the best overall results and differed significantly from 7 of the 13 systems in which wheat was planted. Where wheat followed lupin in the cropping sequence the yield was significantly higher than following canola. Barley produced the best results in the three year sequence (pasture, pasture, barley) and was significantly higher than production in the pure cash crop sequences. Canola yields were the highest in the 6 crop sequence, but only differed significantly from the canola produced in the 4 crop sequence. Canola and wheat produced in the wheat/canola/wheat/lupin system was the lowest yielding for both crops. Of all three crops wheat showed the more stability in production over years. Variation between the highest and lowest yields in wheat and canola was more pronounced by season.

### CONCLUSIONS

Short rotations are a viable option in the southern Cape. It was clear from the data that the production year played a significant part in production. Of the three crops tested, wheat showed the most stable yield over years. All though certain crop sequences had an effect on the yield of the three different crops, the distinction was not clear enough to promote one sequence over another, but rather promoting the effect of rotation as is part of conservation agriculture.

**Keywords:** yield, conservation agriculture, cash crop, pasture

**SUSTAINABLE INCOME GENERATION OPPORTUNITIES THROUGH COMMERCIAL CULTIVATION OF *SUTHERLANDIA FRUTESCENS* AND *MORINGA OLEIFERA* IN SOUTH AFRICA**

B. Taruvinga<sup>1</sup>, P. Ndou and C.P. du Plooy  
Agricultural Research Council – Rooderplaas, Vegetable and Ornamental Plant Institute (ARC-VOPI),  
Private Bag X293, Pretoria 0001, South Africa.

TaruvingaB@arc.agric.za

**INTRODUCTION**

Historically, harvesting of wild plants for medicinal purposes was confined to traditional medical practitioners (traditional healers), mostly in rural areas (Tshisikhawe, 2012). Harvesting of medicinal plants has changed over the years, people who are not necessarily traditional healers are now involved in harvesting and selling medicinal plant material (Botha *et al*, 2004). As a result, an increasing number of people now perceive trade in medicinal plants as important source of income (Williams *et al*, 2000; Magoro, 2008). The challenge facing the medicinal plant sector is that the majority of traders depend on wild sources, and as the traded volumes increase, the natural resource base is threatened and cannot be sustainably used to generate income. In order to address this challenge, commercial production of medicinal plants is advocated. This study seeks to determine the economic viability of commercial cultivation of 2 medicinal plants (*Sutherlandia frutescens* and *Moringa oleifera*).

**MATERIALS AND METHODS**

Gross margin (GM) analysis was employed to determine the economic viability of the 2 medicinal plants. GM involves calculating the financial gains of an enterprise after deducting running costs, for a period of time. Data for calculating gross margins was collected from literature and trials conducted and compared at ARC-VOPI with the intention to evaluate good agricultural practices for these medicinal plants. Production and operational expense records that were captured on a regular basis during the course of the production trials were utilized. An average yield attainable per hectare of the cultivated plant was used to determine the financial output of an enterprise. To calculate GM value, a sum of variable costs were deducted from the financial output.

**RESULTS AND DISCUSSION**

The gross margins per hectare were R1 110 702.27 for *Moringa oleifera* and R28 432.36 for *Sutherlandia frutescens*. These gross margin values indicate that commercial production of the two medicinal plants is profitable.

**CONCLUSION**

Based on the gross margin values presented in this report, it is concluded that commercial production of *Moringa oleifera* and *Sutherlandia frutescens* is economically viable. Medicinal plant enterprises stand a chance to be a sustainable development intervention that has the potential to generate income for participating households.

**Keywords:** medicinal plants, gross margin, enterprise, income

## USING ANCIENT AND RECENT SOIL PROPERTIES TO DESIGN A CONCEPTUAL HYDROLOGICAL RESPONSE MODEL FOR AN ARID REGION

M. Tinnefeld<sup>1\*</sup> and P.A.L. le Roux<sup>1</sup> J.J. van Tol<sup>2</sup>

<sup>1</sup>Department of soil, crop and climate Science, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa

mtinnefeld@gmail.com

### INTRODUCTION

A hillslope conceptual hydrological response model is a depiction of the vadose zone hydrological system, including soil morphological flowpath indicators, distributed along a hillslope, with a layout of soil properties and distribution patterns, underlying geology and qualitative hydrological inputs/outputs of the hillslope.

### MATERIAL AND METHODS

Morphology, chemistry and topography are used to indicate, and hydrometrics used to quantify flowpath and storage mechanism distribution within horizons, soil bodies and hillslopes. Morphology linked to flowpath and storage mechanisms, is done via conspicuous properties such as colour, physical properties such as texture and structure, macropore distribution and carbonate precipitation, and chemical properties such as pH and base saturation.

### RESULTS AND DISCUSSION

Soil and hillslope response of select arid soils and soilsclapes is mainly of soil recharge, resulting in soil rock interflow with slope and ponding, resulting in carbonate precipitation on low slope and flat topography. Flood plains see an increase in clay, resulting in responsive hillslope-segment response. Backslopes show increase in clay, indicating process of luviation- and increase in carbonate -deposition, due to the ponding of water. Soil crusts < 1 mm, with either a medium to hard laminar structure, result in a reduction of the immediate below lying ot horizon macroporosity conducting flux by an average of 14.59% with standard deviation of 75.21%. Total profile  $\phi_{-0.10-3}$  (%) is reduced by 10.51% with a standard deviation of 7.43%. Overall high to very high saturated hydraulic conductivities are observed, with exception of floodplains.

### CONCLUSIONS

Application of conspicuous morphological properties as flowpath indicators, are suitable to conceptualize the hydrology of arid soils.

### ACKNOWLEDGEMENTS

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**Keywords:** Hydrology, arid hdropedology, conceptual hydrological response, morphological indicators

## ECONOMIC RATE OF RETURN OF PRUM RESEARCH IN SOUTH AFRICA: THE ROLE OF BREEDING RESEARCH IN CLIMATE ADAPTATION

Tshabalala Precious M.<sup>1,2</sup>, Liebenberg Frikkie<sup>1</sup> and Kirsten Johann<sup>1</sup>

<sup>1</sup>University of Pretoria, Private bag X20 Hatfield, 0028, Pretoria, <sup>2</sup>Agricultural Research Council, P.O Box 8783, Pretoria, 0001

TshabalalaP@arc.agric.za

### INTRODUCTION

The South African plum industry has been transformed from using exported cultivars to using modern technologies adapted for the country's climatic conditions through research made at the Agricultural research Council. Since government has continued to decrease funding, it is necessary to provide evidence of the benefits of past investments.

### MATERIALS AND METHODS

The production function approach was used to determine the rate of return to research. It expresses production output as a function of inputs; which includes conventional inputs, non-conventional inputs and the stock of knowledge (e.g. investments in R&D). It is assumed that investment in research creates technical changes which increase production and/or productivity. Because these changes have a considerable time lag attached to them, time series data are required. The equation used is given as follows:

$$LQ_t = L\beta_0 + L\beta_1W + L\beta_2F + L\beta_3A + \sum_{i=1}^n \beta_j LRD_{t-i} + u_t$$

The data were regressed on Eviews 8.

### RESULTS AND DISCUSSION

The variation in plum production is explained by changes in fertilizer use, area and RD. A second degree polynomial with both near and far end of the distribution constrained to zero found a ten year lag. With research investments made today having an impact for ten years. The effect of research on productivity was found to be small in the first years, but because with time more producers have access to research results for adoption, the effect to productivity increased. However, when a longer period elapsed, the impact of the improvement decreased, a phenomenon known as diminished returns. There is no lead time with R&D having an impact in the current year. The model suggests that a one percent increase in the use of conventional inputs results in a 0.87 percent increase in industry output and a one percent increase in the area planted will increase the industry output by 2.0976 percent. In order to convert the output quantity into output value, the elasticities were converted into value of marginal products to give a marginal internal rate of return of 14.23 percent. This figure suggests that for every R100 increase in R&D investment, industry output increases by R14.23.

### CONCLUSIONS

The results of this study imply that research and development efforts for plums were beneficial to the industry. For the industry to be sustainable whilst adapting to the climate changes, more investments should be made towards plum research.

**Keywords:** Adaptation, plum research and rate of return

## THE EFFECT OF PLANTING DATE ON THE DRY MATTER PRODUCTION OF ITALIAN AND WESTERWOLDS RYEGRASS IN THE SOUTHERN CAPE

PR Botha<sup>1</sup>, LB Zulu<sup>1</sup>, J. van der Colf<sup>1</sup>, PA Swanepoel<sup>1</sup>

<sup>1</sup>Outeniqua Research Farm, Directorate: Plant Sciences, Western Cape Department of Agriculture, PO Box 249, George 6530, South Africa

JankeVdC@elsenburg.com

### INTRODUCTION

Perennial pasture species such as lucerne, kikuyu, perennial ryegrass and perennial clovers make an important contribution to the fodder flow programmes for dairy production in the southern Cape. One of the main challenges when these species make up the primary pasture base within a pasture system, is the mutually low growth rates during winter. In order to bridge pasture shortages during the critical winter months of June, July and August, producers establish annual Italian and Westerwolds ryegrass in pure swards, mixtures or as crops over-sown into perennial pastures. These annual varieties have different physiological vernalisation requirements for flowering, which could impact on best management strategies regarding planting dates. The aim of this study was to determine the pasture production potential of Italian and Westerwolds ryegrass planted at different planting dates

### MATERIALS AND METHODS

Four cultivars were selected for each annual ryegrass variety and planted successively at monthly intervals over two years. Plots were cut at an approximate interval of 28 days or when the growing points of grasses were being over-shadowed.

### RESULTS AND DISCUSSION

Planting date influenced the production potential of Italian and Westerwolds ryegrass. When planted between December and June, Italian ryegrass had the potential to remain productive for longer periods and achieve a higher total production than Westerwolds ryegrass. If fodder is required for the critical winter months of June, July and August, Italian ryegrass should be planted during February and March. Spring and early summer production between September and December is optimised by planting Italian ryegrass during May or June.

### CONCLUSION

Regardless of the variety, planting ryegrass later than June will result in short production periods and low total production. Unless the aim is to provide short term ryegrass pasture, Italian ryegrass is a more productive variety in the southern Cape, based on growth rate and total production.

**Keywords:** pasture, fodder flow, *Lolium multiflorum*, production potential



## **A NATURAL RESOURCE AUDIT CONTRIBUTING TO THE AGRICULTURAL MASTER PLAN FOR THE FREE STATE PROVINCE**

M van der Walt<sup>1</sup>, JP Carstens<sup>1</sup>, JL Schoeman<sup>2</sup>

<sup>1</sup>ARC-Institute for Soil, Climate and Water, Private Bag X79, Pretoria, 0001; <sup>2</sup>Pedoplan International Consultants, 247 Knysna Avenue, Sinoville, 0182

marjan@arc.agric.za

### **INTRODUCTION**

The development of an Agricultural Master Plan (AMP) for the Free State Province is directly in support of Government's Planning Commission linking to the Department of Economic Development and the specific role of agriculture, in terms of the national economic growth path, for rural development. It will underpin Government's rural development policy in terms of the following three main elements: (1) optimization of land and agrarian reform for food security, (2) economic empowerment of economically vulnerable groups, and (3) the required economic, environmental and human development inputs.

The Natural Resource Audit forms part of Phase 1: the Development of a Decision Support System and an Enabling Environment.

### **MATERIAL AND METHODS**

The project commences with one or more Inception Workshops during which the aims and process will be explained. This is followed by a thorough Situation Analysis, identifying agricultural stakeholders and their roles, and developing a natural resource, environmental and infrastructure dataset, the credibility of which will be tested through expert consultation during workshops. An Information Library is thus created. Finally, an Institutional Analysis will form an integral part of recommendations in terms of an enabling environment. All the data and information will be supplied to the Free State Department of Agriculture and Rural Development (DARD) to be included in an integrated spatial agricultural decision support system accessible on the Internet through SPISYS.

### **RESULTS AND DISCUSSION**

Maps and a spatial database comprising infrastructure, natural resource related information (on soils and climate), socio-economic information, interpreted information (including crop suitability, livestock carrying capacity and environmental information) were supplied together with an overview of the availability and quality of water for agriculture. The outcomes of these were summarized in a table per local municipality.

An Information Library provides a detailed representation of agricultural content related to the Free State Province.

### **CONCLUSIONS**

The Natural Resource Audit as part of the AMP will be supporting the Free State DARD's alignment with the Provincial Growth and Development Strategy (PGDS), Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs). It will assist the Free State Provincial Treasury in the application of scarce resources for unlocking development and in decision making regarding the allocation of funding.

**Keywords:** land suitability, economic planning strategy, sustainable rural development

## STRATIFICATION OF NUTRIENT AVAILABILITY AND PH AS INFLUENCED BY TILLAGE ON A SHALE DERIVED SOIL OF THE SWARTLAND SUB-REGION OF THE WESTERN CAPE

H v Zyl<sup>1</sup>, J Labuschagne<sup>1</sup>

<sup>1</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607

johanl@elsenburg.com

### Introduction

The advantages of conservation driven agricultural practices (CA) are well documented. Stratification of certain nutrients will however result in high concentrations in the uppermost (0-5 cm) soil layer. Drying of the uppermost layer may result in lower availability as well as erosion losses especially during the initial phase of switching to CA.

### Materials and methods

The effect of various degrees of soil disturbance on soil quality parameters are studied in a long-term tillage-crop rotation trial at Langgewens (S 33.27635°; E 018,70623°; altitude 191m). Four tillage treatments, namely: zero tillage (ZT), soil left undisturbed and planted with a star-wheel planter, no-till (NT), soil left undisturbed until planting and then planted with a no-till tined planter, minimum-till (MT), soil scarified to a depth of 100mm to 150mm in March/April and then planted with the no-till planter and conventional-till (CT), soil scarified to a depth of 100mm to 150mm in March/ April, then ploughed before planting, and planted with the no-till planter. Treatments were replicated four times.

One composite soil sample comprising of six sub-samples per treatment combination, was collected at 0-5, 5-10, 10-15 and 15-20 cm depth, respectively during February 2014. The soil was dried at 60 °C for 72 hours and sieved through a 2 mm sieve before being analysed for resistance,  $pH_{(KCl)}$ , Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S and C. This data were used to calculate the mean nutrient content of the 0-5, 0-10, 0-15 and 0-20 soil layers. Only pH, organic C, phosphorus and sulphur will be included in this discussion.

### Results and discussion

The highest  $pH_{(KCl)}$  values for all tillage treatments were recorded in the 0-5 cm layer. The mixing effect of the plough treatment reduced the difference between maximum and minimum pH over depth to 0.1 pH unit in CT, compared to 0.6 for ZT and NT. Soil organic C showed similar responses. The highest organic C values of 1.64 %, 1.53 %, 1.33 % and 0.77 % were recorded for ZT, NT, MT and CT in the 0-5cm layer respectively. The lowest organic C contents recorded in the 15-20 cm layers were 0.63 % (ZT), 0.68 % (NT), 0.66 % (MT) and 0.71 % (CT). Similar trends were found for soil-P content. In ZT the P content decreases from 89 mg kg<sup>-1</sup> in the 0-5 cm layer to 53 mg kg<sup>-1</sup> in the 15-20 cm layer, NT 89 mg kg<sup>-1</sup> to 57 mg kg<sup>-1</sup>, MT 84 mg kg<sup>-1</sup> to 59 mg kg<sup>-1</sup> but in CT only from 67 mg kg<sup>-1</sup> to 66 mg kg<sup>-1</sup>. Sulphur (S), a more mobile element, did not respond to tillage treatments resulting in identical distribution patterns within the sampled layers for all tillage treatments tested.

### Conclusions

Nutrient distribution patterns within the top 0-20 cm soil are determined by the element or parameter under consideration. In the absence of tillage that cause mixing of the top layers, less mobile nutrients will tend to accumulate in the top 0-5 cm, a result not found for S.

**Keywords:** phosphorous, soil organic carbon, soil tillage, stratification of elements, sulphur

## RESPONSE OF WHEAT (*TRITICUM AESTIVUM* L.) AND CANOLA (*BRASSICA NAPUS*) TO A ONCE-OFF STRATEGIC TILLAGE IN THE SWARTLAND SUB-REGION OF THE WESTERN CAPE

J van Zyl<sup>1</sup>, J Labuschagne<sup>2</sup>, GA Agenbag<sup>1</sup>

<sup>1</sup>University of Stellenbosch, Private Bag X1, Matieland, 7602; <sup>2</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg, 7607

JohanvZ@elsenburg.com

### INTRODUCTION

Conservation agriculture (CA) is a very important management strategy in the grain producing areas of the Western Cape. Although the benefits of CA is well known, secondary effects, such as nutrient stratification, increased bulk density, weed control challenges and habitat improvement for certain pests and diseases may develop. Although soil tillage is not recommended under CA, the question however arises whether strategic use of once-off tillage under CA could be feasible and if so, what short term consequences on crop performance can be expected.

### MATERIALS AND METHODS

The study is in process (2014 and 2015) at the Langgewens Research Farm of the Western Cape Department of Agriculture near Moorreesburg (33°16'42.33" S; 18°04'11.62" E; 191 m). The experimental design is a randomised complete block with a split-plot treatment design. Three cropping sequences: medic-clover/wheat/medic-clover/wheat (McWMcW), wheat/lupine/wheat/canola (WLWC) and lupine/wheat/canola/wheat (LWCW) were allocated to main plots and replicated four times. The last letter in the sequence represents the crop on the field at the time of data collection. Tillage treatments were allocated to sub-plots namely: continuous no-till (NT), soil left undisturbed until planting and then planted with a tined no-till planter, non-inversion tillage (DT), deep tine to a depth of ~400 mm and inversion tillage (MP), soil inverted using mouldboard plough to a depth of ~250 mm). Crop data were recorded at 30, 60, 90 and 120 days after planting. Cepto-, chlorophyll- and porometers were used to determine light interception, leaf chlorophyll content and stomatal conductance respectively.

### RESULTS AND DISCUSSION

Preliminary results (2014) showed that light interception ( $670.7 \mu\text{mol m}^{-2}\text{s}$ ) and stomatal conductivity ( $521.14 \text{ mmol m}^{-2}\text{s}$ ) for canola tended to be higher for DT 60 days after planting compared to NT and MP. Chlorophyll content (37.4 SPAD and 44.9 SPAD) tended to be higher for MP canola compared to DT and NT 30 and 60 days after plant. Chlorophyll content (48.5 SPAD) and stomatal conductivity ( $725.52 \text{ mmol m}^{-2}\text{s}$ ) in McWMcW were the highest for MP. The highest chlorophyll content (43.5 SPAD, 49.6 SPAD, 43.3 SPAD) was recorded 30, 60, 120 days after planting for DT in LWCW. Wheat grain yields of  $4066 \text{ kg ha}^{-1}$  (MP),  $3925 \text{ kg ha}^{-1}$  (DT) and  $3888 \text{ kg ha}^{-1}$  (NT) in McWMcW were recorded. LWCW produced  $3802 \text{ kg ha}^{-1}$ ,  $3800 \text{ kg ha}^{-1}$  and  $3656 \text{ kg ha}^{-1}$  grain for DT, MP and NT respectively. The highest canola yield ( $2131 \text{ kg/ha}$ ) was recorded for MP.

### CONCLUSIONS

Preliminary results show no definite trends, positive or negative, in the response of wheat or canola to the different tillage treatments tested in the first year after the tillage treatments were applied.

**Keywords:** canola, no-till, plough, rip, wheat

**INFLUENCE OF TILLAGE AND CROPPING SEQUENCE ON THE SOIL WATER BALANCE AND WATER USE EFFICIENCY OF WHEAT (*TRITICUM AESTIVUM* L.) AND CANOLA (*BRASSICA NAPUS*) UNDER RAIN-FED CONDITIONS IN THE R?ENS SUB-REGION OF THE WESTERN CAPE**

AH Vorster<sup>1</sup>, J Labuschagne<sup>2</sup>, JE Hoffman<sup>1</sup>, W Langenhoven<sup>2</sup>

<sup>1</sup>Department of Soil Science, University of Stellenbosch, Private Bag X1, Matieland 7602  
; <sup>2</sup>Directorate Plant Sciences, Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607

abrahamhercules6@gmail.com

## **INTRODUCTION**

In a water scarce country like South Africa, the efficient use of water by crops under rain-fed conditions is of absolute importance. Identifying management practices that increase water use efficiency (WUE) is necessary to develop management strategies ensuring maximum production from seasonal rainfall. Soil water balance is a helpful tool to evaluate the effectiveness of different treatments. The aim of this study was to investigate to what extent tillage and cropping sequences influence the water balance and the resultant water use efficiency of wheat and canola.

## **MATERIAL AND METHODS**

The study was a component trial (2013 and 2014) within a long-term research programme investigating the effect of soil tillage and crop rotation on soil quality at the Tygerhoek Research Farm near Riviersonderend. Three crop rotations: continuous wheat (WWWW), wheat/medic-clover/wheat/medic-clover (WMcWMc) and wheat/canola/wheat/lupin (WCWL) including all sequences of wheat/canola/wheat/lupin (WCWL) were allocated to main plots. (Last letter of sequence indicates current crop). Two tillage methods, conventional (CT) and no-till (NT) were allocated to sub-plots and replicated three times. Soil water content (SWC) was recorded in 100 mm increments to a depth of 1 m using a capacitive probe (Diviner 2000). SWC was recorded weekly during the growing season and monthly during the fallow period. Water balances, cumulative evapotranspiration (SET), SWC and water use efficiency (WUE) were calculated at the end of the season.

## **RESULTS AND DISCUSSION**

No differences ( $P=0.05$ ) in SWC, SET and WUE due to tillage and crop rotation were reported for 2013. NT resulted in the highest ( $3681.9 \text{ kg ha}^{-1}$ ) mean grain yield while wheat after lupin (CWLW), in the highest grain yield ( $4000.6 \text{ kg ha}^{-1}$ ). Mean end of season SWC for CT was  $170.6 \text{ mm mm}^{-3}$  and  $173.2 \text{ mm mm}^{-3}$  for NT. The mean SET for CT was  $453.7 \text{ mm ha}^{-1}$  and  $480.7 \text{ mm ha}^{-1}$  for NT. Mean WUE for NT was  $6.7 \text{ kg mm}^{-1}$  and  $6.8 \text{ kg mm}^{-1}$  for CT. The most water use efficient treatment combination was CT-CWLW ( $10.7 \text{ kg mm}^{-1}$ ) compared to NT-WLWC with  $2.9 \text{ kg mm}^{-1}$ . Wheat ( $7.3 \text{ kg mm}^{-1}$ ) had a higher WUE ( $P=0.05$ ) compared to canola ( $3.7 \text{ kg mm}^{-1}$ ).

## **CONCLUSIONS**

Preliminary results from the 2013 production season showed that additional cultivations done under CT did not contribute to higher WUE of the treatment combinations tested.

**Keywords:** canola, crop rotation, evapotranspiration, tillage, water balance, water use efficiency

## USING THE APSIM CROP MODEL TO SIMULATE POTENTIAL FUTURE CLIMATE CHANGE IMPACTS ON WINTER WHEAT YIELDS IN THE WESTERN CAPE

Mike Wallace  
Department of Agriculture: Western Cape, P/Bag X1, Elsenburg 7607  
MikeW@elsenburg.com

### INTRODUCTION

Climate change is evident in the Western Cape province of South Africa, particularly in observed warming trends in average temperatures. According to IPCC models, the warming trend seems likely to continue. The province is currently the leading producer of rainfed wheat in South Africa, yet little information exists to guide climate adaptation planning. Furthermore the province is a highly diverse region with regard to geology, soils, topography, climatic influences and agricultural systems. Future climate change therefore, is likely to have different impacts in different zones of the province where wheat is produced. To address this heterogeneity, the APSIM crop model was applied to assess future climate impacts on wheat in 21 relatively homogeneous farming areas (RHFA) across the province.

### METHODS

APSIM soil, climate and crop management parameters were established for each RHFA and two modelling approaches were undertaken. Firstly, wheat sensitivity analyses were conducted per zone, using a series of perturbations of baseline climate data (temperature: +1°C and +2°C; rainfall: +10%, -10% and 0%; CO<sub>2</sub> at 350 ppm and 500 ppm) to drive APSIM. This provided insight into zonal yield responses to individual and combined changes in key climate and CO<sub>2</sub> parameters. Yield declines of up to 20.7% were modelled under the +2°C perturbation, but these were largely compensated for by the impacts of increased CO<sub>2</sub> levels. Secondly, in order to explore the spatial and temporal impacts of future climate change on wheat yield and production risk, statistically downscaled climate data from an ensemble of 8 General Circulation Models (GCMs) representing plausible climate scenarios, were used to drive APSIM at a daily time step per RHFA. Zonal yields under baseline (1979 to 1999) and future (2046 to 2065) climate change scenarios were simulated to investigate yield anomalies. A detailed consideration of the "cascade of uncertainty" throughout the modelling process was undertaken.

### RESULTS

Based on the ensemble of downscaled GCM projections driving APSIM, future yield responses were generally positive in the south and south-eastern wheat zones of the province. The western zone yield projections demonstrated a greater level of uncertainty than the southern zones, and smaller or negative median yield impacts were modelled, particularly in the Swartland zones. Simulated positive responses to elevated atmospheric CO<sub>2</sub>, together with expected increases in precipitation in some areas, largely compensated for simulated yield decline due to future warming, across most of the wheat zones.

### CONCLUSIONS

Uncertainties already inherent in climate change scenario models are propagated through the process of crop modelling. With due consideration of these constraints, APSIM provides a useful toolset for assessing local sensitivities and likely future scenarios, towards developing resilience and long-term sustainability in local wheat production.

**Keywords:** crop modelling, GCM, rainfed wheat, sustainability, uncertainty

**GROWTH AND YIELD RESPONSES OF SWISS CHARD TO BROILER MANURE, INORGANIC AND EFFECTIVE MICROBES ENRICHED COMPOST FERTILISER APPLICATION**

MA Mpaneng, VI Ayodele, and TA Zitha  
University of Limpopo, Private Bag X 1106, Sovenga 0727  
School of Agriculture and Environmental Sciences  
thembizitha032@gmail.com

**INTRODUCTION**

Swiss chard (*Beta vulgaris* L.), is a leafy vegetable known in South Africa for its nutritional values. Low soil fertility is a major limiting factor to vegetable crop production in Limpopo Province. The study aimed at determining the differential responses of Swiss chard to sole and combined application of broiler manure, effective microbes enriched compost and inorganic (NPK) fertiliser.

**MATERIALS AND METHODS**

The field study was conducted during the 2013/2014 growing season on the field next to the horticultural centre (23° 53' 10" S; 29° 44' 15" E), University of Limpopo, South Africa. The study was laid out as a RCBD. Each experimental unit was 2 m x 2 m with 1 m between experimental units. Each treatment was replicated three times with 1 m between the blocks. The treatments were control, inorganic fertiliser NPK (2:3:2(30)) at a rate of 100 kg N, 85 kg P and 200 kg K. This was applied at a rate of 80 g/4m<sup>2</sup> N, 160 g/4m<sup>2</sup> K and 323.8 g/4m<sup>2</sup> P, this was applied as N from urea, P from single superphosphate and K from potassium chloride (KCL), broiler manure of 12 kg/4m<sup>2</sup>, 50% inorganic + 50% broiler manure, EM enriched compost of 12 kg/4m<sup>2</sup>, 50% EM compost + 50% inorganic fertiliser. Leaf harvesting was done from the six weeks after transplanting and harvesting was done at regular intervals. The following parameters were recorded, plant height, number of leaves, plant vigour, leaf yield (fresh and dry mass) and chlorophyll content.

**RESULTS AND DISCUSSION**

Results indicated that fertiliser application improved both growth and yield of Swiss chard. The significantly tallest (67 cm) plant at 6 WAT were observed in combined EM compost and NPK treatment. While the highest mean height at 8 and 16 WAT (41.33 cm and 29.00 cm respectively) were recorder in broiler manure treatment. The lowest mean values were obtained in the control without fertiliser application. Furthermore the plants grown in broiler manure treated soils had highest number of leaves, plant vigor, fresh (7.79 kg/ 4m<sup>2</sup>) and dry (3.03 kg/ 4m<sup>2</sup>) marketable yields.

**CONCLUSION**

Application of materials for improved Chard production is essential and broiler manure can be used for improved production and higher yield.

**Keywords:** chlorophyll content, plant parameters, production, soil fertility