OPTIMIZING NITROGEN APPLICATION WITHIN THE IN-FIELD RAINWATER HARVESTING SYSTEM ON THE GLEN/SWARTLAND ECOTOPE

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Experiments conducted at Glen and Thaba Nchu over a number of seasons have shown that the in-field rainwater harvesting (IRWH) technique increased grain yields on average by 50 % compared to normal conventional (CON) practices. Due to the nature of the physical layout of the IRWH technique, the crops are concentrated on one third of the land, still maintaining the same plant population per hectare as in the case of CON. This phenomenon, as well as the higher yields obtained, induces huge pressure on the natural resource base to provide N, P and K through mineralization processes. The IRWH technique optimizes water use through better control of the water balance processes. The higher amount of available water for crop production should be taken into account with a nitrogen management programme.

On-farm demonstration trials were laid out over a period of two growing seasons (2001/02 and 2002/03) at the Glen Experimental Station on the Glen/Swartland-Rouxville ecotope to demonstrate CON versus IRWH and the effect of nitrogen application on grain yield. Maize was used as indicator crop. During the first season, plots were planted late in December. During the 2002/03 season an early planting took place in October and a late planting during December. The plant populations for maize was 23 000 plants ha^{-1}. Four nitrogen levels (0, 30, 60 & 90 kg ha^{-1}) were used on the IRWH plots and two nitrogen levels (0 & 60 kg ha^{-1}) on the CON plots. The maize on the IRWH plots produced significantly higher yields than the CON. On the CON plots the average seed yield of the 60 kg N ha^{-1} treatment (2158 kg ha^{-1}) was 42 % higher than the 0 kg N ha^{-1} treatment (1515 kg ha^{-1}), which indicates that the crop responded to nitrogen application. On the IRWH plots the seed yield differences between the various nitrogen treatments were not significant, although there was a common trend to obtain higher yields with higher nitrogen application rates. The 30, 60 & 90 kg N ha^{-1} treatments on the IRWH plots induced 8 %, 11 % and 17 % higher yields respectively than the 0 kg N ha^{-1} treatment. Based on the visual differences between treatments, the demonstration trials provided a good platform for introducing the IRWH technique to small-scale farmers and to make them aware of the advantages of nitrogen application.

Keywords: in-field rainwater harvesting, nitrogen application, maize

POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE GRAIN YIELD OF MAIZE

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The increase of atmospheric carbon dioxide concentration [CO_2] and changes in associated climatic variables will likely have a major influence on regional as well as international crop production. An analysis of the potential effects of climate change on maize production at Cedara, KwaZulu-Natal, South Africa was undertaken. Baseline weather data input series were generated by a stochastic weather generator, ClimGen, using 30 years of observed weather data (1971 to 2000). The generated baseline weather data were modified by synthesized climate projections corresponding to a doubling of [CO_2] to 700 ml l^{-1} without air temperature and water regime changes (Scenario A), and a doubling of [CO_2] accompanied by mean daily air temperature and precipitation increases of 2 ^{o}C and 10 % (Scenario B), 2 ^{o}C and 20 % (Scenario C), 4 ^{o}C and 10 % (Scenario D), and 4 ^{o}C and 20 % (Scenario E) respectively. Maize grain yields were simulated for normal, fortnight earlier and fortnight later planting dates using CropSyst, a cropping systems simulation model. Input crop parameters of radiation use and biomass transpiration efficiencies were modified for maize, in CropSyst, to accommodate physiological changes due to increased [CO_2]. The generated baseline weather data series was statistically similar to the observed weather data series for its mean, variance and distribution of the daily and monthly weather variables. Moreover, calculated Penman-Monteith daily grass reference evaporation and simulated maize grain yield (for the respective planting dates) using the observed and generated weather data series were statistically similar. Scenarios A, B and C resulted in increased simulated grain yields when compared with the baseline period, but with the increase being smaller in Scenarios B and C. Scenarios D and E resulted in simulated grain yields lower than that of the baseline. The simulated grain yield did not respond to changes of daily precipitation increases from 10 % to 20 % indicating that the soil water was not limiting. The mean grain yield from the early planting date was significantly greater than that for the local and late planting dates within the respective scenarios. The analysis of the implications of variations in the planting date on maize production may be most useful for site-specific analyses of possible mitigation of the impacts of climate change through alteration of crop management practices.

Keywords: Stochastic weather generation, climate change, modelling, maize yield

HYDRAULIC PROPERTIES OF FILL AND FILTER MATERIALS FOR WETTING FRONT DETECTORS

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Wetting front detectors are simple irrigation management tools that provide a signal when a wetting front of a particular strength has passed a specific soil depth. The funnel-shaped FullStops (FS) and the tube-shaped LongStops (LS) are two designs of wetting front detector that intercept soil water that moves into a reservoir via a mesh filter to activate floats. The rate and direction of wetting front movement in the detector depends on the balance between gravitational filling and capillary emptying forces. The hydraulic properties of materials inside the detectors influence the sensitivity of wetting front detectors. The *filter material* inside the FS should maintain hydraulic continuity between the mesh filter and the surrounding soil and prevent blocking. It should also be inert so that there is minimal change to the composition of the soil solution. However, the filter material should not present a hydraulic impediment to the unsaturated flow of water, as commonly happens when soil texture changes from fine to coarse. The *fill material* inside the LS should have a high-unsaturated hydraulic conductivity so that it can remain in hydraulic equilibrium with the surrounding soil and respond rapidly to changes in hydraulic gradient. The key hydraulic properties offilter and fill materials are water retention and hydraulic conductivity characteristics, as these influence the storage and transport of water through these materials. The laboratory methods used for determination of these hydraulic properties were the controlled outflow cell, Bruce-Klute diffusivity cell test, and the wicking test. The Bruce-Klute test measures the dependence of unsaturated hydraulic conductivity on water content. The controlled outflow method determines the water retention curve in the range of 0 to 100 kPa. The wicking test determines the rate of capillary rise of water through a filter material. Five *fill materials* (PMB sand, ICW sand, B&E sand, FullStop sand, and Diatomaceous Earth) and three *filter materials* (-300 micron sand, +300 micron sand, and FullStop sand) have been tested. The preliminary analysis of the soil water characteristic curves, $h-(\theta)$, and the unsaturated hydraulic conductivity curves, $K-(h)$, indicates that Diatomaceous Earth has the highest ability to store and transport water at higher suctions. From the three tested filter materials, -300 micron silica sand proved best in terms of water transportability and fewer blockages of the mesh filter.

Keywords: Wetting front detector, fill material, filter material, hydraulic properties

HOT PEPPER (*Capsicum annum* L.) RESPONSE TO SOIL WATER REGIMES, AS AFFECTED BY ROW SPACING AND VARIETY

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Hot pepper is a warm season, high value cash crop. Its production is confined to areas where water is limiting. Irrigating at appropriate depletion of plant available soil water (DPAW) coupled with optimum row spacing and variety selection contributes to water saving without scarifying yield. Thus, it was hypothesized that row spacing and variety affects hot pepper response to different soil water regimes. Two field trials were conducted in the 2004/2005 growing season on the Hatfield experimental farm (Pretoria) to understand (i) whether row spacing affects hot pepper response to different soil water regimes, (ii) whether different varieties affect hot pepper response to different soil water regimes. In trial (i), a factorial combination of two row spacings (0.4m and 0.7m) and 3 soil water regimes (D25: 20-25% DPAW; D55: 50-55% DPAW; and D75: 70-75% DPAW) constituted the treatments. In trial (ii), 3 cultivars (Mareko Fana, Jalapeno and Malaga) and 3 soil water regimes (D25; D55; and D75) in a factorial arrangement formed the treatments. The trials were arranged in RCBD in 3 replications and drip irrigation was utilized. Growth analysis, soil water content and yield measurements were made. In trial (i), a 51 % increase in dry fruit yield was observed as row spacing decreased from 0.7m to 0.4m. By irrigating to D25 as compared to D75 dry fruit yield increased by 46 %. In trial (ii), a 64 % increase in dry fruit yield was observed by irrigating to D25 as compared to D75. Cultivar Mareko Fana (3.63 t ha^{-1}) out yielded Jalapeno (3.44 t ha^{-1}) and Malaga (2.11 t ha^{-1}). Row spacing, variety and soil water regimes affected leaf area index, and water use efficiency (WUE) for fresh and dry fruit yield. Average pod mass and specific leaf area were not affected by row spacing and soil water regimes. Irrespective of row spacing used, most parameters studied (WUE for both fresh and dry fruit yield, fresh and dry fruit yield, pod number per plant, succulence, total dry matter, harvest index, leaf fraction) were significantly affected as the soil water status was varied. Except for pod number per plant and succulence, all parameters studied responded to soil water regimes independent of varietal differences. It was concluded that yield loss could be prevented by irrigating to D25, confirming the sensitivity of the crop to mild soil water stress. Furthermore, appropriate irrigation regimes that maximize productivity of hot pepper can be devised across varieties and row spacings.

Keywords: Hot pepper, row spacing , soil water regime

IRRIGATION SCHEDULING WITH SWB – FROM THEORY TO PRACTICE

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Over recent decades many irrigation-scheduling methods have been developed. SWB (Soil Water Balance), a mechanistic, generic crop, real-time irrigation scheduling model is an example of one of the tools that have been developed to assist irrigators in making informed irrigation scheduling decisions. However, low adoption of irrigation scheduling methods is still a problem world-wide. A technology transfer project was carried out with the objective of encouraging adoption of this scientifically sound and well-validated model through various steps, strategies and improvements to the model. In an attempt to increase adoption of SWB, much effort was put into development of a user-friendly interface, which allows three levels of user access. The *irrigator* level is the most simple, with only a few forms displayed in which weather data and irrigation records can be captured in order to make a scheduling recommendation. The *consultant* level allows the user access to several more options in which site specific soil and field settings can be made for irrigation level users. A third, *researcher* level, displays many more options that most irrigation consultants are unlikely to be interested in, but that could be of use to irrigation scientists. As the model developers' time was limited, the strategy followed was to train consultants to equip them to service individual irrigators, who could contract the consultant to run simulations for their fields and advise them on their irrigation management. Alternatively, consultants or extension officers could assist irrigators in setting up SWB for their specific conditions so that they could run their own simulations. In an attempt to also reach resource poor farmers that do not have access to computers and automatic weather station data, SWB was programmed to generate simple site-specific irrigation calendars. Adoption has proved, unfortunately, to be slow and limited. The project team, however, is confident that continued efforts will bear fruit in future, as they are convinced they have an accurate and useful tool that can make a real difference to the efficiency of field scale irrigation management.

Keywords: computer software, crop water requirements, DSS, irrigation scheduling, soil water balance, technology transfer

COMPARISON OF NORMAL AND HIGH-LYSINE MAIZE FOR PHYTATE AND MINERAL ELEMENTS IN EMBRYO AND ENDOSPERM TISSUES

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Environmental scanning electron microscopy (ESEM) and energy-dispersive X-ray analysis (EDAX) were used to examine the seed tissues for cations. Three caryopses per cultivar were selected for ESEM-EDAX analysis, which was performed on the embryo and s tarchy endosperm tissues. Each specimen was mounted on a c arbon planchette and examined using the gaseous secondary electron detector at 2 Torr and 20 ^{0}C. Standard procedures for ferric precipitation were used to measure phytate P. The objective of this study was to compare the embryo and endosperm of *Zea mays* caryopsis in two cultivars, designated cultivar (H) normal maize and the other (Q1) quality protein (lysine-rich) maize, for the occurrence of cations and phytic acid-phosphorus. For both cultivars, no mineral elements were found in the starchy endosperm. Phosphorus, Mg and K were the predominant mineral elements in the embryos of both cultivars. The quality protein maize showed significantly ($P < 0.01$) lower levels of P, Mg and K compared to normal maize. Whereas K was the predominant mineral element in the quality protein maize, both P and K occurred at higher concentrations than Mg in normal maize. Determination of phytate in the endosperm and embryo of the two cultivars, using ferric precipitation, showed significantly low levels of phytate in the endosperm. The normal maize embryo showed a significantly ($P < 0.01$) higher level of phytate compared to the quality protein maize. Comparison of starchy endosperm and embryo using ESEM showed that the embryo had globoids, whereas the endosperm had none. No difference with respect to the occurrence of globoids, between cultivars was discernible, but future transmission electron microscopy (TEM) will provide more detail. This study provided evidence that normal maize has significantly more phytate than lysine-rich maize. Consequently, the mineral concentrations of seed tissues in normal maize are greater than those in lysine rich maize.

Keywords: phytic acid

OUTCROSSING IN COWPEA (*Vigna unguiculata* (L.) WALP) AND ITS INSECT POLLINATORS

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Cowpea is cleistogamous and therefore dominantly self-pollinated. However, outcrossing mediated by insects occurs in nature. This often results in cross pollination among cowpea genotypes. Different insect species visit cowpea flowers but not all are responsible for pollen movement associated with outcrossing. Outcrossing poses many problems in plant breeding and seed production by creating unwanted genotypes or off-types in the field including mixtures in seed lots. Removal of off-types in the field or seed lots increases costs of production. Information on outcrossing level in cowpea and its insect pollinators would be useful in developing strategies to reduce outcrossing related problems. The objectives of this paper were to identify insect pollinators of cowpea, determine the level of outcrossing in the crop, and assess its implications in the deployment of genetically modified cowpeas.

Two experiments were carried out in Nigeria (IITA Ibadan and Mokwa) and the Benin Republic to assess geneflow frequency in cowpea under different field arrangements. The first experiment was to quantify level of out-crossing when three cowpea varieties (IT95K-1491, Sanzi, and IT86D-719) were respectively planted in alternate rows (one metre apart) with IT95K-1093-5, and 20 rows of each pair. The second was to assess the level of outcrossing when IT95K-1491, a breeding line with morphological marker, was planted in three concentric inner rows of 1m apart while IT95K-1093-5 was planted in outer concentric rows up to 16 m from the epicentre. Incidence of insects visiting the plots was taken during the flowering stage of the crop. The insects were captured and examined under binoculars for presence of pollen. Plots were sprayed regularly with insecticide to eliminate flower thrips, legume pod borer and pod suckers that could confound the expected data. During harvesting, pods of IT95K-1093-5 were harvested from every plant within a 3-4 metre length along north, south, west and east axes of each concentric circle. In the case of alternate row planting, pods from single plants were harvested from rows of IT95K-1093-5 of each pair. Seeds derived from these plants (IT95K-1093-5) were planted in the field in order to assess the level of outcrossing that resulted from the movement of pollens from IT95K-1491, Sanzi, and IT86D-719 onto IT95K-1093-5 in the case of alternate row planting and IT95K-1491 onto IT95K-1093-5 for the concentric planting. Percentage of hybrids bearing the morphological trait of the marker parent was determined. Results obtained showed that level of out crossing was higher (0.50% to 0.85%) when cowpea was planted in alternate rows than in concentric rows (0.01% to 0.13%). Outcrossing was found to have occurred in a random fashion beyond 13 meters. Among the insects observed, only honey and bumble bees were found with cowpea pollen dusts on their legs and abdomens, and were responsible for the observed level of outcrossing.

Keywords: cowpea varieties, outcrossing, insect pollinators

FIELD EVALUATION OF COWPEA GERMPLASM FOR RESISTANCE TO LEGUME POD BORER (*Maruca vitrata* Fabricius)

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Insect pests pose great limitations to cowpea production in many countries in Sub-Saharan Africa. The important ones include *Aphis craccivora* Koch, *Megalurothrips sjostedti* Trybom, *Maruca vitrata* Fabricius and pod sucking bugs (PSBs).The International Institute of Tropical Agriculture (IITA) Nigeria has found moderate levels of resistance to aphids and thrips. However, *M. vitrata* and PSBs remain the major cause of yield loss in cowpea production. Scouting for cowpea genotype(s) resistant to these pests is critically important. Thus, resistance to one or both notorious insects if found, would reduce yield loss, use of insecticides and costs of production. Field screening was conducted in 1998/99, at the research farm of The International Institute of Tropical Agriculture, Mokwa, to evaluate approximately 10000 cowpea germplasm accessions from the genebank of the Institute for field resistance to *M. vitrata.* Selections from this evaluation would be utilized for the short-term cowpea breeding programme, while further screening and laboratory bioassays would continue to quantify resistance. The accessions were three maturity groups, early, medium and late, consisting of 1115, 5114 and 3467 accessions, respectively. Each accession was planted unreplicated in a single row of three metres (30 plants per row), using an augmented design with check varieties planted in replicates after every 50 test lines. To eliminate interference by other cowpea insect species other than *M. vitrata*, a selective insecticide, Monochrotophos, was applied at 200-250 gai/ha at intervals of 10-14 days starting at flower bud formation. At flowering, the number of days to produce the first flower was taken, and at 50% pod maturity the accessions were evaluated for pod load (PL) and pod damage (PD). An index called the pod evaluation index (*Ipe*) was derived from both variables. *Ipe* measures two parameters on pods, pod damage (PD) and pod load (PL). Pod damage measures damage caused by *M. vitrata* larvae while pod load measures the degree of successful podding. Both were scored on two scales of 9-points. Each scale is a reverse of the other. Pod load was rated 1 (low) to 9 (high), and pod damage 9 (high) to 1(low). *Ipe* was derived thus: *Ipe* = PL x (9-PD). The values ranged from zero (susceptible) to 72 (resistant). The higher the Ipe value the better the resistance against *M. vitrata* infestation. Data collected were analysed using the SAS procedure. Accessions with higher Ipe values, higher resistance to *M. vitrata* were selected. Results obtained indicated that there was a highly significant difference ($P< 0.01$) among the early maturity accessions with 1030 accessions exhibiting Ipe values ranging between 0 and 20, 78 accessions between 21 and 40, and seven accessions between 41 and 72. Among the medium maturity group, 5074 accessions had Ipe values of <20, and 36 accessions between 21-40. Only four accessions were in the range of 41-72. The performance of the late maturity group was very poor, with all Ipe values less than 20. In summary, a total of 125 accessions that exhibited Ipe values above 21 were selected for hybridisation, further field screening and laboratory bioassays.

Keywords: Cowpea germplasm, *Maruca vitrata*, pod evaluation index (Ipe)

THE ROLE OF ORGANIC FARMING AND RAINWATER HARVESTING IN DEVELOPING AGRICULTURE

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Organic farming methods are highly relevant in the New South Africa as they build on traditional knowledge and conserve soil and water. They also require lower levels of capital and skill at entry level, and open niche markets to emerging commercial farmers. Commercial organic farmers are increasingly supported in Europe, the United States, Australia and Japan by sophisticated scientific research.

The paper reviews organic farmer training courses and the establishment of organic farming projects in the context of the National Skills Development Programme, the National Agricultural Qualifications Framework and the emerging co-operative movement. Two case histories are presented, showing what assistance is needed to help emerging farmers succeed.

Roll-out options are examined strategically in the light of hostility from the National Department of Agriculture, balanced by support from many other government departments (at National, Provincial and Local levels). Market opportunities and constraints are presented and their implications analysed. A research project on indigenous crop production in Africa is outlined. Research and training needs are identified, and a strategy for long-term agricultural development is presented.

Keywords: Organic farming, rainwater harvesting, farmer training, skills development, agricultural policy

YIELD COMPONENTS OF SELECTED AMARANTHUS SPEICES AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZER APPLICATION.

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Amaranth is an herbaceous annual vegetable grown in many parts of the tropics. Limited use of inorganic fertilizers by smallholders farms in Africa is well documented. Judicious use of organic fertilizers therefore could be a pos sible solution. Trials were conducted at two experimental sites: namely KwaDlangezwa, Kwazulu Natal Province and Sovenga, Limpopo Province, . Responses of two cultivars of amaranth (*A. hybridus* and *A. hypochondriacus*) to fertilizer application were evaluated. At KwaDlangenzwa in a field study four rates of nitrogen fertilizer (0, 50, 100 and 200 kg N ha^{-1}) were applied as treatments. At Sovenga, comparative performance of amaranth cultivars grown in soil treated with selected organic and inorganic fertilizers was evaluated in a greenhouse experiment. Organic fertilizer treatments (broiler manure, effective microbes (EM) compost and sewage sludge) with or without inorganic fertilizer 2-3-2 (22) were used. The three manures at the rate of 0, 20, 40, 80 t ha^{-1} were applied separately to the soil or in combination with complete fertilizer 2-3-2 (22) at the rate of 500 kg ha^{-1}. The inorganic (nitrogen) fertilizer treatment (urea) was applied at the rate of 50, 100 and 150 kg N ha^{-1}. Results showed that plant height, number of leaves produced, fresh and dr y weights of plant parts increased with fertilizer treatment. Application of nitrogen fertilizer at the rate of 200 kg N ha^{-1} increased leaf production by 75% and 60% in *A. hybridus* and *A. hypochondriacus* respectively compared to the control (plots without fertilizer application). The two cultivars of amaranth did not differ significantly in their responses to organic or inorganic fertilizer treatments. However, significant differences were observed among the fertilizer types and the rates of fertilizer application in relation to growth and yield components estimated. For instance, comparing organic and inorganic fertilizer treatments, plants grown in soil treated with a combination of organic and inorganic fertilizers produced greater vegetative growth in terms leaf number, plant height, and shoot fresh weight compared to plants grown in soil treated with organic fertilizer only . The percentage increases in shoot fresh weight were 108%, 41%, 9%, for plants grown in soil treated with broiler manure, urea and E M compost respectively, compared to the lowest mean shoot fresh weight observed in plants grown in soil treated only with sewage sludge. Broiler manure was therefore considered to be a suitable organic fertilizer supplement for amaranth growth. Organic fertilizer application at the rate of 20 t ha^{-1} appeared to be the appropriate rate for amaranth production.

Keywords: Amaranthus hybridus, *Amaranthus hypochondriacus*, organic fertilizer, inorganic fertilizer, yield components

IN-VITRO MYCELIAL GROWTH INHIBITION OF SEVERAL PHYTOPATHOGENIC FUNGI BY WATER SOLUBLE POTASSIUM SILICATE

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In-vitro dose-responses towards soluble potassium silicate (20.7% SiO2) were determined for Phytophthora cinnamomi, Sclerotinia sclerotiorum, , Pythium F-group, Mucor pusillus, Drechslera sp, Fusarium oxysporum, F. solani, Alternaria solani, Colletotrichum coccodes, Verticillium theobromae, Curvularia lunata and Stemphylium herbarum. Inhibition of mycelial growth was dose-related with 100% inhibition at 80 ml (pH 11.7) and 40 ml (pH 11.5) soluble silicon per litre of agar, for all fungi tested with the exception of Drechslera sp. and F . oxysporum at 40 ml in one ex perimental repetition. Only Sclerotinia sclerotiorum and Phytophthora cinnamomi were completely inhibited at all soluble silicon concentrations between 5 and 80 $ml.l^{-1}$ agar, while all the other fungi were only partially inhibited at silicon concentrations of 5, 10 and 20 $ml.l^{-1}$ agar. Percentage inhibition was positively correlated with dosage concentrations. Soluble silicon raised the pH of unameliorated agar from 5.6 to 10.3 and 11.7 at silicon concentrations of 5 and 80 $ml.l^{-1}$ agar respectively. Subsequent investigations into the effect of pH in the absence of silicon showed that fungal growth was only partially inhibited at pH 10.3 and 11.7. Clearly, silicon had an inhibitory effect on fungal growth in vitro and this was mostly fungicidal rather than attributed to a pH effect.

Keywords: Silicon, silicate, pH, in vitro, growth inhibition

PREVENTION OF PHYTOPHTHORA CINNAMOMI INFECTION IN COMMERCIAL AVOCADO (*Persea americana*) ORCHARDS WITH THE USE OF POTASSIUM SILICATE APPLICATION

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The world avocado industry has become very reliant on the use of phosphoric acid for the control of root rot caused by Phytophthora cinnamomi. The threat of resistance remains and efforts must be made to develop alternative control measures. To this end water soluble potassium silicate was applied to trees in a commercial orchard with a Ciba Geigy infection rating of 5.5-6. Trees were treated with 400ml silicon in 20l of water either as a soil drench under the drip line of the trees, or as a trunk injection with 100ml of a 200ppm solution into each tree. Untreated trees were used as a control, and trees treated with phosphoric acid as a contrast treatment. Root density was determined digitally, and expressed as percentage roots per surface area. Both two and three silicate applications in the latter part of the growing season resulted in significantly higher root density percentages (viz. 4.4% and 6%) on average than untreated control trees (1.9%). Although tree health according to the Ciba Geigy tree rating did not differ between treatments during the wet rainy season (+/- 3.5), both the two and three (viz. 3 and 2.6) silicate application treatments in the latter half of the season showed significantly better foliar coverage than the untreated control and phosphoric acid (4.8 and 3.9) applications during the dry winter season. Although no differences in total phenolic content were found photo-spectrometrically between treatments, it is expected that concentration differences occur between treatments with regard to different phenolic compounds, which will be determined with the use of HPLC, and this will be reported on. Although no total yield differences were seen between treatments, trees receiving three silicate applications showed higher yields in larger fruit counts than the untreated control trees. From preliminary results the application of potassium silicate appears to be a viable and practical method of controlling Phytophthora cinnamomi infection in production orchards.

Keywords: silicon, silicate, avocado, *Persea americana, Phytophthora cinnamomi*, root rot

CAN CROPS BE IRRIGATED WITH COAL BED METHANE DEEP AQUIFER WATER?

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A preliminary assessment was made on the suitability of deep aquifer water for irrigation of agricultural crops from the proposed Limpopo Province Coal Bed Methane (CBM) operation. This involved the identification of the most suitable crops that could possibly grow in the climate of the Waterberg with highly saline water on the available soils. The Soil Water Balance (SWB) model was also used to evaluate the long-term impact of this water on soil chemical properties. The simulations showed that with well drained soils and a high leaching fraction, root weighted soil saturated EC_e should not exhibit an increasing trend beyond the threshold for salt tolerant crops, thereby suggesting that production of specific crops for a limited period may be feasible. The recommendations made in the assessment were only theoretical and had to be experimentally proven. Drip and sprinkler irrigation systems were, therefore, set up on separate blocks to test the possibility of growing salt tolerant crops. High delivery rate drippers were chosen to minimize the risk of emitter clogging, and a high density of drippers was selected to create a one-dimensional wetting pattern. The drip lines were 0.3 m apart with emitters also spaced at 0.3 m. A line-source sprinkler system with three sprinklers at a distance of 12 m from each other was also used to observe foliage-scorching effects. Barley (*Hordeum vulgare* cv. Puma), and an Italian ryegrass (*Lolium multiforum* cv. Agriton (Diploid)) and S tooling rye (*Secale cereale* cv. Echo) mix were planted. NPK (2:3:4 (30)) fertilizer was applied at planting. The Soil Water Balance (SWB) model was used to schedule irrigations and to assist in identifying appropriate irrigation management strategies. The envisaged treatments were: irrigation to field capacity **(FC)**, a leaching fraction of 23% that applies 30% more water than that needed to return the profile to FC **(LF-23%),** and a leaching fraction of 46% that applies 85% more water than that needed to return the profile to FC **(LF-46%).** Irrigation was applied every second day based on SWB simulated schedules. Barley (*Hordeum vulgare* cv. Puma) and Stooling Rye (*Secale cereale* cv. Echo) were able to survive under drip and sprinkler irrigation, but soil physical problems severely limited production. In terms of biomass production, an **LF of 23%** gave better barley and ryegrass (cv. Echo) biomass production. Crusting of the soil surface was a major problem due to the high sodium content of the irrigation water. Soil physical problems need to be overcome before crops are likely to be grown successfully.

Keywords: Modelling, CBM, $NaHCO_3$, SWB, salt tolerance

MODELLING THE SOIL WATER AND SALT BALANCE OF 15 SEASONS' CROP ROTATIONS IRRIGATED WITH DIFFERENT QUALITIES OF GYPSIFEROUS MINE WATER

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Field trials were established on un-mined and rehabilitated mined soils under centre pivot irrigation at Kleinkopjé open cast Colliery, close to Witbank in Mpumalanga Province. Several crops were grown with two different qualities of gypsiferous mine water between 1997 and 2005. The objectives of the study were to evaluate the potential long-term impact of irrigation with gypsiferous mine water on the soil properties and aquifer and validate the Soil Water Balance (SWB) model for its long-term predictive capability. Field measurements of crop, soil, soil water, runoff and weather data were made. Volumetric soil water content at each site was monitored two-weekly with a neutron water meter. The quality of water draining from the irrigated area after rain or irrigation was determined several times during each season, using soil water samplers. Growth analysis was done at various stages of crop growth. Amounts of irrigation and rainfall were recorded with tipping bucket rain gauges connected to a data logger. Irrigation water quality was monitored monthly. Runoff weirs were installed to monitor the volume and quality of water running off the fields. The data collected were used to determine the components of the soil water and salt balance for each field. Excellent yields were obtained for wheat on both un-mined and rehabilitated mined land, and also for maize grown on un-mined land. Soil chemical analyses indicated that soil salinity increased from its initial condition. Electrical conductivity of the saturated soil extract (EC_e) increased mainly due to an increase in concentrations of soluble Ca^{2+}, Mg^{2+} and SO_4^{2-}, which were the main ionic species in the irrigation water. Saturated soil EC_e did not reach values critical to yields of the crops, and decreased after rainy periods. Crop nutrient status showed that K^+ was low in the soil-exchange complex. Low spots due to subsidence of rehabilitated land caused ponding and water logging. Careful rehabilitation of land destined for irrigation is recommended. Careful fertilization management is essential as Ca^{2+} and Mg^{2+} dominate the soil-exchange complex, with the risk of K^+ displacement and leaching. The model predicted leaf area, top dry matter, soil water deficit, salts and runoff reasonably well. Groundwater quality has not deteriorated within the underlying aquifer.

Keywords: Modelling, SWB model, gypsiferous mine water, groundwater

EVALUATING THE SUSTAINABILITY OF THE IN-FIELD RAINWATER HARVESTING CROP PRODUCTION SYSTEM

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A number of studies have revealed low adoption rates of water conservation technologies or new innovations among smallholder farmers in developing areas. The reason might be that only one or two of the five pillars of sustainability were considered, instead of all five. The question that needs to be answered can be stated as follows: Is the in-field rainwater harvesting (IRWH) technique sustainable?

Short-term agronomic productivity was measured with on-station trials at the Glen Experimental Station, and on-farm trials and demonstrations on croplands and homesteads in rural villages around Thaba Nchu in the Free State. The IRWH technique was compared with normal conventional tillage (CON). Agronomic productivity was also determined over the long term using the stress model Crop Yield Prediction for Semi-Arid Areas (CYP-SA) and long-term climate data to provide long-term yield simulations. Simulated long-term crop yield data for different production techniques were used to draw cumulative probability functions (CPFs) to quantify the risk of crop failures. Runoff and sedimentation were measured under different crop production systems to quantify the conservation of natural resources. In addition, carbon content of the topsoil was measured at the start and end of the experiment. Enterprise budgets for the CON and IRWH techniques were linked to long-term yield data (81 years) to calculate gross margins (R ha^{-1}). CPFs of gross margins determined over the long term were used to determine the economic viability (long-term profitability). Specific “indicators” used to monitor social acceptability of the IRWH technique included: (1) initial number of households and communities that applied the IRWH technique after it had been demonstrated to them; (2) increase or decrease in application number in the following years; and (3) increase in crop diversity. Applying the named criteria to test the sustainability of the two crop production techniques in the specific agro-ecological and socio-economic environment present in the rural villages around Thaba Nchu gave the following result: long-term agro-ecological and short-term socio-economic data indicated that the IRWH technique is sustainable but that the CON technique is not.

Keywords: sustainability

TO PLANT OR NOT TO PLANT MAIZE? IMPACT OF PRE-PLANT SOIL WATER CONTENT

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A valuable property of models is their ability to utilize long-term climate data to provide long-term yield simulations, which can serve to quantify risk, especially in semi-arid areas where rainfall is marginal and erratic with regard to amount, distribution and intensity. To be able to make reliable recommendations concerning the best production techniques for a crop on a particular ecotope it is desirable to have long-term yields. The use of crop models with long-term climate data to achieve this objective has been widely adopted in agriculture for more than a decade. However, the application of this strategy for the production techniques used in this study requires more than standard crop modelling procedures. The latter will be satisfactory for the conventional (CON) treatment. However, for the in-field rainwater harvesting (IRWH) technique, to correctly simulate the soil water regime in the region of the basins requires that one is able to correctly predict runoff from the runoff strip (bare, or covered with stone or organic mulch) for each rainfall event recorded in the long-term weather dataset. Where mulch is applied in the basins or on the runoff area, the suppression of soil evaporation by the mulch also needs to be taken into account. In addition, the effect of the different mulches on the interaction between runoff, infiltration and evaporation from the soil surface in the basins and on the runoff area needs to be quantified.

An empirical stress model termed “Crop Yield Prediction for Semi-Arid Areas” (CYP-SA) was developed to enable long-term yield predictions to be made. The composition of the model for maize is described in detail, together with validation results. Validation results for the short-term yield predictions were reasonable and consequently used to make long-term yield predictions with long-term climate data (81-year period). Cumulative probability functions (CPFs) of simulated long-term yields for maize on the Glen/Bonheim ecotope, using different production techniques, were drawn. The overall conclusions from this study are that on the Glen/Bonheim ecotope the IRWH treatment with organic mulch in the basins and stones on the runoff area gave the highest yield at comparable risk values. It is advisable to plant maize early in January, especially when the soil water profile is between 75 and 100 % full. This strategy could help a farmer on this ecotope to reduce the risks of crop and financial failure, and in so doing promote food security.

Keywords: stress model

INTRODUCTION OF A LEGUME IN A CROP ROTATION SYSTEM

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As part of the further development of the in-field rainwater harvesting (IRWH) system, crop rotational strategies were investigated at the Glen Experimental Station on the Glen/Bonheim ecotope. Bean-maize and bean-sunflower rotations were executed for both the conventional (CON) and IRWH systems over a period of three growing seasons. The purpose of this study was (i) to compare CON with the IRWH technique; and (ii) to evaluate the introduction of a legume (beans) as part of a crop rotation strategy. The indicators of crop response to different tillage techniques and crop rotation were seed yield, dry matter production, harvest index and various water use efficiency indices. Yield and water use efficiency results clearly showed the advantage of the IRWH system over the CON technique, irrespective of rotation strategy. For those farmers who still want to continue with CON, results indicated that monoculture beans performed better than rotation with maize or sunflower. This result can probably be attributed to the water extraction ability of the different crops. Maize, but more so sunflower, has a larger rooting density and soil depth penetration ability than beans and hence a greater potential to exploit the root zone for water, leaving the profile with water levels near the lower limit of plant-available water at the end of the growing season when the beans were planted. Soil water content measurements in the CON treatment have shown how difficult it is to recharge the profile during the fallow period as well as during the growing season. This resulted in the crop being planted at low levels of plant-available water.

Keywords: crop rotation

"THE ENVIRONMENTAL AND SOCIO-ECONOMIC CONTRIBUTION OF PALM GEOTEXTILES TO SUSTAINABLE DEVELOPMENT AND SOIL CONSERVATION": THE SOUTH AFRICAN CONTRIBUTION TO THE EU-FUNDED BORASSUS PROJECT

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In South Africa about 40 000 m^2 coconut and 160 000 m^2 jute mats are utilized annually to minimize erosion on engineered slopes. Both types of geotextiles are imported. A new product, which is manufactured from the leaves of palm trees, has recently been reported and preliminary investigations suggest that it could be an effective and economically viable soil conservation method with enormous global potential. The palm leaves are woven into open mesh square mats of 0.5 m side length. The closely arranged rows intercept the energies of impacting raindrops and water scour, keeping the underlying soil and seeds in place. With time the mats biodegrade, enhancing soil fertility and strength.

Palms are commonly found as ornamental trees in South African urban gardens. Each tree produces several new leaves every year while old leaves dry up. These dry leaves, for which there is no use at present, could be woven into mats, which – when sold – would provide much needed income and create employment for socially-disadvantaged township residents. Locally-produced palm mats might replace imported coir and jute products.

The objectives of the South African contribution to the Borassus project are to
☐ teach disadvantaged community members from the Mamelodi township of Pretoria how to the produce palm mats from leaves, collected in private gardens;
☐ conduct feasibility assessments for social acceptability and economic viability; and
☐ establish the erosion reduction potential of the mats on a variety of soils and gold mine tailings via rainfall simulator and Wischmeier plot experiments.

At the end of the project, the effectiveness of palm mats in reducing water erosion will have been documented and quantified, the socio-economic impact that the production of palm mats has on a poverty-stricken South African community will have been evaluated and the potential for marketing the mats locally or internationally assessed.

Keywords: palm mats, erosion prevention, poverty alleviation

RESPONSE OF TANNIN CONTENT TO NITROGEN NUTRITION OF BUSH TEA (*Athrixia phylicoides* L.) AS INFLUENCED BY SEASON

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Bush tea (*Athrixia phyliciodes* L.) belongs to the *Asteraceae* family. It is a popular beverage predominantly used as an herbal tea and for medicinal purposes. It is used for cleansing or purifying blood, treating boils (carbuncles) and coughs. In some parts of , bush tea is used as an aphrodisiac. Bush tea was grown under varying nitrogen (N) levels throughout the year to determine the seasonal nutrient requirements for improved quality. The treatments consisted of 0, 100, 200, 300, 400 and 500 kg·ha^{-1} N in a randomized complete block design replicated 4 times under 50 % shade nets. Condensed tannins were extracted using butanol-HCl reagent and hydrolysable tannins were extracted using potassium iodate in a spectrophotometer. The results of this study demonstrated that both condensed and hydrolysable tannins increased quadratically in response to N nutrition reaching maximum at 300 kg·ha^{-1} N. The highest contents of condensed tannins were 4.5% during autumn and winter, whereas hydrolysable tannins were 0.1% during spring and summer. Therefore, for improved tannin content in bush tea, 300 kg·ha^{-1} N is recommended.

Keywords: Bush tea, nitrogen, season, tannins

THE EFFECT OF NICKEL AND CHROMIUM TOXICITY ON MAIZE

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Nickel and chromium are the main toxic heavy metals occurring in ultramafic soils. These soils are also characterized by high magnesium relative to calcium levels. Ultramafic or serpentine soils occur in Zimbabwe (many of them potentially arable) and are also associated with the Bushveld Igneous Complex of Mpumalanga, Northwest and Limpopo provinces of South Africa. Waste and effluents containing these heavy metals from steel works and tanneries present real toxic pollution hazards. Furthermore, proposed sequestration of excess CO_2 associated with global warming as $MgCO_3$ by acidulation and hydrolysis of ultramafic rocks, would release useful but also potentially polluting quantities of heavy metals.

The starting point in studying the effects of Ni and Cr on plant growth is to determine levels in artificial culture that present toxic symptoms on indictor plants. Maize was chosen as indicator as it is grown on or near ultramafic soils in the regions mentioned. The objective was to grow maize in purified sand culture with added nutrients and toxic levels of Ni and Cr to determine toxicity symptoms and effects on dry matter production and to determine suitable levels for interaction with low calcium and high magnesium levels as found in ultramafic soils.

Maize was planted in pots of acid washed sand receiving Hoagland's nutrient solution and treated with 2-18 mg/kg Ni and 2-40 mg/kg Cr and combinations of these. Growth was observed over 4 weeks and vegetative yields determined. Results showed that both metals were extremely toxic above 4 mg/kg Ni and 6 mg/kg Cr and that levels in excess of 600 mg/kg Ni and up to 18 mg/kg Cr were translocated to leaves in severely stunted plants. For further experimentation involving interaction of these metals with low calcium and high magnesium levels, 2 and 4 mg/kg Ni and 4 and 6 mg/kg Cr were determined as suitable levels

Keywords: Heavy metal toxicity, Nickel, Chromium, Ultramafic soil, Maize

INTERACTION OF NICKEL AND CHROMIUM TOXICITY WITH HIGH MAGNESIUM RELATIVE TO CALCIUM IN MAIZE

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Ultramafic soils are characterized by high magnesium content relative to calcium and high levels of heavy metals, principally nickel and chromium. Such soils occur in Zimbabwe and South Africa where toxicity prevents significant areas from being cropped. Furthermore, potential toxic pollution from mining, steel works, tanneries and other sources justify investigation into the effects of toxicity on plant growth.

Maize was grown as an indicator crop in a preliminary pot experiment to ascertain suitable levels of Ni and Cr that significantly affected growth and yield without suppressing growth totally. In the current pot experiment, these suitable levels (2 and 4 mg/kg Ni and 4 and 6 mg/kg Cr) were used in combination with 5 levels of Mg increasing relative to Ca as treatments, to assess the effects on maize grown in sand culture. This enabled the effects to be separated compared to ultramafic soils where toxicity and Ca-Mg imbalance are usually confounded. The control treatment was Hoagland-Arnon solution (Ca:Mg ratio 2:1) and the other treatments were the same solution with adjusted Ca:Mg ratios of 1:5, 1:11, 1:19 and 1:29. There were 5 replications.

There were no significant (vegetative) yield differences caused by reducing the Ca:Mg ratio from 2:1 to 1:29, although leaf Ca% and leaf Ca:Mg ratio decreased significantly over the range. Leaf Ni and Cr concentrations increased significantly when the Ca:Mg ratio became inverse, as did chlorosis due to Ni and a leaf splitting symptom. Nickel treatments greatly reduced yield, and increased leaf Ni and chlorosis, and were associated with increased leaf splitting (P=0.05). Chromium treatments greatly reduced yield and increased leaf Cr and scorching, purpling and discolouration (P=0.05).

Although leaf splitting was only present in a few pots of some treatments, it was hitherto unknown and the results show that reduced Ca, especially in the presence of increasing levels of toxic Ni, was the cause of splitting. There was no evidence of Mg toxicity in this respect, as leaf Mg% remained nearly constant as leaf Ca% decreased with decreasing treatment Ca:Mg ratios. An important implication is that Ca deficiency is likely (with respect to maize) in ultramafic soils where Ca is often low relative to Mg. Furthermore, the incidence of Ca deficiency is likely to be increased when Ni toxicity is also present in soils. The bizarre symptoms caused by Cr toxicity in this experiment have not been seen in the field and no interaction with Ca or Mg was found, indicating perhaps a minimal role for Cr in toxicity in ultramafic soils.

Keywords: Heavy metal toxicity, Nickel, Chromium, Calcium deficiency, Ultramafic soil, Maize

PREDICTING THE CHANGE IN SOIL ELECTRICAL CONDUCTIVITY RELATED TO IRRIGATION.

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A saline irrigation experiment ran for eight years in a vineyard near Robertson in the Western Cape Province of South Africa. During this period, six levels of saline irrigation water were applied to four replicated sites each, i.e. 24 plots in total. The six treatments were ~23, 75, 150, 250, 350 and 500 mS m^{-1} of which the first was normal canal water. The vineyard extended over 1.2 ha of land. Soil samples were taken at regular intervals and suction cup lysimeters (SCL) were used to sample the soil water at a fixed time after each irrigation event. The behaviour of the electrical conductivity of the soil water (EC_{sw}) was therefore studied.

All SCL data over the eight years were subjected to a test that searches for EC_{sw} depth trend lines, with highest significance and lowest possible polynomial order. This means that the electrical conductivities of the soil water (EC_{sw}) were used to show how the total amounts of salt in the irrigated soils could be estimated with the minimum amount of data. From all tests it was found that the first order polynomial produced highly significant predictions. Using first order polynomials, a simple procedure was consequently proposed whereby the EC_{sw} values of only two depth increments were used to predict the quality of the soil water below the root zone, which in turn also produced highly significant results. The method was tested on the neighbouring Robertson drip irrigation experiment.

This methodology will help to predict the salt depth distribution pattern for any point in an irrigated landscape down to at least a depth of 1 m. It will hopefully also help to take stock of the total volume of salt in the landscape with much less effort. The procedure also relates to the interpretation of EM38 measurements where two depth increments are often sampled.

Keywords: Soil salinity, polynomials, suction cup lysimeters, prediction

TEMPORAL STABILITY OF CALCIUM, MAGNESIUM AND SULPHATE IN SOILS IRRIGATED WITH NEUTRALISED ACID MINE DRAINAGE

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The environmental sustainability of crop irrigation with Neutralised Acid Mine Drainage (NAMD) is currently being investigated at Kleinkopje Colliery in Mpumalanga, South Africa. Understanding the stability / solubility of calcium (Ca), magnesium (Mg), and sulphate (SO_4) introduced to the soil through irrigation, is important in the management of these systems. Soil samples were collected along a down slope transect across two irrigated fields. Samples were collected every 50 m, starting and ending 100 m outside the irrigated fields. Samples were taken at 30 cm intervals to a depth of 120 cm, or when the limiting layer was reached. Total soluble and exchangeable Ca and Mg were extracted with a 1 *M* NH_4OAc solution and SO_4 with a 0.1 M KH_2PO_4 solution. Sub samples were leached with deionised water. Water-soluble Ca and Mg were taken as the difference between 1 *M* NH4OAc extractable Ca and Mg, before and after leaching. Similarly water soluble SO_4 was taken as the difference between 0.1 *M* KH_2PO_4 extractable SO_4 before and after leaching. On average, the NH_4OAc extractable Ca in the soil profile in June 2004 was 28.8 mol m^{-2} (std dev = 6.2) compared to 7.8 mol m^{-2} in 1997. June 2004 analysis showed that on average 12.6 mol m^{-2} (44 %) of the NH_4OAc extractable Ca was not water soluble compared to 7.3 mol m^{-2} (94.5 %) in 1997. Water-soluble SO_4 and Ca were comparable after 8 years of irrigation, 19.2 mol m^{-2} of the KH_2PO_4 extractable SO_4 was water soluble compared to 16.3 mol m^{-2} of the NH_4OAc extractable Ca. 8 years of irrigation with neutralised acid mine drainage, saturated with respect to gypsum, resulted in a net accumulation of predominantly water- soluble Ca and SO_4 in the soil profile of the irrigated fields.

Keywords: NH_4OAc extractable Ca, water-soluble SO_4 , water- soluble Ca , KH_2PO_4 extractable SO_4, Neutralised Acid Mine Drainage (NAMD)

WEATHER CONDITIONS AFFECTING WHEAT STRIPE RUST: FIELD EXPERIMENT RESULTS

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Stripe rust (*Puccinia striiformis*) is a potentially damaging disease of wheat (*Triticum aestivum*). In addition the pathogen mutates over time and resistant cultivars often become susceptible to the disease. Stripe rust is initiated when cool and wet weather conditions, cultivar susceptibility and primary sources of inoculum coincide. It was decided to develop a deterministic mechanistic model for the prediction of stripe rust occurrence as an early warning instrument. Field experiments were planned in which disease development was monitored using micrometeorological instruments situated within the wheat canopy. The weather variables observed were ambient air temperature, relative humidity, rainfall, leaf wetness, solar radiation, ultraviolet radiation and leaf temperature and these were related to disease occurrence and development.

Results for experiments carried out in 2004 and 2005 showed that the disease was first observed in a cool, wet treatment and was higher than that in the dry treatment, where it only started three to four days later. Severity ratings were carried out three times per week. The disease increased to 100 % in all treatments because of intermittent rain and a low daily average temperature during the two month period following inoculation (<23 ^{o}C in 2004).

Fungicide applications are required to slow or stop the disease and are very costly if the conventional method of spraying at set intervals is used. The development of an early warning system, using a combination of modelling and monitoring methods, will enable farmers to spray their crops timeously as soon as the warning is given. In this way a huge saving on fungicides will allow farmers to improve yield and thus acquire higher profits.

Keywords: disease, temperature, leaf wetness, relative humidity, *Puccinia striiformis*, early warning

EFFECT OF CROP START DATE ON RADIATION USE EFFICIENCY IN RATOON CROPS OF THREE SUGARCANE CULTIVARS

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It is well established that biomass production is linearly related to accumulated intercepted solar radiation in unstressed sugarcane (*Saccharum* spp). Temperature largely governs growth processes e.g. the development of the canopy. The rate of canopy development in turn determines the amount of radiation intercepted. Radiation use efficiency (RUE) has been defined as the aerial biomass produced per unit of global radiation intercepted (g dry mass per MJ intercepted radiation). Some models use RUE as a key parameter for simulating biomass production and this value is reported to be constant at 1.75g/MJ for sugarcane. No distinction is made between cultivars or for crops that start their growth cycle at different times of the year. A growth experiment conducted at Pongola had five start dates and several cultivars, including NCo376, N25 and N 26 as treatments. Recommended amounts of fertilizer and w ater were applied to maximize biomass production. Light interception and biomass production were measured at intervals during the growth of the crops. RUEs of early growth stages were determined and c ompared with annually derived RUEs. Using early growth stages eliminates the possible effects of lodging and l ower nitrogen levels in older growth stages on photosynthesis. The objectives of this study were to determine (1) whether RUE is affected by the time at which crops start their growth (2) and whether cultivars have different RUEs. This study showed that RUE increased from March through to December in young erect crops and were lower after lodging. The high correlation between temperature and RUE (R^2= 0.9112) indicates that RUE increases with an increase in temperature. The RUE values in young crops suggest that there are cultivar differences related to crop start date that could be exploited.

Keywords: sugarcane, radiation use efficiency, crop start date, cultivars

AN HISTORICAL OVERVIEW OF THE AGROMET CLIMATE NETWORK AND DATABANK

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Climate and weather data form the backbone of applied Agrometeorology. Currently, well-developed networks of climate monitoring do exist in South Africa and the ARC-ISCW has developed the AgroMet Climate Databank, which forms the foundation of many research activities and advisory services in both the public and private sectors. This situation was, however, not achieved overnight.

It was in the 1940s that agriculture and research showed interest in weather and climate data and required weather stations at certain locations. The AgroMet Division's first mechanical weather station was installed in 1940. Data measurements are, however, of little use without a means to extract and manage the data. In order to do this effectively, AgroMet created its first databank in 1978 on the Burroughs system. This was updated to a pop-up menu version in the early 1990s, which could work off a desktop computer. The Agromet Databank was again redeveloped in 1999 mainly to solve the Y2K problem. This version of the databank was programmed in Visual Basic for applications to run on MS Access. By the end of 2004 the Division identified the need to develop a sleeker, faster and more user-friendly database and the current AgroMet WebBank was born. The AgroMet WebBank consists of an Informix database server, Web Mathematica for calculations and a Java graphical user interface (GUI). The ultimate goal of the ARC-ISCW system upgrade is to provide timely weather data to researchers and the agricultural community, particularly the formerly disenfranchised rural farmers, in support of the utilization of the region's fragile environmental resources.

Data in the climate databank span a period of over 100 years, from 1900 to the present. Climate data is obtained from various climate-monitoring organizations across the country. These include the ARC-ISCW climate-monitoring network, the South African Weather Service, the Department of Water Affairs and Forestry, commodity research stations, universities, private landowners and other sources. In 1900 there were 326 stations reporting only rainfall (SAWS stations), but by 1950, 3163 stations (SAWS) reported daily rainfall and 42 additional meteorological elements. In 1992, ARC-ISCW installed its first automatic weather stations (AWS) and hourly measurements were made possible. Currently the ARC-ISCW climate-monitoring network consists of 147 mechanical and 359 AWS's, while the SAWS network has 1529 rainfall stations, 120 AWS's and 103 mechanical weather stations.

This presentation aims to give an historical overview of the AgroMet station network and developments in the databank. It will focus on how the system's functionality has improved over time and will also give a sneak peak into future developments.

Keywords: Climate, Agrometeorology, Weather station network, Databank

FATE OF ORGANIC MATTER IN CULTIVATED PLINTHIC SOILS OF THE FREE STATE

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The cultivation of plinthic soils of the Avalon and Westleigh forms in the Free State has resulted in organic matter loss. This investigation was done to elucidate the rates and mechanisms of these losses by prolonged cropping in different agro-ecosystems, viz. Harrismith, Kroonstad and Tweespruit. Samples were collected of the upper 200 mm layer from Avalon and/or Westleigh soils that had been cropped for periods varying from 0 to 98 years in each of the three agro-ecosystems. The concentrations of organic C and N were determined in bulk soil, particle size separates and water-stable aggregate classes. In addition, lignin-derived phenols and amino sugars as markers for plant and microbial residues were measured. The natural abundance of ^{13}C and ^{15}N in bulk soil organic matter, and ^{13}C in individual phenols was also determined to trace the amount of grassland-derived organic matter. Long-term cultivation of native grassland reduced organic matter in bulk soil by 60%, reaching an equilibrium after 30 years. Losses of organic matter occurred from all particle sizes, with increasing rate loss constants as particle size increased. Small amounts of organic matter were lost together with silt by wind erosion. During cultivation aggregates greater than 2 mm decreased in size into finer classes. However, organic matter contents decreased in all aggregates. This occurred fastest in the 2.8 to 8.0 mm aggregates, and less than 10% of the organic matter of the initial 47% in this fraction remained after 90 years of cropping. On average at least 5% of the organic matter was physically protected in aggregates smaller than 2 mm. The contribution of lignin-derived phenols to total C did not change in the bulk soil due to cultivation, suggesting that there was no selective enrichment of lignin moieties as total C was lost during cultivation. Increased ratios of phenolic acids to aldehydes suggested that side chains were increasingly oxidized during cultivation. In the silt fraction, however, the ratios decreased after 10 to 20 years, because grassland-derived lignin moieties were selectively lost together with silt by wind erosion. The lignin-specific ^{13}C analyses supported this finding. No significant changes in the ^{15}N signature in the bulk soil were observed on account of cropping, whereas in the coarse sand fraction, decreasing ^{15}N values reflected increased fertilizer input. The sequestration of fertilizer N into stable C pools of the particle size fractions could not be detected. After 90 years of cultivation ^{13}C values of the bulk soil organic matter indicated that 40% of grassland-derived C was replaced by wheat-derived C, which dominated over maize-derived C. In contrast, 80% of the C in lignin was crop-derived, suggesting that the majority of remaining grassland C was recycled through microbial biomass. Amino sugar analyses suggested that during this recycling, fungal residues were better preserved than bacterial residues, while microbial residues declined by 60%. In addition to organic matter losses, cropping also resulted in significant changes in the composition of this important component of plinthic soils. Rapid aggregate breakdown reduces physical stabilization of organic matter, and enhances mineralization, thereby reducing the capacity of the soil to keep organic detritus in the internal C and N cycles.

Keywords: aggregates, amino sugars, microbial biomass, phenols

THE INFLUENCE OF HYBRID, SEED SIZE, SEED DRESSING AND HERBICIDE TREATMENT ON THE RATE OF EMERGENCE AND VIGOUR OF CORN SEEDLINGS

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During the 2004 planting season various problems in establishing a proper stand of corn were experienced. Abnormal weather conditions were experienced, but many farmers put the blame for the poor stand on the seed. In trials to investigate the possible reasons, significant differences were measured in the rate of emergence and the vigour of the seedlings. The possibility of enhancing the vigour with seed dressing was investigated.

The rate of emergence and vigour data from four different trials will be presented. A field trial with seven cultivars, including some opposition cultivars, was conducted in the Gerdau area. Two field trials were conducted on a sandy soil in Bloemhof to evaluate seed dressing with different macro and micro nutrients (Zn, Zn + S, N+P+K+Ca+Mo+B+Co, Zn+P, Mo+P and Myconate). Also a pot trial was conducted by the ARC in the glasshouse on two soils (one the Bloemhof soil), with two seed dressings (Zn+P and Zn+S), two seed sizes and two acetochlor herbicide treatments with three dosages. In the field trials the rate of emergence was measured from the day the first plants emerged, the day 50% of the plants had emerged and the growth stage on day 8. The vigour was measured on a score of 1 to 9 on days 10, 14 and 21. Plant height was measured on day 21. In the pot trial the mean days to emergence were determined and dry mass was determined after 17 and 32 days.

Significant differences in the rate of emergence between hybrids were recorded with a normal distribution between companies. In the Bloemhof trial significant differences in the rate of emergence and vigour were recorded between hybrids and seed size. The small kernels emerged first, but the vigour of the seedling was less than that of the bigger kernels. The vigour of the seedling was not influenced by the rate of emergence, but was determined by the hybrid and seed size. The seed dressing increased the vigour significantly in the Bloemhof trial, but the increase was less than the influence of the hybrid and kernel size. The type of seed dressing gave inconsistent results.

The pot trial gave similar results in respect of seed size. Spraying acetochlor herbicide delayed the germination time and decreased the mean dry mass. The herbicide effect was greater on the small seed and increased with increasing dosage. The seed dressing gave inconsistent results.

Keywords: Emergence, Seed size, Seed dressing, Corn

SOIL FORMATION IN THE SUMMER RAINFALL REGION OF SOUTH AFRICA: A CHICKEN AND EGG SITUATION AMONGST SOIL FORMING FACTORS

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As part of a study to describe the soils of the Savanna Biome and surrounding Grassland, Forest and Nama Karoo Biomes in South Africa, using land type data, interesting inter related relationships between the influence of climate and parent material on the occurrence of broad soil patterns within these regions, were found. Mean annual rainfall and Class A pan evaporation data were used to calculate an aridity index (AI) for certain land types within a vegetation region. Multiplying AI with AW integrated the combined effect of climate and available soil water. This index was called Profile Available Water Index (PAWI). The effect of temperature was quantified using the heat unit values (HEOM) for the same macroclimate zones. It appeared that climate (especially rainfall, evapotranspiration and heat units during summer months) and soil type (especially texture and depth) play a very important role in separating the Savanna Biome from the Grass and Forest Biomes (higher PAWI and lower HEOM than for the Savanna Biome) or the Nama Karoo Biome (lower PAWI and higher HEOM than for the Savanna Biome). When an index of PAWI/HEOM was calculated to give a single value for the combined effect of water and temperature, the order from low to high was: Nama Karoo<Kalahari Savanna< Sub-Escarpment Savanna<Lower Bushveld Savanna<Central Bushveld Savanna< Dry Highland Grassland< Forest<Mesic Highland Grassland<Sub-Escarpment Grassland. For the broad soil patterns (indicated by the landtype symbols Ag, Fb, etc.) the PAWI/HEOM index, grouped from low to high were Ag<Fb<Ae<Fa<Ea< Ca<Ba< Bc<Ac. The distribution (expressed as percentage total coverage of the measured region) of the broad soil patterns show that Ag only occurs in the Nama Karoo; Ae dominate in the Savanna and Nama Karoo Biomes; Ac in the Forest and Grassland Biomes while soils with a plinthic subsoil (Ba, Bc & Ca) are mostly associated with the Grassland Biome with only limited occurrence in the Forest and Savanna Biome. Swelling clay soils, supporting mainly grasses, occur in the Grassland and Savanna Biomes on basic parent material. The results indicate the close relationship between vegetation, climate, terrain and parent material (the time factor was not taken into consideration) in the summer rainfall region. The question can be asked: Are the trees and shrubs that use water throughout the year and prefer warmer conditions and characteristic of the Savanna Biome, responsible for the limited occurrence of plinthic soils and contribute to the formation of more red apedal, high base status soils in this region, compared to the Grassland Biome regions where it is cooler and where less water is used during the winter months when the grasses die-off? Alternatively, can the types of soil found in the Savanna region (soils where roots can utilize the deep soil layers for water and nutrients and where no clay-pans or cemented layers occur) separate this Biome from the other surrounding Biomes? This illustrates the important findings of the early pioneers of soil genesis (e.g. Dokuchaev and Jenny) that no soil forming factor is more important than any other in soil genesis – despite the fact that locally one factor may exert a particularly strong influence.

Keywords: Soil formation, Summer rainfall region, Soil forming factors, Vegetation biomes, Profile available water

EVALUATION OF THE MORPHOPHYSIOLOGICAL TRAITS HERITABILITY DROUGHT STRESS CONDITIONS IN BREAD WHEAT GENOTYPES (*Triticum aestivum* L.)

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This study was conducted to evaluate the effects of water stress on heritability of some physiological traits, including leaf water potential, osmotic potential, and water loss in excised leaf in bread wheat. The experiment was conducted in 2002-2003 on 11 bread wheat cultivars with diverse reactions to water stress. The experiment was arranged as a randomized complete block design with three replications at two experimental sites at the College of Agriculture, Shiraz University. The physiological traits were measured during stem elongation, booting and flowering stages. The results indicated a significant difference between cultivars in respect to physiological indices. The combined analysis of variance indicated that cultivars were significantly different in respect to 1000 seed weight, plant height, harvest index and spike length. Biological yield, harvest index, and number of spikes had the lowest heritability, while plant height, spike length, and 1000 seed weight had the highest ones. The results also showed that the genotypic variances and hence the heritabilities increased as the water conditions became more favourable. The heritability of leaf water potential varied from 0.33 to 0.50 during their maturity stages. The heritabilities of osmotic potential (0.58 to 0.64) and water loss from excised leaf (0 to 0.33) also showed similar trends. The results indicated that the expression of adaptive traits related to stress environments became more significant as the plants were under more stressed conditions. The comparision of locations showed that the heritability of traits increased as the plants were under more stressed conditions.

Keywords: Wheat, heritability, drought stress, physiological traits, grain yield

PREDICTING EMERGENCE OF CABBAGE (*Brassica Oleracea* Var. Capitata L.) AND ONION (*Allium cepa* L.) SEEDS USING VIGOUR TESTS

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The predictive values of standard and non-standard germination temperatures, standard accelerated ageing (AA) and saturated salt accelerated ageing (SSAA) tests were investigated. Germination tests were performed at standard and non-standard temperatures of 10°, 20°, 20°/30° and 30°C for cabbage, and 10°, 15°, 20° and 30°C for onion respectively. The AA and SSAA tests were conducted using four relative humidities: standard AA (RH100), NaCl (RH75), $Ca(NO_3)_2$ (RH43) and $MgCl_2$ (RH32). Emergence trials were also conducted at varying temperatures (winter, 15°/25° and 30°C) and media (Hygromix and soil) using seedling trays. Correlations were calculated to evaluate the relationship between laboratory and emergence test results. There were vigour differences among different seed lots of cabbage and onion seeds used in this study. Using the different laboratory tests, seed lots were distinguished as high, medium and low vigour seed lots. For both crops a low temperature germination test (10°C) was found to be good for separation of seed lots according to their vigour levels. All SSAA vigour tests were also useful in differentiating seed lots based on their physiological stage of deterioration. Using the standard AA (RH100) the seed moisture content was high (29 to 45%), resulting in fungal growth. However, in the SSAA test the moisture content was below 14% and no fungal growth was observed. For both crop seeds, there was no significant difference in the percentage emergence between the two growth media. For cabbage, highly significant correlations were obtained between germination percentage at 10°C and RH32 and all emergence trials. However, in onion, the correlations were not consistent; highly significant correlations were observed from germination capacity (GC), 15°C, 20°C, 30°C, RH75 and RH32; and emergence parameters at specific conditions. The germination rate parameters: MGT (mean germnation time) and GI (germination index) were valuable in categorising seed lots with moderate vigour levels, however, except GE all other germination rate characters failed to correlate with any emergence parameters.

Keywords: Cabbage, onion, Saturated Accelerate ageing, seed vigour

A KEY TO SOIL GROUPS AND CONCEPTUAL NOMENCLATURE FOR FORMS AND FAMILIES IN THE SOUTH AFRICAN SYSTEM OF SOIL CLASSIFICATION

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Having only a few classes at the highest level simplifies soil classification and affords more opportunities for generalisation. International classification systems such as Soil Taxonomy and the World Reference Base (WRB) employ a key which permits unambiguous identification of the soil order or reference soil group by a process of elimination. A similar scheme is presented here for organizing the 73 soil forms of South Africa into a dozen groups (Organic, Humic, Vertic, Melanic, Silicic, Calcic, Duplex, Podzolic, Oxidic, Plinthic, Hydromorphic and Inceptic, with the last group being further divided into cumulic, lithic and anthropic sub-groups) using nomenclature that is internationally familiar while at the same time being based on key diagnostic horizons as defined in the SA system. The nomenclature has been extended to cover soil forms and families by making use of qualifier terms similar in concept to those in the WRB and Soil Taxonomy but defined according to diagnostic criteria currently in local use. This conceptual nomenclature should (i) provide more intelligible legends for soil maps (ii) conceivably facilitate future revision of the classification system by encouraging the use of WRB-style qualifiers and (iii) universalize local classification while preserving its essential structure and consequently the usefulness of existing soil maps. The twelve soil groups have provided the basis for a systematic account of SA soils (their properties, geography, genesis and use), which is currently in preparation.

Keywords: Soil classification

SPATIAL DISTRIBUTION OF MANGANESE IN SOILS IN THE PROXIMITY OF THE KGWAKGWE MANGANESE OXIDE ORE ABANDONED MINE, BOTSWANA

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Pressing demand for use of uncultivated land for agricultural purposes was the rationale behind this study. Its primary aim was to establish the spatial distribution of manganese (Mn) concentrations in the surface soil within the proximity of manganese oxides (Mn oxides) ore abandoned mine in order to determine the suitability of the land for agricultural activities. Four hundred soil samples were obtained from a 4 km^2 area close to the Kgwakgwe Mn oxides ore abandoned mine, Kanye, South eastern . The determination of Mn concentrations after acid digestion of samples was performed on a Varian Spectra AA-220 FS atomic absorption spectrometer (Varian,) equipped with a deuterium background correction. Results were processed using Geographical Information Systems (GIS), and Remote Sensing (RS) techniques with the int egrated Land and Water Information System (ILWIS), Geosoft Oasis Montaj and ArcGIS software packages. Microsoft Excel was used for statistical and graphical presentation of data analyses. The range of concentration levels of Mn in soils was 35 *m*g g^{-1} to 24907 *m*g g^{-1} with a mean of 1088 *m*g g^{-1}. The gridded soil maps for Mn concentrations show anomalies in different parts of the study area. Manganese concentrations were high at the mine workings and in the northwestern part of the study area. A model is suggested for the Mn int erplay in the soils within the proximity of the Kgwakgwe abandoned Mn oxides ore mine. The predominance of Mn in the soil renders the land unsuitable for commercial agriculture. Nonetheless, it could be used for subsistence agriculture.

Keywords: contamination, manganese, spatial distribution, soils, subsistence agriculture

INTRODUCING SATELLITE AND CLIMATOLOGICAL PRODUCTS TO IMPROVE AN EXISTING MAIZE YIELD ESTIMATION SYSTEM

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After deregulation of the agricultural markets in South Africa in 1997, the estimated maize crop could no longer be verified against the actual crop, due to a lack of control data from the marketing boards. This drove the need to explore remotely sensed data as a supplement to the current crop estimation methodology for improved crop estimations.

Input data for the development of a GIS-based model consisted of point data extracted from three spatial datasets. Rainfall grids were generated from station data. NDVI (Normalised Difference Vegetation Index) values from the MODIS (Moderate Resolution Imaging Spectrometer) sensor aboard the Terra platform were extracted. Objective yield point data from field surveys were available for two growing seasons.

Relationships between MODIS NDVI, age of the maize plant, objective yield and rainfall values yielded satisfactory coefficients of determination (r^2). Results suggest an alternative to the traditional method of using the mean NDVI for several districts in a region over a growing period of 11 months. Current remote sensing-based methods of crop monitoring in South Africa do not accommodate the range of planting dates over the whole of the country for maize. Maize production areas extend over seven provinces with eight different temperature and rainfall zones. Planting date zones were established based on uniform age of the maize plants. These were identified from the planting dates obtained from the objective yield data and expanded with MODIS data. MODIS imagery proved to be affordable and covers the whole of South Africa daily. Several recommendations such as establishing different yield equations in the different zones for a normal, dry and wet season were made. It is also suggested that irrigated and dryland areas be evaluated separately.

Keywords: Maize, MODIS, GIS, Remote Sensing, estimates, yield

AN OVERVIEW OF THE ENVIRONMENTAL AND SOCIO-ECONOMIC CONTRIBUTION OF PALM GEOTEXTILES TO SUSTAINABLE DEVELOPMENT AND SOIL CONSERVATION

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Field and laboratory investigations suggest that geotextile mats, manufactured from palm leaves, are an effective, sustainable, cheap and economically viable soil conservation method. A three-year (2005-08), EU-funded, research programme (Project acronym: Borassus; contract: INCO-CT-2005-510745) is currently evaluating their long-term effectiveness in controlling soil erosion and, moreover, assessing their sustainability and economic viability. The Project is based in Europe, Africa, South-East Asia and South America. The technique is novel and offers new bioengineering solutions to environmental problems. Multi-faceted environmental benefits include technologies for sustainable plant production, sustainable use of indigenous plants, improved ecosystem management, decreasing deforestation, improved agroforestry and cost-effective geotextile applications in diverse environments. Palm geotextiles improve socio-economic foundations for sustainable development and the benefits for developing countries include poverty alleviation, engagement of disadvantaged groups as stakeholders, employment for disadvantaged groups, SME (small and medium enterprise) development, earning hard currency, environmental education and local community involvement in land reclamation and environmental improvement programmes. These benefits are achieved through: (a) Promotion of sustainable and environmentally-friendly palm agriculture to discourage deforestation, promoting both reforestation and agroforestry, and offer a potential for commercial development; (b) Construction of palm geotextiles to develop into a rural based labour-intensive industry, particularly encouraging employment of socially disadvantaged groups. In turn, this contributes to the stabilization of rural populations, thus decreasing migration to urban areas; (c) Export of completed palm geotextiles to industrialized countries earns hard currency for rural developing economies, based on the principles of fair trade; and (d) Application of palm geotextiles is especially beneficial for complex engineering problems, as temporary application of geotextiles allows sufficient time for plant communities to stabilize engineered slopes.

Keywords: geotextile, soil conservation technology, soil erosion, agroforestry, slope stabilization, socially disadvantaged employment

COMPARISON BETWEEN TRADITIONAL AND SCIENTIFIC IRRIGATION SCHEDULING PRACTICES FOR FURROW IRRIGATED POTATOES IN ETHIOPIA

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Small-scale traditional irrigation schemes make up about 40 % of the total irrigated land in Ethiopia. Despite this, the sector has been overlooked and is not supported at all by improved water management technologies. Due to land and water resource shortages and the need for food self-sufficiency in the region, it has become essential to improve the productivity of this sector. The current farmer practices at one of the representative schemes, Godino, were evaluated during a survey. Preliminary survey results revealed that farmers of this scheme were applying the same amount of water at a fixed interval, despite crop type and stage of maturity. . In view of this, an experiment on potato (*Solanum tuberosum* L.) was established at Debre-Zeit Research Centre comparing two traditional irrigation regimes with the newly developed soil water balance calendar scheduling method (SWB), and the conventional neutron probe soil water measurement (NP). The experiment was arranged in a randomized complete block (RCBD) design with four replications. Four irrigation regime treatments were applied under furrow-flood irrigation and plant sampling for dry mass analysis was undertaken on a weekly basis. Results of the leaf dry mass (LDM), canopy dry mass (CDM) and total dry mass (TDM) indicated that the NP and SWB irrigation treatments were significantly superior ($P<0.05$) to the traditional water application methods, with LDM the overriding parameter responding to adequate water application. The canopy covers of the treatments also substantiated these results, where fractional interception of the PAR was significantly higher for the NP and SWB treatments, compared with traditional practices. The NP and SWB treatments appeared to perform similarly with regard to dry mass yield. Results for the fresh potato yield also followed a similar trend to that of the dry mass yield, where the traditional irrigation practices were inferior by about 25 % to both the NP and SWB treatments. There was no significant difference between treatments for leaf area index, specific leaf area and number of stems. The over all result showed that the traditional irrigation practices were not performing to the water demand of the potato crop for adequate yield and quality production. This emphasizes the need for introducing new effective and efficient irrigation scheduling practices at the Godino scheme. The best performing treatment, NP is tedious and unaffordable by individual farmers. The SWB method which had a similar performance to NP, is simple to use at farmer skill level, and economically affordable. It is suggested that this method be introduced both to the Godino scheme and the adjacent Debre-Zeit Agricultural Research Centre (DARC). Therefore, the extension staff at DARC can generate SWB calendars for specific site and different crop requirements of farmers on the scheme.

Keywords: Potato yield, Traditional irrigation practice, Irrigation scheduling, Furrow irrigation

EVALUATION OF REMOTE SENSING PRODUCTS FOR CROP YIELD PREDICTIONS

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Crop production is one of many elements of food security. In order to find out how much food is produced at a specific time, it is important to determine early in the growing season which crops were planted, what area of land was planted per crop and what the predicted yield is.

Since satellite imagery is available, this study aimed to evaluate the use of remote sensing products for improving the spatial modelling prediction of maize and wheat yields. NOAA-AVHRR (National Oceanic and Atmospheric Administration - Advanced Very High Resolution Radiometer) and MODIS (Moderate Resolution Imaging Spectroradiometer) imagery were used for predicting crop yield, while point data from the objective yield surveys were used to evaluate the accuracy of predictions. The methodology made use of planting dates to align time series data in order to compare the NDVI (Normalized Difference Vegetation Index) and EVI (Enhanced Vegetation Index) over time for plants of the same age. Differences in the planting date (early, intermediate and late) relating to the growth period (long, medium and short) are highlighted in this methodology.

The changes in NDVI or EVI over the growing season can be used to predict expected yield if the planting date is known. This methodology will predict if the expected yield will be above or below the average. Averages were determined per region for wheat and per planting time for maize. The yield can be predicted from 64 days after planting for maize and from 48 days after planting for wheat.

The methodology will be very useful to supply the National Crop Estimates Committee with additional information for their estimates at provincial level.

Keywords: Maize, Wheat, Yield, Remote sensing, NDVI, EVI

THE EFFECT OF RESISTANT SORGHUMS ON APHID POPULATION DEVELOPMENT

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Two of the most common aphid genera that occur on sorghum in are *Schizaphis graminum* (Aphididae: Homoptera), and *Melanaphis sacchari* (Aphididae: Homoptera). Resistance to one aphid species and susceptibility to another is an unfortunate but not unusual phenomenon among crop cultivars. The aim of this study was to evaluate population dynamics of *Schizaphis graminum* and *Melanaphis sacchari* on resistant and susceptible sorghums and thereby determine the possible mechanism of resistance. Sixteen sorghum cultivars were evaluated for resistance to aphids by determining the duration of the reproductive period and number of progeny produced per female. Two to three weeks after emergence, the seedlings were infested with a single aphid per plant. Aphids were confined in clip-cages. The number of nymphs produced were counted and removed daily until the female died. The total number of days survived by the aphids were the same for twelve varieties, while two were significantly higher and two lower. The aphid population development studies were repeated on these four sorghum varieties. On susceptible cultivars *M. sacchari* progeny was 2,96 nymphs per female per day, and on resistant cultivars 0,13 nymphs per female per day. The life duration of aphids was influenced by plant resistance. Aphids survived between 5-16 days on susceptible cultivars and between 3-4 days on resistant cultivars.

Keywords: Schizaphis graminum , Melanaphis sacchari , Sorghum, Population development, Resistance

ESTIMATION OF PHOSPHORUS REQUIREMENTS OF SOME SOILS FROM THE TRANSKEI REGION, SOUTH AFRICA USING SORPTION ISOTHERMS

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A good understanding of a soil's phosphate sorption capacity is important for predicting crop response to added P and for identification of appropriate P management strategies. This study was therefore conducted to determine the phosphate sorption properties of selected soils from the Transkei region of South Africa, and to relate the derived sorption values to selected soil parameters using simple regression and correlation analysis. A further objective of this study was to estimate the P requirements for those soils, based on the standard P requirement (SPR) indices calculated from the Langmuir equation. Sorption behaviour was adequately described by the classical Langmuir sorption model, with Langmuir coefficients of determination (r^2) values >0.95 observed for all the soils under study. Sorption isotherms for the seven soils showed that the soils differed considerably in sorption characteristics, which was evident from the sorption equations and sorption parameters. The Langmuir sorption maxima (S_{max}) ranged from 192.3 to 909.1 (mg P kg^{-1}) and were highly and positively correlated with the affinity b constant (r=0.931, p=0.001) and total C (r=0.706, p=0.001). The quantity of P sorbed by the soils followed the trend: Flagstaff > Chevy Chase > Ntlonyana > Ncihana > Kwalu > Qweqwe > Qunu. The Langmuir adsorption affinity constant, b was smaller for Kwalu, Qweqwe and Qunu suggesting that P was more loosely bound to the soil surfaces and should be more available to plants. The amount of added P sorbed by the soils to maintain a soil solution concentration of 0.2 mg P L^{-1} ranged from 21.2 to 180.5 mg P kg^{-1} soil and was positively correlated with exchangeable acidity (r=0.946, p=0.001). Generally soils collected from Qweqwe, Qunu, Ncihana and Kwalu had lower standard P requirement values and thus could be classified as lower sorbers whereas, soils from Ntlonyana, Chevy Chase and Flagstaff are moderate sorbers.

Keywords: P-sorption, S-max, Standard P requirement, Sorption Isotherms

THE EFFECTS OF GOAT MANURE ADDITION ON PHOSPHATE SORPTION CHARACTERISTICS OF TWO SELECTED SOILS FROM THE TRANSKEI REGION, SOUTH AFRICA

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Addition of organic residues such as animal manures to acid soils has previously been reported to have a similar effect to that of lime and a r esulting reduction in P sorption capacity. The objective of this study was to investigate the effect of partially decomposed goat manure on phosphate sorption characteristics of two soils from the Transkei region of South Africa, selected for their high P sorbing capacity. Treatments evaluated consisted of a c ontrol, three rates of goat manure (5, 10 and 20 t ha^{-1} on a dry weight basis) and a lime treatment (applied to raise soil pH to ~6.5). The amended soil samples were mixed, moistened to 75% field capacity and incubated for 84 days. Destructive sampling was done on days 0, 7, 14, 28, 56 and 84 for P sorption determination. Addition of the partially decomposed goat manure or lime to both soils had an immediate effect on soil pH. The soil solution pH of amended soils increased over that of unamended soils. The effect persisted for the entire 84 day s of incubation and w as most pronounced in soils amended with lime. The pH increases were, however, much higher for the Chevy Chase than for the Flagstaff soil, probably indicating higher soil buffering capacity for the Flagstaff soil. Amending the soil with goat manure consistently reduced P sorption maxima, affinity constant, and P sorbed at 0.2 mg P L^{-1} in both soils relative to the control. The magnitude of decrease of P sorption maxima induced by goat manure was relatively small, but consistent, in both soils. The highest reductions in P retention among the manure treatments were observed on the Chevy Chase soil (25.8% reduction) on day 28 where the soils had been amended with 20 t ha^{-1} of goat manure, but lime was superior with a 34.8% reduction that occurred on day 84. Application of 20 t ha^{-1} of goat manure also consistently lowered sorption affinity constants and standard P requirement (SPR) values compared with other treatments for the Flagstaff soil, whereas the SPR values were lower in the lime treatments for the Chevy Chase soil. Lime addition to the Flagstaff soil resulted in higher amounts of P sorbed compared to the control treatment during the first 28 days. The results of this study indicated that the two soils reacted differently to the amendments applied and would therefore require different management strategies. The agronomic and environmental implications of the results are that the use of goat manure may allow lower levels of commercial phosphate fertilizer use, because of reduced P sorption and increased soil solution P.

Keywords: P-sorption, S-max, Standard P requirement, Goat manure

SEEDING RATES FOR WHEAT IN THE WESTERN CAPE: DO WE NEED TO ADJUST OUR RECOMMENDATIONS?

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Recommended seeding rates for the winter rainfall region of the Western Cape province range from 100 kg to 140 kg seed per hectare. The recommendations are based on seeding rate trials conducted in the 1970's and 1980's. The trials included both row and broadcast seeding within conventional tillage practices. Row planting was most commonly done with 178 mm inter-row spacing. Within such row spacing, plant populations of 107 to 243 plants m^{-2} would be expected to ensure yield potentials from 1.0 to 4.0 tons of grain ha^{-1} respectively. The results of local research corroborate the results of numerous seeding rate trials conducted in similar environments in Australia. However, the recommendations are now being questioned by producers who have converted to conservation farming systems with no-till planting using inter-row spacings that range from 220 to 300 mm. The objective of the research presented in this paper was to determine the effect of seeding rate on grain yield of wheat in a conservation farming system using a lucerne-grain crop rotation and no-till planting with a 260 mm inter-row spacing.

Data were collected over three seasons. Conventional no-till farm implements were used. Gross plot size was 210 m by 9.2 m. Normal agronomic practices were implemented as determined by the specific season. In the first season a non-replicated demonstration (using cv. SST 57) indicated no difference in grain yield at seeding rates ranging from 40 to 70 kg of seed ha^{-1}. The second season's replicated seeding rate trial (using cv. SST 57) showed a higher ($P<0.05$) grain yield at 40 kg seed ha^{-1} than at 70 kg seed ha^{-1}. In the third season, twenty plots were planted to wheat (SST 88) to provide a range in plant populations from < 50 to > 250 plants m^{-2} (seeding rates from < 40 to > 140 kg ha^{-1}). Plant populations (plants m^{-2}) were determined at 40 days after emergence. Tiller and ear densities (plant^{-1} and ha^{-1}), grain yield (kg ha^{-1}) and yield components (thousand kernel mass [TKM], kernels per ear) were determined just prior to and after harvesting. As expected, plant density increased with increased seeding rate. Ear density (ears m^{-2}) increased asymptotically ($P<0.01$) while the number of ears plant^{-1} decreased ($P<0.05$) with increasing plant population. TKM and number of kernels ear^{-1} decreased ($P<0.05$) with increasing ear density. Due to this negative correlation between ear density and both TKM and kernels ear^{-1}, grain yield was not affected ($P>0.05$) by plant or ear density. Grain yield was also not related ($P>0.05$) to the TKM or number of kernels ear^{-1}.

These results clearly show the wheat plant's physiological and phenological ability to adapt to decreased plant populations by increasing ear density, number of kernels per ear and TKM towards maximising grain yield if soil and climatic conditions are favourable. Further research within conservation farming systems, no-till, wide-row seeding practices, to quantify the effect of soil potential, climate and cultivar is required for efficient wheat production under winter rainfall conditions.

Keywords: Thousand kernel mass

BACKGROUND TO METAL LIMITS FOR THE NEW SOUTH AFRICAN GUIDELINES ON AGRICULTURAL USE OF SEWAGE SLUDGE

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For the past seven years sludge guidelines in South Africa have been the centre of much debate. The WRC initiated a research programme in 2000 to further develop the knowledge base for the management of sewage sludge in the South African context. Although the results of these research projects do not give all the answers, they enabled the formulation of the "Guidelines for the Utilisation and Disposal of Wastewater Sludge". The aim of this paper is to give background to the new pollutant class for wastewater sludge and the metal limits for soils for agricultural use.

To enable scientists to speak the same language in terms of the environmental risk of metals, it is necessary to standardize on analytical methods and apply specific protocols. For the purposes of appraising contamination of soils and sludge, the "so-called" total content (*aqua regia* digestion method) is determined as an expression of the maximum hazard potential. The information derived from the total metal content of soils, however, is useful only to a limited extent in the investigation of ecological issues and hazard assessment. Therefore, immediately available and mobile metal content needs to be determined (NH_4NO_3 extraction method). This method gives a better indication of actual risk and removes some of the uncertainty in environmental risk prediction.

Since the metal limits set in the US EPA Part 503 rule have been researched extensively and recorded in a scientific background document and were recently re-assessed, they were used for the pollutant class classification of South African sludge. They comprised Pollutant class a (use without restrictions), Pollutant class b (use with restrictions) and Pollutant class c (not permissible for agricultural use). A further precaution has been introduced using soil metal limits for agricultural use of Pollutant class b sludge, taking into account natural background levels of South African soils as well as the previous sludge guidelines and new research data. It includes a total investigative level (agricultural use permissible), total maximum threshold (additional sludge applications are not allowed) and a maximum available threshold based on NH_4NO_3 extractions.

The limits set for metals in soils, as well as the monitoring of the soils which receive sludge, will help to protect the environment and increase our knowledge of availability of metals in sludge-applied soils in order to further improve the guidelines with time. By promoting the use of sludge in agriculture the positive effects of the sludge are used beneficially and the number of dedicated land disposal sites can be decreased.

Keywords: guidelines , wastewater sludge, metal limits

COTTON : FOUR YEARS OF COLLABORATION IN RESEARCH ON SMALL-SCALE COTTON FARMING SYSTEMS

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Cotton was introduced in South Africa in the 19th century and is mainly produced by large-scale commercial farmers in five provinces: Limpopo, Mpumalanga, KwaZulu-Natal, Northern Cape and North-West. Nevertheless, it has been demonstrated that cotton is an excellent cash crop for small-scale farmers in the sub-Saharan regions. In South Africa, about 3 000 small scale farmers (mainly in KwaZulu-Natal) adopted the crop as their main resource. In 1997, the first transgenic cotton seeds were released in South Africa. Nowadays, 95% of these small-scale farmers are using transgenic cotton varieties containing the Bt-gene. It is the aim of this poster to inform people in the crop science field about the research that has been done on cotton in a collaborative project between CIRAD and the University of Pretoria. The emphasis was placed on the impact of transgenic cotton on yields, identifying and generation of agricultural management practices in small-scale cotton cultivation, and the biosafety of transgenic cotton crops. A one-day seminar on the results will take place during October 2006.

Keywords: Bt-cotton, cotton, gene-flow, small-scale farmers

A COMPARATIVE STUDY IN SOIL EROSION BETWEEN LITHUANIA AND SOUTH AFRICA

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The processes of soil erosion, as a s econdary stage of terrestrial erosion, are governed by natural climatic factors such as wind and water. They depend on t he properties of soils and rocks and can be changed by flora and fauna. The processes of accelerated soil erosion are associated with human activities and are known either as mechanical soil erosion or tillage erosion. Soil erosion becomes a problem when human activity causes it to occur much faster than under natural conditions (http://www.botany.uwc.ac.za/Envfacts/facts/erosion.htm). An overview of conditions conducive to soil erosion in Lithuania and some views relating to conditions in South Africa will generate an understanding of similarities and differences of soil erosion problems in both countries, which represent temperate and semi-arid climate zones, respectively. The Combined Congress of GVSA and SSSSA will give us a chance to discuss the differences in climate, soil and landscape that influence soil erosion processes.

Lithuania is mainly a lowland country, but has two upland regions. About 52% of relief in Lithuania consists of undulating hills, where the soil is erodible. About 17% of agricultural land is eroded, increasing to 43-58% in the hilly regions. Water erosion rates on sloping clay loam soils of the Baltic Uplands in Lithuania vary from 1.3 t ha^{-1} yr^{-1} under cereal grain crops to 56.6 t ha^{-1} yr^{-1} on bare fallow soils. On the Zemaiciai Uplands the annual rates of water erosion on agricultural land are 9.4-9.7 t ha^{-1} yr^{-1} on slopes of 10-14^0, 6.0-6.2 t ha^{-1} yr^{-1} on slopes of 5-10^0 and 2.8-2.9 t ha^{-1} yr^{-1} on slopes of 2-5^0 .

South Africa is a land of contrasts with a great variability in climatic zones, topographic positions, geological substrates and land management practices, which individually and combined influence soil erodibility. Climatic conditions, for example, vary from hyper-arid in the Kalahari Desert to subtropical along the border with Mozambique and the geological history records an extreme in rock types from the early Archaeozoic to the present (http://en.wikipedia.org/wiki/Southern_Africa,). Soil erosion is one of southern Africa's major environmental problems. It degrades agricultural land and reduces crop yields. There is no single average figure for soil erosion in southern Africa, but soil loss rates vary from less than 1 t ha^{-1} yr^{-1} to over 200 t ha^{-1} yr^{-1} (http://www.sardc.net/imercsa/Programs/CEP/Pubs/CEPFS/CEPFS01.htm). Annual soil loss in South Africa is estimated at 300-400 million tonnes, nearly three tonnes for each hectare of land. Wind and water are the main agents of soil erosion (http://www.botany.uwc.ac.za/Envfacts/facts/erosion.htm).

Keywords: Soil erosion, Temperate Climate, Semi-arid Climate, Soil properties, Landscape

REACIDIFICATION RATES OF LIME-AMENDED SOILS IN A SMALL-SCALE FARMING AREA IN THE MPUMALANGA PROVINCE

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Although soil acidity amelioration through liming is an accepted practice, the initial cost of liming makes the investment a daunting proposition for many farmers. The longer the beneficial effects of lime persist, the more economically favourable the investment becomes. Therefore, for lime application strategies to be effective, the longevity of liming responses and the frequency of lime inputs should be determined. The objectives of the study were to determine (i) the buffer capacity, and (ii) the soil acidification rates, of two lime-amended soils in the Mlondozi district of Mpumalanga.

Liming experiments, lasting five and six years, were set up on an Oakleaf and Hutton soil, respectively. Six lime and fertilizer treatments with three replications were arranged in a randomized block design. The lime treatments consisted of a control, 5 and 10 tons of dolomitic lime ha^{-1}. The lime was applied via once-off broadcast applications in September 1997 and 1998, and ploughed in. Topsoil samples (0 - 250 mm) were taken annually in March, and prepared for analysis according to standard procedures. Potentiometric titrations were performed on the two experimental soils, equilibrated overnight with 1M KCl, and the pH buffer capacity (pHBC) was calculated. The reacidification rates of the soils were calculated by determining the relationship between soil acidity properties (soil pH (H_2O), extractable acidity and acid saturation) and basic cations (Ca^{2+} + Mg^{2+}).

The pHBC of the Hutton and Oakleaf soils were 0.648 and 2.494 cmol kg^{-1} $(pH)^{-1}$, respectively. The higher pHBC of the Oakleaf soil is due to the higher organic carbon content of the soil. The pH (H_2O) reacidification rate for the Hutton soil varied from -0.03 for the unlimed treatment at an initial pH (H_2O) of 5.19 to -0.22 pH (H_2O) unit yr^{-1} for the 10 ton lime treatment at a maximum pH (H_2O) of 6.54. The exctractable acidity and acid saturation reacidification rates in the Hutton soil varied from +0.03 to +0.25 cmol (+) kg^{-1} yr^{-1}, and +0.61 to +4.92 % yr^{-1} at the 0 and 10 ton lime rates, respectively. The pH (H_2O) reacidification rates for the Oakleaf soil varied from +0.02 for the unlimed soil at an initial pH (H_2O) of 4.39 to 0.08 pH (H_2O) unit yr^{-1} for the 10 ton lime rate at a maximum pH (H_2O) of 5.03. The exctractable acidity and acid saturation reacidification rates in the Oakleaf soil varied from -0.01 to +0.05 cmol (+) kg^{-1} yr^{-1}, and -1.48 to +5.99 % yr^{-1} at the 0 and 10 ton lime rates, respectively. The rate of acidification depended on the rate of lime application. As the lime rate increased the acidification rate increased. Acidification rates could be used to determine the risk of soil reacidification and serve as an indicator to adapt management practices to reduce soil acidification.

Keywords: pH buffer capacity, liming, reacidification rate

REDOX BEHAVIOR IN A SOIL OF THE KROONSTAD FORM IN THE WEATHERLEY CATCHMENT, EASTERN CAPE PROVINCE

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The redox condition of soil water plays a primary role in soil formation. Redox reactions occur under subsoil saturation as the oxygen is depleted by the metabolising microbes. The soil enters an anaerobic phase. Fe^{3+} is reduced to soluble Fe^{2+}. The Fe^{2+} is redistributed as it migrates from reducing to oxidising conditions where it precipitates and forms a mottle. It can also be leached to initiate ferrolysis resulting in the degradation of silicate clays. The qualitative methods of interpretation of soil water regime using soil morphology are well known, but little is known about redox behaviour.

A soil of the Kd 1000 family (orthic A, E and G horizon), a typical gleyed soil, was described and analysed. Rainfall was measured at an automatic weather station. Neutron water meter readings was done weekly. A pipe was inserted with the perforated bottom end in the middle of each diagnostic horizon. Samples were collected weekly from the pipes by extracting water from the bottom of the pipe. Dissolved Fe concentrations were determined.

The Fe^{2+} concentration in the soil solution was found to be considerably higher in the E horizon than in the orthic A or G horizons. Contrary to what was expected the horizons often reacted independently to each other. The orthic A horizon's reaction is largely affected by the intensity and duration of rainfall event. Bigger showers of high intensity (> 20 mm d^{-1}) had little or no effect on the Fe concentration of the A horizon. Continuous, low intensity rainfall events had a greater effect.

Reaction of the Fe concentration in the E horizon could not regularly be linked to a rain event. The reason could be that the change in Fe concentration is caused by water entering laterally into the profile from adjacent saprolite and soils. This water could have been in a freatic water table for quite some time and contains reduced substances. In some of the events there is a lag of 7 to 20 days between reactions in the orthic A to the E horizon.

Improved understanding of redox behaviour of soils can improve land suitability evaluation and the classification of soils.

Keywords: Dissolved iron, orthic A horizon, E horizon, G horizon, rainfall intensity, gley

CHARACTERIZATION OF THE MPUNDU/WESTLEIGH-HELENA ECOTOPE

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Effective evaluation of sustainable land use is primarily based on the smallest production unit, i.e. the ecotope. An ecotope can be defined as an area of land on which the natural resources (climate, soil and topography) are homogenous. For effective evaluation of sustainable land use, ecotope characterization is imperative since it incorporates the three natural resources that affect productivity. It is not feasible to do detailed research on every ecotope used for crop production in the country. To maximize research efficiency, benchmark ecotopes should be selected. To ensure efficient extrapolation of the results on these ecotopes to others (pedotransfer actions), it is important that the main ecotope that affects productivity be characterized in detail. Crop growth models are initially calibrated against these units.

The Mpundu/Westleigh ecotope was characterized in detail with respect to slope, long-term climate data and soil characteristics. A profile pit was dug and a detailed soil profile description was done. Samples of the topsoil and subsoil were taken and analyzed for clay percentage, exchangeable cations, cation exchange capacity (CEC), pH (H_2O & KCl), organic carbon and phosphorus (Bray 1). Bulk density samples were also taken with a core sampler. The climate (rainfall, temperature, sunshine, wind and atmospheric moisture) was analyzed using long-term data and the slope was estimated with the use of a Global Positioning System (GPS). The mean annual temperature is 16 °C with the maximum temperature peaking at 30 °C in February and the minimum of 6 °C occurring in July. Long-term climate data shows that the mean annual rainfall is 608 mm of which 69 % occurs during the summer months, leaving the winter generally dry and cold. This selected ecotope represents large areas of the villages in the Eastern Cape Province. The slope of the ecotope is 5 %. The bulk density of the topsoil is 1.83 g cm^{-3} while the subsoil is 1.92 g cm^{-3}. The soil has 20 % clay content in the topsoil and 25 % in the subsoil with a clear transition.

Keywords: soil characterization

EFFECT OF SEQUENTIAL HARVESTING AND STORAGE ON SENSORY AND STORAGE QUALITY OF ORGANICALLY GROWN LANDRACE POTATOES (*Solanum tuberosum*)

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Effective storage of potatoes is essential to satisfy consumer expectations of quality. This study investigated the effect of storage practices on the quality of potatoes produced by small-scale organic farmers of the Ezemvelo Farmers' Organisation in KwaZulu-Natal, a province of South Africa . A Preference Ranking test was used to find out if panellists could differentiate steamed organically produced potatoes stored in situ, under ambient conditions on the farm and in a controlled environment (7 ^{o}C and 90% relative humidity) for two, four and six weeks. Potato firmness, reducing and total sugar content, specific gravity, total starch and dry matter content were measured. Potatoes left in situ were the more preferred by the panellists ($p<0.01$) and were firmer than those stored in other conditions. Dry matter content and the specific gravity of potatoes stored under the three conditions were not significantly different. Leaving potatoes in situ is seemingly an efficient storage option for resource deprived small scale farmers.

Keywords: potato, sensory evaluation, sequential harvesting, keeping quality, dry matter content, organic production

COMPARING DIFFERENT INTEGRATED SOIL FERTILITY MANAGEMENTS FOR SMALL-SCALE FARMING

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Studies were conducted on a porous, low fertility, sandy loam, representative soil of the Roma valley to identify the best integrated soil fertility management for small-scale farmers in the same area. The soil represented soils that occupy about two thirds of the arable land in that region. The adoption of chemical fertilizers is very poor because of their high cost which makes them unaffordable for use by small-scale farmers with limited financial resources. Therefore, there is a need to find alternative soil amendments that can improve the fertility status of the soils but which are cheaper and readily available. All the studies were *in situ* experiments. Prior to the experiments, the soil was pH 5.0, had an average available P (Bray-1) of 11ppm, 1.22 %OrgC and 17% gravimetric field capacity. In the first study the soil was treated with basalt crusher dust, cattle manure and green legume manure in a factorial experiment. In the second experiment, non-factorial, the soil was treated with different types of manure, viz. cattle manure, goat and sheep manure, and farmyard manure (a compost mixture of cattle/goat/sheep manure and all farm organic wastes). The third, factorial experiment consisted of two treatments, viz. lime at 0, 8.5 and 12.75 tons/ha and fertilizer (2:3:2 (22)) at 0 and 300 kg/ha. Thus, the first and second experiments utilized locally and readily available fertilizer materials, whereas the last one utilized imported and expensive chemical fertilizer. Analyses of pH and available P were common for all the studies while %OrgC and N (available/total) were common for the last two. In the first study, green legume manure and cattle manure individually significantly improvemed % OrgC but the highest %OrgC was obtained with the combination of green legume manure and minimal basalt. Basalt alone increased the WHC and pH, and when it was combined with cattle manure its effect on pH was even greater.. Available P and N were only increased by cattle manure alone. Application of different types of manure increased pH, %OrgC, available P and total N relative to control. Except for pH where all the three types of manure were equally significant, poultry manure performed better than cattle manure and farmyard compost in most cases. In general, lime and chemical fertilizer ranked highest, raising pH to as high as pH 7.0 and available P to 345 ppm, but this was the expensive and unaffordable management method not suitable for this region. The different types of manure raised pH to 6.8, available P to 116 ppm and % OM to 8.4 – 9.5 while the basalt plus cattle manure raised pH to 5.6 and available P to 47 ppm. Basalt and greenlegume manure increased %OM to 2.1. It was concluded that use of animal manure, especially poultry manure was the cheapest and most efficient method for soil fertility management of the low fertility soils of the Roma valley, particularly for small-scale farmers.

Keywords: soil fertility improvement , animal manure, basalt crusher dust, liming, green legume manure

INFLUENCE OF LONG-TERM WHEAT RESIDUE MANAGEMENT ON ORGANIC MATTER CONTENT OF AN AVALON SOIL IN THE EASTERN FREE STATE

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Awareness of the environmental aspects of soil quality and crop production has been increasing in recent years, which has led to renewed interest in crop residues as a source of soil organic matter and nutrients for crops. Crop residue management is known to both directly or indirectly affect soil quality and therefore soil fertility. This study was initiated to determine the influence of different wheat residue management practices, that were sustained for about 20 years, on some fertility indicators of an Avalon soil in a long-term wheat trial at the ARC-Small Grain Institute near Bethlehem in the Eastern Free State. This trial also offered an opportunity to establish whether differences in wheat grain yield could be attributed to changes in the soil fertility indicators. The treatments that were applied are two methods of straw disposal (burned and unburned) x three methods of tillage (ploughing, stubble mulch and no tillage) x two methods of weed control (mechanical and chemical). Soil samples were collected at depth intervals of 0-50, 50-100, 100-150, 150-250, 250-350 and 350-450 mm from the 30 kg N ha^{-1} plots for analysis, reducing the number of treatments to 12. Organic C and total N, as indices of organic matter, were then determined on these samples. The effect of either straw burning or weeding method on organic matter in this Avalon soil were small compared to that of tillage practice. A slightly higher organic C and lower total N content were measured in the unburned compared with burned plots to a depth of 450 mm. The tillage practices affected organic C and total N significantly in a similar manner to a 100 mm depth. In this upper 100 mm the organic matter content of no-tilled plots was the highest, followed in decreasing order by the mulched and ploughed plots. The organic matter content of the chemically-weeded plots was significantly higher than that of the mechanically-weeded plots to a 100 mm depth, as indicated by organic C and total N. Significant interactions between the treatments on either organic C or total N were almost absent. However, based on these two indices to approximately 150 mm depth, ploughing combined with mechanical weeding resulted in the lowest organic matter content, whereas no tillage combined with chemical weeding resulted in the highest organic matter content. The latter combination is therefore recommended to maintain and even increase the organic matter content of this Avalon soil when cropped annually with wheat.

Keywords: Organic carbon, straw disposal, tillage practices, total nitrogen, weed control

A SURVEY OF PANICLE-FEEDING HEMIPTERA IN SORGHUM FIELDS OF COMMERCIAL AND SMALL-SCALE FARMERS

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During the past two decades, panicle-feeding Hemiptera have become major pests of sorghum in West and Central Africa, and particularly in Mali, where this cereal is a staple food crop. Of the more than 100 sorghum insect pest species that have been recorded in Africa, more than 40 were found to be panicle-feeding pests. Prior to this study, no research had been done on the Hemiptera panicle-feeding insects in South Africa. The aim of this study was to compile a list of Hemipteran species that occur on sorghum panicles in South Africa. Sorghum fields were examined for panicle-feeding insects from boot stage until the crop was mature and ready to be harvested. The study sites were: Potchefstroom (North-West Province), Burgershall (Mpumalanga Province), Lebowakgomo and Polokwane (Limpopo Province), as well as Koppies and P arys (Free State Province). Insects were collected with a D -Vac machine. Twenty-five different panicle-feeding Hemiptera species were recorded. The average number of Hemiptera recorded in commercial fields ranged between one and 24 per 50 panicles, while as many as 1312 adults and nymphs per 50 panicles were recorded in small-scale farmers fields. *Eurystylus* sp. dominated the head bug complex in small-scale farmer fields, where it constituted 94% of the total population. A succession study was also conducted in a sorghum nursery near Potchefstroom, where sampling was done at 3-day intervals from the boot stage until harvest. Sixteen Hemiptera species were recorded. *Nysius natalensis* (Hemiptera: Orsillidae) and *Nezara viridula* (Hemiptera: Pentatomidae) were common on panicles from the milk stage onwards. A ten-fold increase in Hemiptera numbers was observed during the soft dough stage compared to the milk stage of grain development.

Keywords: Sorghum, Panicle, Hemiptera, Head bugs

MAIZE PERFORMANCE IN MIXTURE UNDER TWO LEGUMINOUS CROP SPECIES GROWN IN KABBA, SOUTHERN GUINEA SAVANNA OF NIGERIA

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Soil fertility decline as a consequence of nutrient mining continues to be a major threat to sustainable crop production in Africa; with N and P deficiencies being the greatest problems. The conventional soil fertility improvement method of fertilizer application has continued to suffer major setbacks in many developing countries due to problems of procurement including scarcity, delayed delivery, and material defilement among others. Also there is the problem of prohibitive costs on the part of the resource poor farmers who constitute the major food producer in the area. Worse still, the scarcity of organic wastes (including animal droppings), and the constraints to plant residues re-use on farmers' fields, justify the search for alternative soil fertility improvement strategies that can be both affordable and adaptable to farmers' practices; as well as economical. It is common knowledge that the incorporation of leguminous crop species into the cropping system has potential for improved soil fertility. The choice of the leguminous species on any farmer's field is a function of numerous factors including culture and preference. Groundnut and bambaranut represent the two commonly grown grain legumes after cowpea by farmers within this area. These are mostly grown as sole crops; but sometimes grown along with crops like cereals (e.g. maize) and cassava. However, information is scanty on the comparative performance of component crops in an intercrop of these two leguminous species. A study was therefore carried out through a field trial over a 2-year period to evaluate the performance of component crops under a maize based intercrop of these two leguminous species with and without fertilizer application to maize.

The results of this study showed that the introduction of any of the two leguminous species into a maize based cropping system improved maize performance greatly. Maize plant vigour and the mean number of harvestable cobs; as well as the grain yield were significantly ($P \leq 0.05$) increased by fertilizer application (F), cropping systems (Cs) and F*Cs interaction. Maize grain yield in an intercrop under the two leguminous crop species though comparable was 27% higher in the maize-groundnut than the bambaranut intercrop without fertilizer application to maize. Grain yields of bambaranut under the different cropping systems were significantly higher than those of groundnut; with significant reduction in the yields of both crops following fertilizer application to maize. The implication of these results is that optimum fertilizer application to maize particularly N in a maize- legume intercrop may not be desirable for the legume component of the intercrop. Economic analysis of the returns from the yield of the component crop in an intercrop is recommended to provide recommendations on which cropping system is better.

Keywords: Intercropping, Maize fertilization, Legumes, Groundnut, Bambaranut

THE EFFECTS OF STRATEGIC N FERTILISER APPLICATION DURING THE COOL SEASON ON THE DRY MATTER PRODUCTION OF A PERENNIAL RYEGRASS-WHITE CLOVER PASTURE IN THE WESTERN CAPE

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Grass-clover pastures, including perennial ryegrass-white clover pastures, form an integral part of the dairy industry in the Western Cape Province. One of the most important constraints however is low dry matter production during the cool seasons (late autumn to spring), also referred to as the winter gap. Successfully addressing the winter gap will ensure an even supply of fodder throughout the year and thereby reducing off-farm purchases of roughage. The objective of this study was to determine the optimum fertilizer N rate (applied as a single dressing) and season of application as a possible management tool to increase the dry matter production of irrigated perennial ryegrass-white clover pastures during the cool winter months.

The response of an irrigated perennial ryegrass-white clover pasture to fertilizer nitrogen application rates of 0, 50, 100 and 150 kg N ha^{-1} applied in either autumn, early winter, late winter, early spring or late spring was investigated over a three year period. Primary dry matter production (PDM) and residual dry matter production (RDM) were recorded five and ten weeks after fertilizer N application respectively. PDM responses were determined mainly by fertilizer N application rate. On average the highest PDM was obtained following N applications in spring and the lowest when N was applied in early winter. Although RDM production generally also increased with increasing fertilizer N rates, responses were much smaller than those recorded for PDM and were affected by the season of fertilizer N application. The highest RDM was obtained when N was applied in autumn and winter while application in spring had no, or even a negative affect, on RDM. Total dry matter production (PDM+RDM) increased ($P<0.05$) with increasing N application rates. Nitrogen application can be used to improve dry matter production during a short predetermined period. Although 150 kg N ha^{-1} applied in early- and late spring generally gave the best results in terms of PDM, 50 kg N ha^{-1} application treatments resulted in a more efficient conversion of N applied to additional DM produced.

Keywords: dry matter production, perennial ryegrass-whiteclover, strategic nitrogen

THE EFFECTS OF STRATEGIC N FERTILISER APPLICATION DURING THE COOL SEASON ON THE CLOVER CONTENT OF A PERENNIAL RYEGRASS-WHITE CLOVER PASTURE IN THE WESTERN CAPE

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Clovers are included in ryegrass-clover pastures for various reasons. Firstly, a high proportion of clover in the pasture improves pasture quality resulting in increased milk, beef or wool production. Secondly, as a legume it is capable of fixing large quantities of atmospheric nitrogen that may become available for uptake by the ryegrass due to recycling. Thirdly, legumes improve seasonal distribution of the forage by reaching its peak production at a later stage (spring) in the year compared to the companion ryegrass crop. To ensure ryegrass-clover pastures of acceptable quality and quantity the percentage clover must remain between 30 and 50 percent on a dry matter basis. Boosting the soil N pool through the application of fertiliser N, however, often results in a decrease in the clover content of grass-clover pastures. Applying too high levels of nitrogen may reduce the clover fraction to such low levels that the sward becomes N deficient later in the growing season. Applying moderate levels of fertiliser N during the cool season, when white clover activity is low, can increase DM production of grass-clover pastures without permanently suppressing clover growth. The value of the increased herbage production from fertiliser N must be weighed against the decline in white clover performance during the season and possibly thereafter. This study was conducted to develop a better understanding of the possible effect of a strategic N fertiliser application during the cool season on the grass-clover balance in a ryegrass-clover pasture and to develop fertiliser nitrogen guidelines to address low pasture productivity during the cool seasons without disturbing the sensitive grass-clover balance. The influence of a single application of fertiliser N (0, 50, 100 and 150 kg N ha^{-1}) applied in either autumn, early winter, late winter, early spring or late spring on the grass-clover balance in a perennial ryegrass-white clover pasture was studied over a three year period. Clover content (%) of pasture dry matter was determined at 5 (Primary) and 10 weeks (Residual) after N application. Clover content (%) tended to decline with increased fertiliser N rates. No differences in primary clover content were recorded between the 100 and 150 kg N ha^{-1} application rates. The effect of season of application was inconsistent. Partial recovery of clover content was noted at the second regrowth cycle - the 5 to 10 - week regrowth period. Fertiliser N did not reduce ($P>0.05$) total clover DM production (kg clover ha^{-1}) over 10 weeks when applied in autumn and early winter. Clover DM yields were however reduced ($P=0.05$) when fertiliser N was applied during early and late spring, excluding 50 kg N ha^{-1} applied during early spring 2000. The application of 50 kg N ha^{-1} can be regarded as relatively safe as the clover content was not reduced to values less than 30 % when N was applied to a pasture with an initial clover content of at least 48 %. In contrast, the 150 kg N ha^{-1} rates resulted in a drop in clover content to below 30 % especially during autumn and winter. Early and late spring applications however caused a reduction in clover DM production suggesting a direct negative effect on the clover component.

Keywords: clover content, perennial ryegrass-whiteclover, strategic nitrogen

THE EFFECTS OF STRATEGIC N FERTILISER APPLICATION DURING THE COOL SEASON ON THE DRY MATTER AND CRUDE PROTEIN CONTENT OF A PERENNIAL RYEGRASS-WHITE CLOVER PASTURE IN THE WESTERN CAPE

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The use of fertiliser N to increase pasture productivity when environmental conditions restrict nitrogen absorption and availability to perennial ryegrass-white clover pastures is regarded as an important management tool to boost dry matter production. The application of fertiliser N may however influence the quality of the pasture as environmental conditions, including soil N supply and the season of pasture utilization, effect fodder quality. The objective of this study was to determine the effect of fertiliser N application during the cool season on dry matter (DM) and percentage crude protein of the pasture. This information will be instrumental in developing a strategic N management programme aiming at maximum dry matter production to bridge the winter gap.

The influence of a single application of fertiliser N (0, 50, 100 and 150 kg N ha^{-1}) applied in either autumn, early winter, late winter, early spring or late spring on selected nutritive and mineral parameters of a perennial ryegrass-white clover pasture was investigated over a three year period. Responses were measured over one regrowth cycle five weeks after the application of N treatments. A sample of the plant material harvested was separated into grass and clover fractions, dried and ground. Dry matter (DM) and crude protein (CP) content were determined for each sample. Increased fertiliser N rate resulted in lower DM contents with the lowest DM produced during winter, while the highest DM contents were produced where no fertiliser N was applied in spring. Winter applications of fertiliser N, in combination with the higher N rates, resulted in higher ryegrass CP contents. Clover CP content was decreased ($P=0.05$) with spring (early and late) applications, but fertiliser N rate did not appear to affect clover CP content.

Pasture DM tended to decrease with increasing N application rate. The CP content of the pasture increased with increasing N due to increases in the % CP of the grass component. Animal performance would not be expected to be negatively affected at the levels of crude protein recorded in the herbage sampled from any treatment.

Keywords: crude protein, dry matter content, perennial ryegrass-white clover

DRAINAGE CHARACTERISTICS OF THE LONGLANDS FORM IN THE WEATHERLEY CATCHMENT, EASTERN CAPE PROVINCE

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Changes in water content in the soilscape during the year have a pulsating nature. The characteristics of this heartbeat of the soil water regime are both a cause of a specific pedogenetic environment and the effect of the soil properties formed during pedogenesis. Drainage water residing in the soil profile impacts on the redox conditions reflected in the soil morphology as grey matrix colours, mottles, concretions and texture gradients in E, plinthic B and G horizons. Some soil properties, like texture, impact on soil behaviour. Matrix colour and mottles, however do not influence soil behaviour directly but reflect it. These conditions may present previous environmental conditions. The aim was to characterise the soil water regimes of two soils one of the "yellow" and one of the "grey" family of the Longlands form. Except for the E horizon, the morphology of the soft plinthic B horizons also differs. Daily soil water content data at 28 sites were generated with water balance modelling using weekly neutron water meter data gathered over a six year period in the Weatherley catchment. Soil profiles of the pedons at the measuring sites were described in detail, classified and analysed. Although the soil water regimes of all 28 soils investigated in the catchment differed, the soil water regimes of the three soils of the Longlands form, profiles P201, P204 and P225 were fairly similar. The annual cycles of the water regimes of these soils have distinct wet, draining, drying and wetting phases in contrast to freely drained soils without a draining phase, and poorly drained soils with only wetting and drying phases. The soil of the "grey" family is wetter than the two soils of the "yellow" family. Advanced development of the soft plinthic B horizons in these profiles is visible as increased segregation of Fe-Mn. This coincides with an increase in the yearly average duration of conditions approaching saturation, the yellowish colour turns more grey, gravel content increases, Fe/Mn decreases, CEC_{clay} decreases and pH increases. Indications are that in the Weatherley environment the two families of the Longlands form react differently. The degree of soft plinthic B horizon development is a good indicator of the duration of conditions approaching saturation in these subsoils and could serve as an improved criterion for classification and evaluation of soils of the Longlands form.

Keywords: gley, hydropedology, plinthic soils, soil classification

EFFECT OF SOIL TILLAGE, CROP ROTATION AND NITROGEN APPLICATION RATES ON BREAD-MAKING QUALITY OF SPRING WHEAT (*Triticum aestivum* L.) IN THE SWARTLAND WHEAT PRODUCING AREA OF SOUTH AFRICA

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Spring wheat (*Triticum aestivum L*.) is produced in the wheat producing areas of the Western Cape Province, Republic of South Africa , primarily for bread-making purposes. Milling and baking characteristics are therefore of utmost importance. In a long-term tillage and crop rotation experiment in the Swartland, it was found that during the 2000 growing season, flour yield was increased by conventional tillage but hectolitre mass did not respond to tillage during the same season or on average for the period 1992-1998. Although grain protein content and ultimately loaf volume were also higher with conventional tillage when compared to no-tillage, the latter resulted in the highest grain protein yield due to slightly higher grain yield obtained with no-tillage. The inclusion of a legume crop (lupin) and canola in rotation with wheat had little effect on either milling or baking characteristics, possibly due to the fact that legumes were only planted once in a four-year cycle. Increased N-fertiliser rates (140 kg N ha^{-1}) resulted in reduced hectolitre mass, but higher grain protein when compared to low N rates of 60 kg N ha^{-1}. This study once more illustrated the complexity of the bread-making process and the need for good management practices in order to obtain both high yield and good bread-making quality under Mediterranean climatic conditions.

Keywords: Bread-making quality, tillage methods, N-fertiliser rates, spring wheat, crop rotation

SALT AND WATER MANAGEMENT AT FIG TREE C PROJECT - MPUMALANGA LOWVELD

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Irrigation projects for small-scale farmers that have been developed for sugarcane production in the eastern Lowveld have resulted in degradation of some farms. This is due to inadequate irrigation scheduling that has resulted in waterlogging and build-up of salts, thus rendering some farms marginal for farming. The objectives of this study are to determine the change in salt levels in soil profiles of varying pedogenesis, to monitor the fluctuation in salt and water table levels between seasons and to be able to make recommendations on ways to mitigate the build-up of both salt and water table levels in the profile.

This is part of an ongoing study carried out at Fig Tree C Project (near Tonga) to monitor the salt and water table levels at six observation points in a 100 ha area. It involves carrying out a soil survey and monitoring the salt and water levels quarterly. A land classification based on the South African Soil Classification System was used and the survey was done by auguring on a 150 m grid. At every observation point, the soil colour and clay percent was determined as well as the depth to any limiting horizon such as gleyed material, plinthic material, water table and mottling. Six sample points were sited within the dominant soil units and modal profile sites were identified. Pits were dug and sampled for physical and chemical analysis. A soil map was drawn and the soils have been grouped into the broad groups: soils with an E horizon, duplex soils and freely drained soils.

Four of the six sample points have yielded electrical conductivity results of the saturated paste extract (ECe) that exceed the 200 $mS.m^{-1}$ threshold recommended for sugarcane production and also fall within the exchangeable sodium percentage range (ESP) 6 – 14, which is regarded as sodic.

It is important that the growers are empowered to adequately handle their irrigation scheduling requirements and that the farms are rehabilitated to once again realise sugarcane yields that are commensurate with the potential of the production areas.

Keywords: waterlogging, soil survey, gleyed material, plinthic material, ESP, ECe

IDENTIFICATION OF FUNGAL DISEASES AFFECTING PROTEAS IN ZIMBABWE

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Surveys were conducted to identify fungal diseases affecting proteas in Zimbabwe, in June and July 1999 (winter, cold and dry) and November 2000 to January 2001 (summer, hot and wet). The surveys covered 34 plantations from the main protea growing areas, which include Norton-Darwendale, Juliasdale and Karoi. Diseased plant materials, based on symptoms, were collected from the field and tested in the laboratory for the presence of pathogens. Information on cultivars grown and control methods used by the farmers was also gathered. Pathogens detected from Norton-Darwendale and Juliasdale in winter were Alternaria spp., Drechslera spp., Fusarium spp. and Pestalotiopsis spp. Other diseases like Coniothyrium spp and Curvularia spp. were identified in Norton-Darwendale only, while Coleroa senniana was observed only in Juliasdale. In summer the pathogens detected in all the surveyed areas were Alternaria spp., Fusarium spp., and Colletotrichum spp. Pestalotiopsis spp. was isolated from Karoi and Juliasdale while Elsinoe spp was isolated from Juliasdale and Norton-Darwendale. Armillaria mellea, Curvularia spp and Phytophthora spp were identified in Norton-Darwendale only while Coleroa spp., Botryosphaeria ribis and Cladosporium spp. were isolated from Juliasdale. The incidence of Alternaria leaf spot, the most common disease, was much higher in Juliasdale (52-95 %) than in Norton-Darwendale (45-87 %). Fungicides commonly used by the farmers on the proteas were benomyl, captan, and mancozeb. These were applied at intervals of either one week or two weeks depending on the farm. Prochloraz and fosetyl-Al were used as drenches.

Keywords: fungal, diseases, protea, Zimbabwe, fungicides

BASE TEMPERATURES FOR SEEDLING GROWTH AND THEIR CORRELATION WITH CHILLING SENSITIVITY FOR TROPICAL GRASSES

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Base temperatures for seedling growth were estimated in switchgrass (*Panicum virgatum* L.), big bluestem grass (*Andropogon gerardii* Vitman), indian grass (*Sorghastrum nutans* L. Nash) and prairie sandreed (*Calamovilfa longifolia* (Hook) Scribn.). Seedlings at the two-leaf stage were grown at 4, 8, 12, 16 and 24°C for four weeks with representative harvests every week. Relative growth rates were calculated for each species/variety at each temperature and these were used, in conjunction with regression techniques, to estimate the base temperatures. The base temperatures were then correlated with chilling sensitivity of the plants, estimated using visual scores, chlorophyll fluorescence and electrolyte leakage. The estimated base temperatures ranged from 2.6 to 7.3°C. There were variations among and within species in base temperatures for seedling growth. There were positive correlations between base temperatures for growth and r ate of electrolyte leakage (r=0.73), chlorophyll fluorescence (Fv/Fm; r=0.80) and l eaf damage (visual score; r=0.76). Differences in base temperatures for the entries corroborated field observations.

Keywords: tropical grass, chilling sensitivity, relative growth rate, base temperature

EFFECT OF FERTILIZATION AND TIMING OF HARVESTING ON LEAF NITRATE CONTENT AND TASTE IN MUSTARD RAPE (*Brassica juncea*)

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Mustard rape (Brassica juncea) is an important traditional vegetable that is grown in Zimbabwe in both summer and winter. The main problem limiting its major utilization is bitterness that is thought to be linked to high nitrogen fertilization and time of harvest. An experiment was carried out on red clay soils at the University of Zimbabwe, Department of Crop Science field plots, to determine the effects of nitrogen fertilization and time of harvest on mustard rape growth, leaf taste and nitrogen levels. The experiment was conducted over 2 growing periods, February to June and August to November 2004. Four nitrogen fertilizer levels (0, 34.5, 69 and 103.5 kg N ha-1) were applied to mustard rape at three weeks after crop emergence (3 WACE) and two harvesting times (morning and sunset) were also included. The experiment was laid out as a 4 (nitrogen fertilizer level) x 2 (harvesting times) factorial experiment in a randomized complete block design with three replications. Spad meter readings were taken from three to nine WACE on a weekly basis to determine leaf nitrogen content. Leaves were harvested for testing through taste panels at five WACE using untrained panelists. After harvesting and drying, leaves were also analyzed for percent nitrate and percent total nitrogen using the improved Kjedahl method. Harvesting time significantly affected nitrate and total nitrogen content of leaves but had no effect on all other parameters measured. Leaf nitrate content at five WACE showed higher leaf nitrate levels (0.537 %) in samples harvested in the morning compared to the ones harvested in the evening (0.464 %). Leaf size, plant height, fresh leaf yields, Spad meter readings, percent nitrogen and nitrate content all significantly increased with increase in nitrogen fertilization. Leaf yields ranged from 5000kg ha-1 in the control to +16000 kg ha-1 at the highest nitrogen fertilization rate (103.5 kg N ha-1) in the February planting. Percent leaf nitrogen increased from 3.66 % (control) to 4.31 % (103.5 kg N ha-1). Leaf nitrate content also increased from 0.425 % in the control to 0.575 % at the 103.5 kg N ha-1 rate. Spad meter readings increased from 24.48 in the control to 32.43 at 103.5 kg N ha-1. Bitterness increased with increasing level of nitrogen fertilization with a significant correlation between nitrogen level and level of bitterness of $R= 0.503$ ($p< 0.01$). . Moderate levels of N application may need to be applied to reduce bitterness in mustard rape leaf vegetables at the cost of yield.

Keywords: Mustard rape, nitrogen, nitrate, harvesting time, taste panels

SUBSURFACE DRIP IRRIGATION ON LUCERNE

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Subsurface drip irrigation on lucerne is relatively unknown. Small commercial plantings were established seven years ago. The aim of these plantings was to investigate the viability of such an irrigation method. Results on medium textured soils show that drip lines with 2 litre per hour emitters, spaced every 60 cm, 1.3 m apart and installed at a depth of 20-30 cm, yield uniform growth on the total soil surface area. The most common method for scheduling the irrigation is to apply a long irrigation cycle of 10 hours once a week. In this manner good lateral water distribution and wetting of the total soil profile is ensured. Commercial yields of up to 25 tons dry material per hectare per year have been achieved. These yields are the same or even better than above surface irrigation methods while only 25 mm of water is applied each week. This is approximately half of what is used with other irrigation methods to achieve the same yield. The drastic saving of water and ease of management are the main motivations for the use of this irrigation method. Critical aspects are the establishment of lucerne and potential root and soil intrusion into the emitters. This irrigation method has since developed into a recognized way of irrigating lucerne.

Keywords: subsurface drip irrigation, Lucerne, soils, yields, water savings

THE DEVELOPMENT OF A SOLAR RADIATION PRODUCT FROM MSG SEVIRI DATA FOR APPLICATION IN CROP MODELS

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Recently, data have become available from a new geostationary satellite called Meteosat 8, the first satellite in the Meteosat Second Generation (MSG) suite of geostationary satellites. The on-board Spinning Enhanced Visible and Infrared Imager (SEVIRI) produces data with a 15-minute temporal resolution for the entire African disk of the globe. Over the spatial resolution of the data is in the order of 3 km. The ARC-ISCW has developed products from the data for application in agriculture.

For the development of various agricultural products (drought monitoring, plant and animal pest and disease indices, and crop estimation) it is important to remove cloud-contaminated pixels from the received data. While cloud detection with traditional polar-orbiting satellites has been based on methods that apply physically meaningful thresholds to data from specific wavelengths to distinguish cloudy from non-cloudy pixels, the development of the cloud masking procedure from MSG SEVIRI data provides bigger challenges and opportunities due to its high temporal resolution of 15 minutes throughout the diurnal cycle. The method proposed for MSG SEVIRI data utilizes a combination of temporally dynamic (physically meaningful wavelength-specific) thresholds as well as comparisons of data for a specific MSG slot to a calculated reference value.

Solar radiation is an important input variable in crop models. For this reason, a solar radiation product was derived entirely from MSG SEVIRI data. As input data into the product, cloud detection grids with weighting given to the assumed cloud thickness (based on temperature and brightness) derived from MSG SEVIRI data for every 15-minute slot, as well as the latitudinal position of each pixel within an image, were used. The FAO formula was used to derive the expected total extra-terrestrial radiation value for each day. Using weather station data from clear days, the total mean amount of solar radiation compared to the expected extra-terrestrial radiation was calculated. Weather station data for cloudless days were utilized to obtain the clear-sky mean solar radiation curve, which varies according to the time of the year. Finally the weighted cloud-detection images, for all 15-minute slots, were used in conjunction with the mean daily solar radiation curve to calculate a total hourly solar radiation value per pixel. These hourly values were accumulated to obtain a final total solar radiation value for each day.

The procedure estimates the total solar radiation value with a root-mean-square error of 2.5 MJ/m^2/day and will be improved by the inclusion of an atmospheric transfer model to estimate attenuation caused by atmospheric constituents.

Keywords: Remote sensing, Coarse resolution, Meteosat Second Generation, Solar radiation

WATER REQUIREMENT SATISFACTION INDEX AND WATER PRODUCTION FUNCTION FOR SORGHUM PLANTED DURING MARCH-SEPTEMBER IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

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Climate variability is an unavoidable aspect of rainfed farming globally. However, it is not a unique problem that cannot be managed at least partially, or may even be tuned to one's advantage, while at the same time being difficult to solve. Maps of crop water requirement satisfaction index (WRSI) were drawn for 120-day and 180-day sorghum cultivars that grew concurrently during a March-September season in the Central Rift Valley (CRV) of Ethiopia. This helps to evaluate growing season performance, and whether a given crop cultivar obtained sufficient water to achieve potential yield. The water production function (WPF) that predicts long-term sorghum yields was also computed using the weighted average WRSI (as summarized from WRSIs at various critical growth stages) and grain yields of the respective cultivars planted in May and June. The resulting seasonal WRSI maps showed that the WRSI performance for the March-June season was reasonably satisfactory for a 120-day cultivar in the southern part including Arsi Negele and Awasa (80 to 100%), and moderate at Abomssa, Kulumsa and Ziway (58 to 60%). For Langano the WRSI was 54% indicating that sorghum would essentially not experience a total failure every year. The WRSI for Miesso was 49%, indicating a chance of total failure for 120-day rainfed sorghum. The WRSI for a 120-day sorghum grown during April-July season showed southern, southeastern and northwestern ensure values of above 75%, while the central part maintained a WRSI of 57 to 73%. This shows in general that much of the CRV would be able to support a 120-day sorghum cultivar with May-August and June-September being suitable seasons. A similar result was obtained for a 180-day sorghum cultivar planted in March and April in the southern and southeastern sections with possible soil water management practices. The results from the WPF, using the weighted average WRSI analyses for a 120-day sorghum planted in June at Miesso and Melkassa, revealed that grain yield was three times more sensitive to the mid-season or flowering stage WRSI than the WRSI of the other growth stages. Similarly, the WPF for a 180-day sorghum planted in May at Arsi Negele showed the sensitivity of grain yield to the flowering stage WRSI by a factor of three over the WRSI from the other growth stages. Overall, WRSI and WPF have demonstrated the potential usefulness of historical climatic data for quantifying the climate risk and long-term yield prediction.

Keywords: rainfed, growing season length, sorghum cultivars, planting date, yield

THE EFFECT OF CYANOBACTERIAL INOCULATION ON THE STRUCTURAL STABILITY OF TWO SOILS IN THE EASTERN CAPE PROVINCE, SOUTH AFRICA

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Some cyanobacteria strains are known to have biofertilization and ameliorative effects on soil structure as a result of their ability to fix nitrogen and/or produce exopolysaccharides. There is, however, little or no information on the effects of cyanobacteria inoculation on soil properties in South Africa. This preliminary study was carried to evaluate the effect of a Tanzanian cyanobacteria strain 9v (a *Nostoc*) on the aggregate stability of sandy soil from Guquka and clayey soil from Hertzog soils from the Eastern Cape, with and without cropping under glasshouse conditions. Treatments were a factorial combination of three factors at two levels each, namely: soil (Herzog and Guquka), inoculation (with and without cyanobacteria), and cropping (cropped vs non-cropped with maize). The cyanobacteria strain 9v was applied to potted soils soon after maize germination to provide an equivalent dry biomass of 3g/m^2. Sampling for aggregate stability was done six weeks after inoculation by carefully scooping the top 5 mm of soil at selected spots. The stability of dry soil aggregates > 3 mm but < 5 mm was then determined by Le Bissonnais (1996) method which involves slow wetting; fast wetting and mechanical breakdown tests. The parameters measured as indices of aggregate stability were the mean weight diameter (MWD) and fragment size distribution (FSD) which provided a measure of disaggregation. Aggregates with MWD below 0.4 mm were characterized as unstable and those MWD > 2 mm as very stable. Results showed that Herzog soil had more disaggregated aggregates and had aggregates with lower MWD than Guquka soil indicating that it had a less stable structure. The much weaker aggregates observed on Hertzog soil could have been the cause for the greater crusting tendency observed on this soil. Inoculation of the uncropped soils with cyanobacteria strain 9v increased aggregate stability of both Guquka and Hertzog as indicated by the high MWD obtained by the three tests. The fast wetting test showed improved aggregate stability of Guquka soil from unstable aggregates to partly stable aggregates, whilst aggregates from Hertzog soil changed from very unstable to unstable. The slow wetting test showed a change in aggregate stability of Guquka soil from unstable aggregates to near-stable aggregates, whilst Hertzog soil had unstable aggregates changed to partly stable aggregates. The mechanical breakdown test showed an increase in aggregate stability of Guquka soil from unstable aggregates to partly stable aggregates, whilst Hertzog soil remained unstable with an increase in MWD not making any significant difference. A similar trend was observed on the cropped soils but the aggregates were much weaker than in the uncropped soils. Nevertheless, the results suggested that the cyanobacteria strain 9v could have produced exopolysaccharides in the inoculated soils that enhanced the aggregate stability of the soils. The results indicated the potential of cyanobacteria to be used for the structural amelioration of degraded soils in South Africa and therefore there is need to identify local cyanobacteria strains with this potential. This aspect of the work is currently receiving attention as part of an ongoing project with cyanobacteria.

Keywords: Aggregate stability, Cyanobacteria

LEAF STRIPPING AND DETASSELLING INCREASES MAIZE COB GROWTH RATE AND GRAIN YIELD

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An experiment was carried out in the 2003/2004 season using weekly destructive sampling of maize plants to determine dry matter distribution to the cob after removing the four lowest leaves (leaf stripping), detasselling, and leaf stripping and detasselling maize plants at 50% silking. These treatments were compared with an intact control. The experiment was organized as a randomized complete block design, replicated four times. Cob mass significantly increased by 11.1%, 15% and 15.7% in the leaf stripped, detasselled and leaf stripped and detasselled maize, respectively, when compared to the intact control. One thousand grain weight and mass of grain per cob showed a similar trend. Maize grain yield increased by 32% in both the leaf stripped and detasselled treatments, and by 43% when the maize was leaf stripped and detasselled. The results of the study showed that leaf stripping and detasselling at anthesis has a profound influence on the amount dry matter allocated to the cob and on grain yield and can be used to increase the productivity of maize monocrops. Our results from other studies also show that leaf stripping and detasselling can increase incident radiation on the minor crop and increase the productivity of maize legume/cucurbit intercrop systems.

Keywords: leaf stripping, detasselling, cob growth rate, intercropping

EFFECT OF PLANTING DATE ON YIELD AND YIELD COMPONENTS OF BAMBARA GROUNDNUT GENOTYPES UNDER MULTILOCATIONAL TRIALS IN SOUTH AFRICA

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One of the major problems facing bambara groundnut production in South Africa is yield instability due to the inherent low genetic potentials of local bamabara genotypes as well as the existence of different environmental (weather and soil) conditions in the production areas. Eight bambara groundnut (*Vigna subterranea*) genotypes were studied across three locations during 2004 and 2005 growing season. The objective of the study was to determine the relationship between yield and yield components and to select the best planting date for cultivation of bambara groundnut. A randomised complete block design (RCBD) with three replications was used. Plot size was 6m x 5rows. The treatments were eight bambara genotypes, two planting dates and three localities. The locations were Potchefstroom, Taung and Vaalharts. Dates of planting were 9 and 23 November 2004 respectively. All the locations were supplemented with irrigation to allow seedling establishment. At flowering, the number of days to 50% flowering, and number of days to maturity were taken. Other parameters measured were number of pods per plant, pod weight, seed weight, leaf weight (biomass) and root weight. During harvesting, plants from middle rows were sampled for grain yield determination. Highly significant interactions ($P< 0.01$) were observed between genotypes, environments and planting dates for all traits measured. SB 1-1, SB 4-4 and SB 19-3 produced the highest grain yield across the three locations. Results on correlation matrix indicated that all traits were highly significant and positively correlated to one another except for 50% days to flower and days to maturity. Grain yield obtained from Vaalharts was the highest when compared to Taung and Potchefstroom. The highest grain yield was obtained from the second planting date across the three locations and that was selected as the best planting period for cultivation of bambara groundnuts.

Keywords: Bambara groundnut, genotypes, planting dates, location

THE SEASONAL OUTLOOK AND THE SPATIAL VARIABILITY OF DROUGHT RISK

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The Seasonal Outlook has been available for several years, but how can the individual small-scale dryland farmers utilize it? Does the government support them when droughts occur? What recommendations, in relation to the outlook, can we give the dryland farmer to mitigate risk, taking care of local conditions? The Seasonal Outlook gives the distribution of dry, normal and wet conditions for large generalized areas. This paper aims to ascertain the relationship between the spatial and temporal variability. Food security at family level is dependent on both spatial variability (exchange between neighbors) and temporal variability (stockpiling for future use). The question that is raised is whether areas are mostly homogeneous (large areas with small differences) or heterogeneous (large differences in small areas)? This to a great extent will determine the farmer's methodology to mitigate risk and improve food security. Drought is not only related to the amount of rainfall, but also to its distribution. Hence drought cannot simply be classified on the basis of total rainfall, but rather on the water balance. The Food and Agriculture Organization's Water Satisfaction Index (WSI) is used for this study. As differences in planting dates during the same season can result in large differences in yield production, the average WSI for a set of planting dates was used. The WSI values for nearly 40 years were used to establish, for each pixel, the boundaries (tercile values) for dry, normal and wet conditions. These values were used to calculate the distributions for small, medium and large areas. Results were tested against the forecast made at the start of the season using the chi-squared (2) test. The type of variability found in the different areas defines the usefulness of the Seasonal Outlook and the optimal utilization thereof for the farmer in a specific area. The spatial distribution, even over large areas (200 x 200 km) can be much 'dryer' or 'wetter' than the Seasonal Outlook. Relative homogeneous distributions as pronounced as 0-10-90 or 90-10-0 can occur over large areas. Strong changes of distributions can occur over small distances and hetereogeneous spatial distributions such as 30-40-30 can occur over small areas (25 x 25 km). This poster will present the various maps resulting from this study, whilst the paper "THE SPATIAL VARIABILITY OF DROUGHT AND THE SEASONAL OUTLOOK" will focus on the methodology and background.

Keywords: Seasonal Outlook, Response farming, Water Balance, WSI (Water Satisfaction Index), Small-scale farming, South Africa

THE SPATIAL VARIABILITY OF DROUGHT RISK AND THE SEASONAL OUTLOOK

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The Seasonal Outlook has been available for several years, but how can the individual small-scale dryland farmers utilize it? Does the government support them when droughts occur? What recommendations, in relation to the outlook, can we give the dryland farmer to mitigate risk, taking care of local conditions?The Seasonal Outlook gives the distribution of dry, normal and wet conditions for large generalized areas. This paper aims to ascertain the relationship between the spatial and temporal variability. Food security at family level is dependent on both spatial variability (exchange between neighbours) and temporal variability (stockpiling for future use). The question that is raised is whether areas are mostly homogeneous (large areas with small differences) or heterogeneous (large differences in small areas)? This to a great extent will determine the farmer's methodology to mitigate risk and improve food security.Drought is not only related to the amount of rainfall, but also to its distribution. Hence drought cannot simply be classified on the basis of total rainfall, but rather on the water balance. The Food and Agriculture Organization's Water Satisfaction Index (WSI) is used for this study. As differences in planting dates during the same season can result in large differences in yield production, the average WSI for a set of planting dates was used. The WSI values for nearly 40 years were used to establish, for each pixel, the boundaries (tercile values) for dry, normal and wet conditions. These values were used to calculate the distributions for small, medium and large areas. Results were tested against the forecast made at the start of the season using the chi-squared (2) test.The type of variability found in the different areas defines the usefulness of the Seasonal Outlook and the optimal utilization thereof for the farmer in a specific area.The spatial distribution, even over large areas (200 x 200 km) can be much 'dryer' or 'wetter' than the Seasonal Outlook. Relative homogeneous distributions as pronounced as 0-10-90 or 90-10-0 can occur over large areas. Strong changes of distributions can occur over small distances and hetereogeneous spatial distributions such as 30-40-30 can occur over small areas (25 x 25 km).The paper will focus on the methodology and background, whilst the poster "Seasonal Outlook and Spatial Variability of Drought Risk" will present the various maps resulting from this study.

Keywords: Seasonal Outlook, Response farming, Water Balance, WSI (Water Satisfaction Index), Small-scale farming, South Africa

ESTIMATION OF EVAPOTRANSPIRATION FROM DIFFERENT PLANT CANOPY SURFACES USING A SURFACE RENEWAL METHOD

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Accurate and routine measurement of evapotranspiration is crucial in micrometeorology, agriculture and water resources management. Evapotranspiration may be es timated using different micrometeorological methods, such as eddy covariance, Bowen ratio energy balance, surface renewal and o ptical scintillation. The surface renewal (SR) method for estimating sensible heat and latent energy fluxes from canopies is based on high frequency measurements of scalar parameters. The SR method involves measuring air temperature at high frequency, usually at 8 Hz. In this study, air temperature was measured using an unshielded 75-µm chromel-constantan thermocouple. The high frequency data are analyzed for ramp-like characteristics and the amplitude and i nverse ramp frequency are used in energy balance equations to estimate fluxes. High frequency air temperature data were collected at different measurement heights above different plant canopy surfaces to estimate sensible heat and latent energy flux densities using the SR analysis. The half-hourly sensible heat and latent energy flux densities from the SR method showed very good agreement with the eddy covariance (EC) and surface layer scintillometry methods. The 20-minute averages of sensible heat and l atent energy fluxes from the SR analysis showed also good agreement with Bowen ratio measurements. The surface renewal method offers simple, low cost, and accurate estimates of sensible heat and latent energy flux densities. The SR method provides a possible alternative for estimating evapotranspiration from different plant canopies.

Keywords: Surface renewal, evapotranspiration

IDENTIFYING PEDODERMAL SOIL PROPERTIES THAT LIMIT RAINWATER INFILTRATION: A NEW APPROACH IN ARID SOUTH-WEST AFRICA

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A new approach was used to calculate an Infiltration Response Index (IRI) relating water infiltration to various properties of soil surface (pedoderm) samples collected from 31 localities in Namibia and western South Africa. The index refers to a specific soil property and combines the magnitude and predictability of infiltration response to a change in the value of that property. By means of this index, several physico-chemical factors (pH, EC, water-soluble cations and anions, ammonium acetate-extractable cations, organic carbon, total nitrogen, a 7 -fraction particle size distribution, water-dispersible silt and clay, and clay mineralogy) were ranked in terms of their effect on infiltration, achieving this result in a conceptually similar manner to that of DRIS. Clay quartz (relative IRI of 100), water-dispersible silt (99) and clay (98), very fine sand (92), medium sand (88), and organic carbon (88) appeared to have the greatest influence on infiltration. Medium sand and fine sand (56) contents exhibited constrained infiltration at low values and unconstrained infiltration at higher values, indicative of their skeletal role in shaping macro and mesopores. By contrast infiltration was related negatively to very fine sand (92), coarse silt (42), fine silt (73), clay (64) and water-dispersible silt and clay contents, reflecting a probably plasmic (mobile) role of these constituents in blocking pores. An important finding is that the particle size effect appears to exhibit a skeletal- plasmic switch between fine and very fine sand (0.106 mm). Infiltration was constrained at high values of mica, kaolinite and smectite content of the clay fraction. The converse was found in the case of quartz, probably meaning that layer silicate clays are more predisposed to dispersion and to oriented close-packing than quartz, consequently blocking pores more effectively.

Keywords: soil water, crusting, biocrust, DRIS, soil texture, aridisols

EVALUATION OF COTTON CULTIVARS AND THEIR EFFECTIVE PLANTING DATES IN THE EASTERN CAPE PROVINCE (SOUTH AFRICA)

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Currently there are only eight recognized cotton production regions in South Africa. If cotton proves to be a viable crop for the Eastern Cape, this production region should be included. Among numerous factors that contribute to a successful cotton crop, management decisions on variety selection and planting dates can have a profound effect on the development and final outcome of the crop. The early planting and establishment of a cotton crop can be a practicable approach to countering late-season insect pressure. The short-term objectives of this study were to evaluate the performance of different cotton cultivars in the Eastern Cape Province and to determine the optimum planting date for cotton at the different localities. The long-term objectives were to supply cotton farmers with guidelines on planting dates and suitable cultivars that could produce optimum seed cotton yields and good fibre quality. A field study was started during the 2003/2004 growing season. Seven cultivars were evaluated at four localities: Addo, Qamata, Tyefu and Cradock. Seven cultivars, NuOPAL, DeltaOPAL, DeltaOPALRR, SZ9314, Sicala, DP001B and DP002, were planted at different planting dates. The first planting at Addo (28 October 2003) resulted in a seed cotton yield of 6149 kg ha^{-1} compared to 4146 kg ha^{-1} for the second planting (24 November 2003). The two trials at Tyefu were planted one week apart. The first planting resulted in a yield difference of nearly 1000 kg ha^{-1} higher than the second planting. No data were collected at Cradock and Qamata due to high weed infestation. This study was continued during the 2004/2005 growing season and was carried out at three localities: Addo, Cradock and Qamata. Seven trials were planted on different planting dates, namely at Addo on the 1st and 15th of October and 2nd and 18th of November, at Cradock on the 1st and 17th of November, and at Qamata on the 9th of November 2004. Four cultivars were used: NuOPAL, DeltaOPALRR, DeltaOPAL and DP404B. The results indicate that there was significant interaction between planting dates and cultivars. Overall, the seed cotton yield declined significantly with later planting dates and varied significantly among the different cultivars planted on the same planting dates. NuOPAL gave the highest average seed cotton yield at Addo and Cradock, whereas DP404B gave the highest seed cotton yield at Qamata compared with the other cultivars that were included. Results show that planting late in the season in the Eastern Cape Province had a negative effect on seed cotton yield. Late planting and cultivar selection play a major role in the success of cotton production and farmers should be made aware of the disadvantage of late planting.

Keywords: planting date, seed cotton, yield

OPTIMIZATION OF FERTILIZATION (CHEMICAL AND ORGANIC) OF NEW SWEET POTATO CULTIVARS

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Sweet potato is a good food source, especially orange-fleshed sweet potato which is rich in provitamin A, thus addressing vitamin A deficiency and benefits disadvantaged households. Proper fertilization management adds value to the storage root yield and quality. Not much research has been done on the fertilizer requirements of sweet potato. Recently, ARC-Roodeplaat released several new sweet potato cultivars specifically for production in rural areas. A trial was established with six sweet potato cultivars, planted with two rates of organic and chemical fertilizers (50% and 100%) based on soil analysis. A control with no fertilizer was also included in the trial. The impact of fertilization (organic vs. chemical fertilizer) on the sweet potato storage root yield and quality was evaluated. Quality assessments included nutritional analysis of storage roots in order to optimise nutritional value. Storage roots had lower nutrient levels than leaves. There was no particular trend in increasing storage root yield and total soluble solids with increasing fertilizer levels. Applying fertilizers had a beneficial effect on the carotene and starch content of orange fleshed cultivars even though it was not statistically significant. In future, optimal economic fertilizer levels will be determined.

Keywords: Sweet potatoes, Fertilization, yield, Quality

CALCIUM SEED TREATMENT AND POLYGALACTURONASE EXPRESSION IN GREEN BEAN SEEDS

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A typical symptom of calcium deficiency in plants is disintegration of cell walls. Previously, it was shown that cotyledonal cracking during green bean seed germination can been alleviated by calcium seed treatment administered as a coating or priming osmoticum. The physiological basis of the calcium effect in alleviating cotyledonal cracking requires explanation. The objective of this study was to determine the effect of seed coating and priming with calcium salts on the expression of plygalacturonase, the enzyme that mediates cell wall degradation in plant tissues. Two concentrations of $Ca(NO_3)_2$ (10 mM and 100 m M) were compared for their effect on polygalacturonase expression in seeds of three green bean cultivars. Calcium was applied as a seed coating or priming osmoticum and seeds were examined for the expression of polygalacturonase at least one week after storage and eight days after initiation of germination. Cotyledonal calcium content was determined using EDAX. Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) was used for protein profile analysis, followed by lytic identification based on zymographic analysis. Total protein was extracted from cotyledons and enzyme activity was determined. Enzyme activity decreased significantly in the presence of calcium-treated seeds compared with control samples (dry seeds, seeds imbibed in water only and seeds coated without calcium salt). There was a correlation between enzyme activity and tissue calcium content. A putative polygalacturonase enzyme with an apparent molecular mass of 100 kDa was observed. Protein sequencing is in progress to confirm the protein as polygalacturonase. The preliminary findings of this study suggest that seed treatment with calcium inhibits polygalacturonase activity.

Keywords: Calcium, cotyledonal cracking, green beans, polygalacturonase

TRANSLATION OF LAND TYPE AND SOIL INFORMATION INTO SOUTH AFRICAN LANGUAGES

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The Land Type Survey was conducted during 1972 to 2004 with the main objective of documenting natural agricultural resources (terrain, soil pattern and macro-climate) of South Africa in the form of maps and tables. The survey resulted in 7 200 soil and terrain inventories, 3 000 climate zones and 2 200 soil profile descriptions and sets of soil analyses throughout the country. Seventy maps showing areas of uniform terrain, soil pattern and macro-climate were generated. The products are available in printed and CD formats from ARC-ISCW. Initially, this information was available in a technical format in English and Afrikaans only, but now the technical soil information has been translated into easily understandable language available in English, isiZulu, isiXhosa, siSwati, Sesotho, Sepedi, Xitsonga and Afrikaans. The broad soil classification descriptions, soil series descriptions and summary of climate descriptions were translated. These translations can now be printed for each of the 7 200 soil inventories. The English and Afrikaans versions of the inventory are technical and are understood mainly by people with some scientific background. In contrast, untrained readers can easily understand other versions as they contain mostly non-technical terms. Access to the results of the survey enables less-formally trained workers to assess land-use options and other activities important to the enhancement and proper usage of natural resources.

Keywords: Land type information, soil classification, natural agricultural resources

HOST STATUS OF WILD CUCUMBER TO ROOT-KNOT NEMATODE

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Fruits and roots of wild cucumber (*Cucumis myriocarpus*) contain curcubitacins that are the most bitter of all known organic compounds. Various studies at the University of Limpopo demonstrated that ground fruits of *C. myriocarpus* suppressed *Meloidogyne incognita* numbers. Because roots of this plant also contain cucurbitacins, a microplot trial was conducted to evaluate the host status of *C. myriocarpus* to *M. incognita*. Two-week-old *C. myriocarpus* seedlings were transplanted into 30 cm diameter plastic pots, containing a sand:Hygromix (3:1 v/v) medium. Six treatments comprising approximate initial densities of 0, 25, 125, 625, and 3125 nematodes (Pi) were arranged in a completely randomised design, with 10 replicates each. Eight weeks after inoculation final nematode numbers (Pf) were determined from the total root system. The study was repeated after 10 months. The reproduction factor (Pf/Pi) at all inoculation levels was lower than 1. The productivity of *C. myriocarpus* was not affected by the presence of nematodes at all levels.

Keywords: Wild cucumber, *Meloidogyne incognita*, Reproduction factor

EVALUATING MAIZE YIELD UNDER CONVENTIONAL AND IN-FIELD RAINWATER HARVESTING TECHNIQUES WITH DIFFERENT NITROGEN APPLICATIONS

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In central South Africa a large area east of Bloemfontein, sometimes termed the “resettlement area”, has been earmarked for developing farmers. The problem is that this area is marginal for crop production because of low and erratic rainfall and mainly clay soils on which high unproductive water losses occur. These losses contribute towards constant crop failures associated with the normal conventional tillage (CON) technique. Another problem is that farmers in this area do not apply fertilizer when they plant and this results in low crop yields and mining of natural resources. The questions that need to be answered can be stated as follows: (i) can the in-field rainwater harvesting (IRWH) technique increase maize yield as compared to CON?; and (ii) can nitrogen application increase maize yield?

On-station and on-farm trials were conducted. The on-station trial was conducted at the Glen Experimental Station on the Glen/Swartland ecotope over a period of two growing seasons (2001/02 and 2002/03). On-farm trials were conducted on croplands in rural villages in the Thaba Nchu area on the Sediba/Sterkspruit and Bofulo/Sterkspruit ecotopes over a period of two growing seasons (2002/03 and 2003/04). Maize was used as the indicator crop. In these experiments the IRWH technique was compared with CON at different nitrogen application levels. The nitrogen applications were 0 and 60 kg N ha^{-1} with three replicates for both IRWH and CON. Ammonium nitrate was used as the N-source. Seed yield was used as an indicator to compare the response to nitrogen application.

Results showed that IRWH can increase maize yield by as much as 58 % on average as compared to CON tillage. Nitrogen results indicated that 60 kg N ha^{-1} increased maize yield by 29 % as compared to 0 kg N ha^{-1}. In conclusion, farmers should implement the IRWH technique if they want to achieve good yields and reduce the risk of crop failures. Farmers should also apply fertilizers, especially nitrogen, for long-term sustainability.

Keywords: nitrogen application

EVALUATION OF YIELD FROM MAIZE-BEAN INTERCROPPING

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Common beans (*Phaseolus vulgaris* L) and maize (*Zea mays* L) are grown for human consumption in the traditional cropping system in sub-Saharan Africa. Maize-Bean intercropping is practiced in an effort to increase food production within small-holder farming systems in the developing world. However, yield of both species is affected by intercropping. Quantitative methods for evaluation of intercrop productivity include (i) intensity of land use, (ii) energy value (iii) capital return. The objectives of the study were to compare yield advantages of the cropping systems on a common scale using land equivalent ratio (LER) given variable weather conditions and to compare variation over the seasons (2000-2003) with two planting dates. In the first planting, the sole and intercrop maize showed a higher biomass accumulation than sole and intercrop beans from 40 days after sowing (DAS). In the second planting, the sole maize had a higher biomass than the intercrop maize from 55 DAS to the end of the season. Leaf area development for maize during the first three harvests showed no statistical difference, after which there were differences in the leaf area index (LAI) (53,67, 74 DAS). In general, the second planting maize crop attained a higher LAI early in the season compared to the first planting. Sole maize attained a higher maximum stem growth than the intercrop maize for both planting dates. The overall land equivalent ratio (LER) for all the seasons was 1.28 (+/-0.20) showing that in general the intercropping system had an advantage over the sole crop system for this ecotope. Environmental factors including temperature and soil water played a key role in crop growth. Although there is competition for environmental resources, intercropping maize and beans provides a sustainable solution in semi-arid areas.

Keywords: biomass, planting dates, land equivalent ratio

THE EFFECT OF NPK FERTILIZATION ON HEMP PRODUCTION IN SOUTH AFRICA

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Recognition of the potential of best fibre crop production for growers, especially emerging farmers and industries, led to the general objective of this research. Very few research results applicable to South African conditions are available at present and the real production cost of hemp in South Africa is unknown because no commercial production is taking place. The Eastern Cape Province was identified as a climatic zone, which receives sufficient rain during the summer months to enable hemp production. Research has been undertaken to determine the optimal growing conditions for the plants, which may respond differently to different fertilizer levels. Trials were conducted with various levels of nitrogen, phosphorus and potassium during the 2002/2003 growing season to determine their influence on the growth and characteristics of hemp. Soil and leaf samples were taken for chemical analysis. Stem height was measured every two weeks. At harvest , stem height, stem diameter and biomass were measured. The stems were retted to determine the fibre percentage. The effect of different levels of fertilizer on all the above-mentioned characteristics was statistically determined. Phosphorus had an effect on the growth of hemp plants. During the 2004/2005 growing season only nitrogen was repeated. Four different nitrogen fertilizer levels (0, 50, 70 and 90 kg ha^{-1}) were applied twice in the form of ammonium nitrate, as a top dressing at Addo and Bathurst. Cultivar, Kompolti from Hungary was planted at both localities. The effect of nitrogen fertilizer levels on plant height, stem diameter, biomass production, fibre percentage and chemical content of the leaves was determined. The greatest plant height and biomass were obtained at 90 $kgNha^{-1}$ at both localities. Stem diameter of hemp plants increased with increased nitrogen fertilizer levels at Addo. At Bathurst the effect of increased nitrogen fertilizer levels resulted in increased biomass production and nitrogen content of hemp leaves. The 90 $kgNha^{-1}$ level gave significantly higher biomass and fibre percentages than the 0, 50 and 70 $kg.ha^{-1}$ fertilizer levels. The fundamental principle of fertilization is that the plant must be supplied with the amount of nutrients it needs to produce a specific yield. Further research will still have to be done to evaluate the different levels of fertilizers and their effect on the fibre percentage, and other characteristics of hemp.

Keywords: Nitrogen

PHOSPHORUS BUFFER CAPACITY OF THE BENCHMARK SOILS OF LESOTHO: ITS RELATIONSHIP WITH PHOSPHORUS RETENTION AND OTHER SOIL PROPERTIES

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Productivity of most soils with high potential fertility is limited by high phosphorus (P) retention. The latter is usually attributed to factors such as clay content and type, organic matter and pH of the soil together with iron and/or aluminium compounds. The same factors are also attributes of CEC and nutrient availability, hence soil fertility and subsequently soil productivity. In most cases where P retention is high P buffer capacity is also high, especially in soils with high clay content as the most determining factor. Thus, retention of P can be seen as a way of creating a labile pool of P that replenishes soil solution P, in which case the clayey soils will have an advantage over the sandy soils, which have low P retention capacity and hence low buffer capacity. Maintenance of soil solution P, which is available P, is a very important indicator of high soil fertility. In Lesotho, more than 50% of the key agricultural soils are characterized by high P retention. The fertility status of these soils and hence their status as benchmark soils therefore depends on their ability to maintain a significant concentration of P in soil solution. The objective of this study was to determine the buffer capacity of the benchmark soils and compare it with their P retention indices and other soil properties.

P retention was determined by incubating the soils with a range of P fertilizer (0, 100, 200 and 400 $kgPha^{-1}$) for a period of six weeks after which available P was extracted by two different methods, viz. Bray-1 and Olsen, and used to calculate amount of P retained. Then available P was plotted against retained P for each soil and the slopes of the plots were referred to as the respective P buffer indices (PRI). The parameters of P retention capacity were P retention index, viz slope of applied P against retained P (PRI), and P retention capacity at a single point, viz. application level of 400 $kgPha^{-1}$ (PRC at P400). The results showed that P buffer capacity was positively correlated with P retention. The correlation coefficients between PRI and PBI were 0.94 for the Bray method and 0.81 for the Olsen method. The respective correlation coefficients between PRC at P400 and PBI were 0.85 and 0.70. Both P retention, viz PRI and PRC at P400 and P buffer capacity were significantly (r^2 = 0.6 – 0.8) and strongly ($P<0.001$) correlated with texture, organic carbon, CEC, amorphous iron and aluminium, crystalline iron and sample density. Multiple linear regression models were established for both parameters of P retention and for P buffer capacity.

Keywords: soil phosphorus, soil fertility, Lesotho soils, P retention plots, extractable P

AVAILABLE PHOSPHORUS AND MICRONUTRIENTS UNDER CONTROLLED SOIL pH

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The fertility status of most agricultural soils is reduced by low phosphorus (P) availability which is in turn attributed to, among others, soil acidity. Low pH is one of the prevalent characteristics of the low fertility soils of the Roma valley, which comprise close to two thirds of the entire arable land in that region. The problem of low P availability in acid soils is always accompanied by toxic levels of micronutrients. These problems together or individually negatively affect agricultural production, hence agricultural sustainability. To address this situation in the Roma valley, a pilot study was conducted under laboratory conditions to demonstrate the impact of P fertilizer on available P on the acid soils compared to soils with reduced acidity, and also to study the impact of liming and fertilizer application on the concentration of extractable micronutrients, viz. copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn). The experiment was conducted on a representative soil with two rates of fertilizer, viz. zero and 300kg/ha of 2:3:2 (22); and three rates of lime, viz. 0, 8.5 and 12.75 tons/ha to 20-cm depth. The 8.5 tons/ha was lime requirement of the soil to attain pH 6.0, while 300kg of fertilizer was the maximum recommended rate of fertilizer for most field crops. . Lime was added six months prior to fertilizer application to allow for stabilization of colloidal material in the soil, and reduce chances of retention of applied P. After fertilizer application the soil was sampled and analyzed for pH, available (Bray-1) P, and Cu, Fe, Mn and Zn (extracted by EDTA method), at time intervals of 1, 2, 4 and 8 weeks. The pH and Cu increased with each increment of lime while conversely Fe and Mn decreased.. There was also a decrease in Zn with application of lime which was greater with the smaller amount of lime. Available P decreased with application of lime but with no variation between the levels of applied.

Keywords: nutrient availability, Roma valley, micronutrients extraction, liming

IRRIGATION CONTROLLED BY A FULLSTOP WETTING FRONT DECTECTOR UNDER DRIP IRRIGATION

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The FullStop wetting front detector (FS) is a simple irrigation-scheduling tool that shows whether a wetting front has passed a predetermined soil depth. The FS is a funnel-shaped device that is buried in the soil. When a wetting front reaches the detector, unsaturated flow converges at the base of the funnel to create saturated conditions. The detector will respond by raising an indicator once a wetting front with a matric potential of ≥ - 3 kPa is sensed or when about 20 ml of water is collected. It has been shown for rain and sprinkler irrigation that the wetting front will move more slowly in a dry soil than a wet soil, so that, the length of irrigation required to activate a detector is related to the initial water content.

The objective of this study was to investigate the influence of the initial soil water content on the irrigation amounts permitted by the FS under drip irrigation. The trial was conducted on a bare soil under a rainshelter. Consecutive irrigations were given to plots with different initial soil water contents. A series of “weak” wetting fronts at depth were created by turning off the irrigation when an FS at 30 cm depth was activated. The response of a second FS at 60 cm was then evaluated. The results showed that the irrigation amounts permitted by the FS, depended more on the shape of the wetting patterns, rather than the initial soil water content. The FS did not respond to weak fronts (drier than 3 kPa suction), although most of the deep detectors were able to collect some water.

Keywords: Wetting front detector , drip irrigation

SOIL CHEMICAL CLASSIFICATION FOR GROUNDWATER VULNERABILITY ASSESSMENT

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Two–thirds of South Africa, including more than 280 towns and settlements, are largely dependent on groundwater for their drinking water supply and development. However, groundwater resources in South Africa are limited both in terms of quantity and quality, especially in the semi–arid parts of the country. Therefore, the importance of protecting groundwater resources from pollution has been recognized. This study investigated the attenuation capacity of a selection of diagnostic soil horizons and materials representing major types of diagnostic horizons and materials in the South Africa soil classification in order to validate their chemical attenuation ratings, as provisionally specified by Sililo et al. The research also aimed at assessing the pollutant attenuation capacity of South African soils as well as describing the diagnostic value of key chemical properties of soils for conveying information on their contaminant attenuation potential. The chemical retention capacity for ionic pollutants in about 170 soil materials was tested by adding 500, 1000, 2500, 5000 and 10000 mg/kg Cu, and 100, 250, 500, 1000 and 1500 mg/kg P and developing sorption isotherms from which retention at an equilibrium concentration of 1 mg/L Cu or P could be derived. The retention capacity was statistically examined to check the predictability based on soil classification and then was correlated with several key soil chemical properties. The results suggest that soil classification provides imperfect categorization of soils in terms of pollutant attenuation. The latter can be predicted to some degree, however, if we include key soil data not directly employed as classification criteria. This implies that soil maps can be useful for making predictions about groundwater vulnerability provided the soils have been well characterized by laboratory analysis. **Reference:** Sillilo O T N, Saayman I C and Fey M V 2001. Assessing groundwater pollution impacts: a research strategy. WRC Rep. 1008/1/01. Water Research Commission, Pretoria. 58pp.

Keywords: copper , phosphate, water pollution, sorption isotherms, environmental soil classification

MONITORING OF SOIL SALINITY UNDER IRRIGATION WITH GYPSIFEROUS MINE WATER

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Gypsiferous mine water can be regarded either as one of mining's greatest problems or as a potential asset. Large amounts of waste water could possibly be made available to the farming community and utilised for irrigation of high-potential soils in the coalfields of Mpumalanga Province, where water resources for irrigation are already under extreme pressure. In this summer rainfall region, dryland winter cropping is not feasible and mine water is often the only source of water for irrigation. Moreover, concentrating the gypsiferous soil solution through evapotranspiration, thereby precipitating gypsum in the profile, could limit environmental pollution.The objective of this study was to map the salinity distribution across the field and hence determine the overall impact of pivot irrigation with gypsiferous mine water on soil salinity, by comparing salinity data generated over previous studies. A field trial was set up in 1997 at Kleinkopje Colliery, Witbank, where wheat was being irrigated on rehabilitated land under three irrigation regimes. In January 2002, the site was surveyed using an EM-38 salinity sensor mounted on a non-metallic trailer towed across the field. A total of 3849 measurements were taken. At 10 sites, soil profiles were sampled to a 1.20m depth and the electrical conductivity and Ca, Mg, K and Na contents of the saturated paste extracts were measured. The weighted mean electrical conductivity of the extract (EC_e) for the 10 profiles was related to EM-38 readings taken at the same points by regression analysis. The regression was then used to predict EC_e values from the EM-38 values taken during the survey. Following this, the ArcView GIS package was used to process the data and produce a salinity contour map of the area. Results from the 10 sampled sites revealed that salinity increased with increasing soil depth. This was attributed to downward leaching of salts over the summer rainfall period. The contour map showed that salinity levels were highest in the central area of the pivot, where the most irrigation water was applied. A relatively large area of the pivot had EC_e values ≤400mS/m, so relatively salt-tolerant crops such as wheat would be expected to grow well at the site. Salinity levels at the soil surface are, however, expected to increase over future seasons as irrigation is applied. It was concluded that the EM-38 sensor provides an effective way of mapping salinity over a wide area and that there was evidence of significant downward movement of salts at the site over the period as irrigation was applied.

Keywords: Salinity, Electrical conductivity, Irrigation, Gypsiferous mine water

CHEMICAL CHARACTERISTICS OF REHABILITATED COAL MINE SPOILS IN SOUTH AFRICA

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Mining is a temporary land use and therefore great onus is placed on the industry to rehabilitate land. The limited amount of land available to agriculture in South Africa makes the destruction of prime land even less acceptable and therefore a scientific approach to soil characterization is of importance. Nine different mines provided 1634 profile pits for classification and sampling.

The spoil component of minesoils is important in two respects: it can extend the effective depth provided by the cover-soil, but certain spoils may weather to produce harmful products. Dissolution of Na, K and Cl-bearing minerals represents the first interaction between the rock, hydrosphere and lithosphere, following mining activity. The prolonged oxidation of sulphide-bearing minerals, of which pyrite is the dominant species, is simultaneously set in motion.

The pH_{water} of the spoil is very variable, ranging from 2.6 to 9.2. Acidity is less severe in the spoil than expected, although for certain specific areas it can be problematic. The high carbonate content of the spoil has a neutralising effect, which results in relatively high pH-values. Salinity, measured as the electrical conductivity (EC) of the saturation extract, ranges from 4 to 1076 mS/m. Carbolithic spoils have the highest median EC of 254 mS/m and matric spoils the lowest at 72 mS/m. The salinity is mainly caused by sulphates, which originate from pyrite weathering and the relatively high carbonate content of the spoil material. The sulphate values range from 0.5 to 3669 cmol(+)/kg. Carbolithic spoils have the highest median sulphate value of 596 cmol(+)/kg and matric spoils the lowest at 128 cmol(+)/kg. Median carbon content (Walkley-Black method) in the spoil is 1.8% C, with a range from 0.02 to 27.3% C. The carbon-rich carbolithic spoils have the highest median carbon content of 3.45% C as can be expected. The argilithic spoils have the lowest median carbon content of only 0.3% C. The total carbon content in spoils should not be considered as biologically-active plant residue. Cation exchange capacity (CEC) values range from 0.7 to 55.9 cmol(+)/kg. Matric spoils have the highest median CEC value of 9.6 cmol(+)/kg and argilithic spoils the lowest at 5.6 cmol(+)/kg.

The view that rehabilitated opencast minesoils are inferior to natural agricultural soil in the long run is not always true, especially if the compaction and organic carbon problems in the cover soil can be solved.

Keywords: rehabilitation, opencast, Coal mine spoils

VERIFYING THE DELTA YIELD PROCEDURE FOR NITROGEN FERTILISATION OF MAIZE IN SOUTH AFRICA

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The fertiliser nitrogen requirement for maize in South Africa is mainly estimated through the optimum yield-nitrogen rate procedure of which the efficacy is questionable. Delta yield, the difference between the maize grain yield at the economic optimum and that of a zero nitrogen control, was verified for its ability to estimate the economically optimum nitrogen fertilisation rate for the South African maize producing area. Data from 124 site-year fertilisation trials scattered over this area were used for the analyses. As in North America, optimum nitrogen rate correlated better with delta yield (R^2 = 0.66) than with optimum yield (R^2 = 0.51). Consequently, it shows potential to be a more trustworthy predictor of the fertiliser nitrogen requirement of maize than the traditional optimum yield-nitrogen procedure. The delta yield nitrogen model ($Y = X^{0.602}$ with Y the amount of fertiliser nitrogen and X delta yield, both measured in kg ha^{-1}) was not only uniform for different soil and climatic regions in South Africa but appears to be similar to that found for five states of the USA.

Keywords: Delta yield, nitrogen fertilisation, maize

RELATIONSHIP BETWEEN SEED GERMINATION, SEEDLING ESTABLISHMENT AND YIELD IN PEPPER AND TOMATO

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Seed germination is generally used in the seed industry to indicate seed quality. The relationship between seed germination and seed performance during seedling establishment in the nursery and during crop production has not been widely investigated for vegetable species. The objective of this study was to determine the effect of stress created by imbibition temperature and desiccation on the performance of tomato and pepper cultivars during germination, seedling growth and fruit production. Results showed that germination overestimated seed quality, with respect to seedling and crop performance. However, there was a consistent effect of stress on germination, seedling establishment and crop production. It is concluded that seed germination is a useful seed quality measure, but it is less sensitive to factors that influence seedling growth and crop production.

Keywords: Dessication, Imbibition

THE EFFECT OF VARIOUS MULCHING STRATEGIES ON TEMPERATURE REGIMES IN A CLAY SOIL UNDER SEMI-ARID CONDITIONS

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The water regime for the Glen/Bonheim-Onrus ecotope has been continually studied over a period of seven years, with the aim of conserving water for crop production using a technique called “In-field Rain Water Harvesting” (IRWH) versus conventional tillage. The results from these experiments using the IRWH technique revealed that water loss through evaporation (Es) amounted to 75 % of the annual rainfall for maize. Since temperature plays a significant role in evaporation the following experiment was conducted to further study the effect of various mulching strategies on temperature. The mulching treatments were: bare soil surface (control), 50% reed mulch coverage, 50% stone coverage and 100 % reeds mulch coverage. Temperature measurements were taken at 2, 25 and 75 mm below the soil surface using Hobo sensors and 75 and 160 mm above the soil surface using thermocouples for approximately a year in each of the three replicates. An automatic weather station within the site provided air temperature data at 1400mm above the soil surface.

A comparison of temperature at the various levels above and below the soil showed that percentage cover of mulch influenceed temperature especially near the soil-mulch interface but not 160 mm above the soil surface. It was established that there are strong linear relationships between average station reference air temperature and soil temperature at 25 and 75 mm depths. It was also found that mulching treatments did not have an effect on soil temperature when the air temperature fell below 5 ^{o}C. Mulches progressively lowered the soil temperature as the average air temperature increased towards 30 ^{o}C. For example at 30 ^{o}C station air temperature, the soil temperatures (25 and 75 mm layers) of the 50 % stone, 50 % reed and 100 % reed were: 2, 3 and 6 ^{o}C, respectively, lower than the bare soil treatment. The results indicated that percentage mulch cover is important in lowering soil temperature during the summer months and, hence, decreasing available energy for evaporation.

Keywords: soil temperature, reed mulch, stone mulch

SAMPLING AND HANDLING OF SOIL SAMPLES FROM BIOSOLID AMENDED SOILS FOR NITRATE AND AMMONIUM ANALYSIS

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Field validation of mineralisation and nitrification rates is essential for accurate predication and modeling of the environmental fate of nitrogen entering the soil system through biosolid application. Mineralisation and nitrification are ongoing processes, and sampling and handling will determine how representative the determined nitrate and ammonium speciation is to that in the soil at the time of sampling. The aim of the study was to compare nitrate and ammonium speciation of dried and sieved samples with that of samples extracted directly from the field, without drying, and to establish the correct sampling procedure for biosolid amended soils. Soil samples were collected from biosolid amended dryland fields. In the field, sub-samples of a known volume of soil that passed thought a 2 mm sieve, were directly transferred to containers with 50 cm^3 1 *M* KCl and transported to the laboratory for immediate extraction and nitrate and ammonium analysis using the Kjeldahl method. The other sub-samples were taken to the laboratory, dried and sieved, and then extracted and analysed for nitrate and ammonium. There were significant differences in nitrate and ammonium speciation. The average ammonium content of the direct extraction was 11.2 mg kg^{-1} compared with 4.3 mg kg^{-1} for the dried and sieved samples, and the average nitrate content of the direct extraction was 36.5 mg kg^{-1} compared with 65.0 mg kg^{-1} for the dried and sieved samples. The nitrate and ammonium speciation determined after direct extraction is expected to be more representative of the nitrate and ammonium speciation in the soil at the time of sampling. Based on the results, drying and sieving will result in an underestimation of the ammonium content of the soil and an overestimation of the nitrate content of the soil. Artifacts introduced by drying will result in an overestimation of nitrification as well as mineralisation in the biosolid amended fields.

Keywords: mineralisation, sampling and handling , biosolid , nitrate and ammonium speciation , direct field extractions

RESPONSE OF COWPEA (*Vigna unguiculata*)TO PHOSPHORUS APPLICATION AND RHIZOBIA INOCULATION IN VHEMBE DISTRICT, LIMPOPO PROVINCE

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Cowpea (*Vigna unguiculata*) provides an important dietary source of carbohydrates and proteins in both underdeveloped and developed countries. The immature pod contains vitamins A and C, while dry seeds contain protein, carbohydrates and some essential minerals. Considering the pressing need to improve the welfare of rural poor in this region of the Limpopo province, issues relating to food security and opportunities for income generation are of great significance. A field study to determine the response of cowpea to phosphorus (P) application and rhizobia inoculation was conducted at the University of Venda, School of Agriculture experimental farm on a deep, well-drained clay, Hutton form soil type. Treatments were two levels of P applied as single superphosphate (SSP) at 0 and 75 k g ha^{-1} with or without rhizobia inoculation. The cowpea cultivar used was Bechuana white. The experiment was a 2x2 factorial laid out in a randomized complete block design with four replications. Plants were sampled at 50% flowering for determination of biomass yield and nodule weight, and again at maturity to determine grain yield. At 50% flowering, biomass yield and nodule weight ranged between 173 to 225 kg ha^{-1} and 54 to 130 mg $plant^{-1}$, respectively. Phosphorus application with rhizobia inoculation increased biomass yield by 30% over the control. Rhizobia inoculation alone increased nodule weight almost threefold over the control, while P application, either alone or with rhizobia inoculation, led to a twofold increase in nodule weight over the control. At maturity, grain yield ranged between 384 to 428 kg ha^{-1} with P application, with rhizobia inoculation producing the highest yield. Phosphorus application, either alone or with rhizobia inoculation produced higher grain yield than rhizobia inoculation alone and the control. Results from this study indicate that inoculation may not be necessary, possibly due to greater population sizes of indigenous soil rhizobia. Phosphorus application, however, is necessary in these soils in order to maximize cowpea grain yield production.

Keywords: Cowpea, Phosphorus, Rhizibia inoculation, Nodulation, Grain yield, Biomass yield

EFFECT OF SEED PRODUCTION SITE ON COWPEA (*Vigna unguiculata*. L) SEED PERFORMANCE

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Interactions between seed developmental processes and environmental factors acting on the mother plant may influence seed quality. It is surmised that in cowpea (*Vigna unguiculata*), there is a relationship between pre-maturation seed quality and prevailing conditions in the production environment that ultimately influences seed performance. Seeds of six cowpea cultivars were produced under dryland and irrigated conditions. Water content, dry matter accumulation, and seed performance were determined during six developmental stages (weekly intervals after pod formation until harvest maturity) and mature seeds aged using the accelerated aging (AA) test. Interactions between site, cultivar and developmental stage were highly significant ($P<0.001$) for water content and seed performance. Seeds produced under dry land conditions showed consistently higher water content and less dry matter accumulation throughout the development period and a significantly ($P<0.001$) higher percentage of abnormal seedlings at stage 3 of seed development. There were no significant differences in germination capacity and physiological seed vigour between sites from stages 4 to 6. However, solute leakage for seeds produced under dryland conditions was consistently and significantly ($P<0.001$) lower than that under irrigated conditions at HM and 3d after AA test. It is concluded that differences in seed performance could be attributed to cell membrane properties. The relationship between the development of vigour and acquisition of desiccation tolerance as influenced by drought stress in cowpea will be discussed.

Keywords: Seed vigour, Environment, development, Interactions

THE MICROLYSIMETER: A SIMPLE TECHNIQUE FOR MEASURING DIRECT EVAPORATION FROM SOIL BENEATH A CROP CANOPY

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Direct evaporation from the soil surface beneath a crop canopy, Esc can be a major component of the crop water balance. Thus, accurate estimation of Esc is important in crop water use studies. This study aimed to directly measure the Esc component of water use by maize crops grown with and without fertiliser N in two contrasting moisture regimes. A field experiment was undertaken using a split-plot design with watering regimes (rainfed and irrigation) as main plots and N (0 and 100 kg N ha^{-1}) as subplots. Esc was measured daily using microlysimeters. The amount of moisture lost daily through soil evaporation was calculated from the changes in microlysimeter weight (´W) over 24 hours as ´W/A, where A is the cross-sectional area of the microlysimeters. With the microlysimeter used, a loss in weight of 1 g was equivalent to 0.51 mm of water. Esc was also indirectly estimated using the intercepted radiation (IR) technique. Esc ranged between 121.1 and 174.0 mm. The values of Esc determined by the IR technique were highly correlated (r^2=0.97) with Esc values determined from direct microlysimeter measurements. However, the IR technique underestimated Esc (by 30-88%) when the rate of soil evaporation was <1.0 mm d^{-1}. Also, the IR technique underestimated Esc between two and six days after a rainfall event. Therefore, the microlysimeter gives good estimates of Esc and hence can be used to partition components of crop water balance in studies that involve development of cropping systems for rainfed agriculture in dry areas.

Keywords: Microlysimeter, evaporation, soil, canopy, radiation, intercepted

THE EFFECT OF MULCH LAYERS ON SUGARCANE GROWTH AND WATER USE

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In South African there is continued pressure on the limited water resources available to the sugar industry through area expansion, competition with other crops and frequent droughts. The industry is under pressure to demonstrate that water is being used both efficiently and economically. One way of achieving this goal is through the retention of a mulch blanket of crop residues. The objective of this study was to determine the effect of different types of mulch layers on 1) crop growth, 2) cane yield and 3) crop water use. A field trial was conducted at Pongola on three weighing lysimeters which either had no mulch cover (bare soil surface), soil covered by a light mulch (cane tops) and soil covered by a heavy mulch (tops plus additional leaf material). Stalk population, stalk height, radiation interception, depth of mulch layers and crop water use were recorded regularly. Growth and radiation capture was negatively affected by the presence of a mulch layer. The bare treatment reached 80% radiation capture 45 days before the heavy mulch treatment. Crop water use of mulch treatments was on average 20% less than the bare soil treatment. Yield responses were inconclusive. Results obtained from this study will be used to develop best management practices for the optimal use of irrigation water.

Keywords: mulch layer, sugarcane, crop water use, lysimeter

THE ROLE OF HERBACEOUS LEGUMES IN THE CROP-LIVESTOCK SYSTEMS OF THE NORTHERN GUINEA SAVANNAH OF NIGERIA, WEST AFRICA.

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Sustainable crop-livestock production systems are a challenge to agricultural research in the northern Guinea savannah of Nigeria. In order to promote the intensification of agriculture and foster crop-livestock integration practices amongst resource poor farmers, an evaluation of herbaceous legumes (3 dual-purpose grain legumes- cowpea (*Vigna unguiculata* (L.) Walp.), groundnut (*Arachis hypogea* L.), and soybean (*Glycine max* L.) and three forage legumes- *Stylosanthes guianensis, Centrosema pascuorum*, *Aeschynomene histrix*) as well as natural vegetation were tested on station. The experiment also included 3 management practices- legume residues left in the field, legume residues harvested and not returned to the plot and legume residues harvested, fed to livestock and manure/compost returned to the plot. All treatments were followed by a maize test crop after the fallow phase. Length of fallow and legume rotation influenced forage biomass, grain yields of herbaceous legumes and maize growth. Overall results indicate that production of forage legumes was significantly enhanced after two years of consecutive fallow. The benefit of legume fallows to subsequent maize was mostly related to the residual N of the previous legumes and the management practices. Forage legumes produced substantially more biomass than the grain legumes. However, grain components from grain legumes were able to compensate for this. Taking account of the legume biomass and grain production, maize grain and stover yields after the legume, and the performance of sheep in terms of liveweight gain and manure output, over the three year period, *G. max* and *S. guianensis* gave the best overall performance. *A. hypogea* did best on plots where the fodder was fed to livestock and the manure returned to the plot, and *S. guianensis* recorded the best outputs when the biomass was harvested and not returned to the field. The management practice of feeding livestock and returning manure to the field gave the best results, although there were variations between years and species. This appeared to be a very positive result with respect to opportunities to use herbaceous legumes to address issues relating to livestock and crop production integration. Overall ranking indicated that *G. max* performed best among the grain legumes, followed by *S. guianensis* and *A. hypogea* while among the forage legumes *S. guianensis* performed better than the other two forage legumes. All the legumes except to some extent cowpea, performed better than the natural fallow plots in terms of biomass for livestock and maize production.

Keywords: Maize grain, sheep, animal weight gains, crop-livestock systems

USES OF GEOTEXTILE AS ANTI-EROSIVE AND WATER HARVESTING TECHNIQUES TO IMPROVE SUSTAINABLE DRYLAND MULTIPLE CROP PRODUCTION ON SLOPING HIGHLAND

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Shifting and annual intensive cultivation on sloping highland in northern Thailand is leading to severe soil erosion, degraded soil fertility, drought and flood disasters and critical agro-ecological and socio-economic problems. Strategies to solve the problems include decreasing soil erosion and increasing multiple crop production by using anti-erosive and water harvesting cultural practices. This field experiment aims to compare the effects of different soil conservation and water harvesting techniques on soil properties, soil loss and surface runoff, soil water storage and crop yields. The experiment commenced in May 2004 in the two catchments in Chiang Mai (Site A) and Mae Hong Son Provinces (Site B), both in northern Thailand. The experimental plots have been established in the farmers' cultivated plots at altitudes of 980-1100 m and 780-800 m with slopes of 100% and 30%, respectively. The 3 replicated treatments comprise five soil conservation techniques in Site A (CP, CP-BM, CF-IM, CF-AL and CF-IM-AL) and four in Site B (CP-BM, CF, CF-IM and CF-AL). The treatments are (i) Conventional contour planting after slash and burn or control (CP); (ii) contour planting as (i) mulched with bamboo mat geotextile (CP-BM); (iii) contour furrow planting mulched with imperata grass panel geotextile in the furrow (CF-IM); (iv) contour furrow planting in alley cropping (CF-AL); and (v) contour furrow planting mulched with imperata grass panel in alley cropping (CF-IM-AL). The hedgerows in alley cropping consisted of mixed fruit-trees (mango, lemon and jujube) and groundcover with graham stylo. The annual multiple crops are rotations of sweet corn followed by upland rice and lablab bean during the summer early, mid-late rainy season and late rainy season, respectively. The measured data were basic soil properties, surface runoff, soil loss, soil water storage and crop yields. The results showed that (i) CF-IM-AL tended to improve soil properties more than the other treatments. (ii) Least surface runoff and soil loss occurred in CF-IM-AL (Site A) and CF-AL (Site B) plots, while the highest values were found in CP (Site A) and CP-BM (Site B) plots. (iii) Most soil water storage during dry periods tended to be obtained under CF-IM-AL (Site A) and CF-IM (Site B) compared with the other treatments. (iv) CF-IM-AL and CF-AL tended to give the highest corn and lablab bean yields, while the lowest yields were given by CP and CF practices in both Sites A and B. Generally, CF-IM-AL tended to be the best and CF-AL and CF-IM the second best, while CP and CP-BM were the poorest and the second poorest cultural practices for soil and water conservation, multiple crop production and sustainable land use on the sloping highland under tropical humid climate conditions. Therefore, contour cultivations mulched with biodegradable geotextile mats in alley cropping, with hedgerows of mixed fruit trees and leguminous ground cover crops, are expected to be the best soil and water conservation practices on sloping highlands.

Keywords: Anti-erosive technique, Furrow cultivation, Geotextile, Soil erosion, Runoff

RAINFALL AND MAIZE YIELD ANALYSIS FOR THE HIGHVELD PART OF THE OLIFANTS CATCHMENT

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Agriculture is highly vulnerable due to annual rainfall variability, especially in the case of dryland crop production. Long-term rainfall records of 5 stations along the Olifants River in Mpumalanga were examined to reveal short- and long-term rainfall patterns. Currently, Mpumalanga 's rainfall amounts to 600 mm and 150 mm for summer and winter respectively. Annual and seasonal rainfall data were analysed to provide an assessment in terms of homogeneity. High correlation coefficients between annual and seasonal rainfall at the stations were observed. The time series data were homogeneous for the Middleburg and Loskop Dam weather stations.

The correlation between ENSO (El Niño Southern Oscillation) and rainfall in certain parts of Southern Africa has been recognised for at least a decade. An analysis was made of the potential for using ENSO phase predictions to reduce risk associated with seasonal rainfall variability and maize production. Maize yields were generally lower in El Niño years. The variability in the summer seasonal rainfall pattern was high within most ENSO phases. There is no simple relationship between seasonal precipitation and maize yield, but precipitation distribution plays an important role. This indicated that a more precise seasonal climate prediction would be necessary for the forecast to be utilised to enhance decision making in dryland crop production.

Using the framework to be outlined , with improvements in both climate forecasts and crop simulation models, there is potential for identifying management strategies that can reduce agricultural risk associated with climate variability in the Highveld area of Olifants catchment.

Keywords: Climate variability, Seasonal forecast, ENSO, El Niño

SOIL NUTRIENT DYNAMICS IN WILD MUSTARD INTERCROPPED WITH GREEN BEANS

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The effect of crops on soil mineral composition is important for crop management. The objective of this study was to determine the effect of wild mustard and green beans on changes in mineral content in the presence or absence of organic fertilizer, under field conditions. Soil samples were collected around the root zones of three wild mustard species and green beans grown as sole crops or in intercropping with green beans before planting and at flowering. Soil analysis was performed to determine changes in nutrient contents as influenced by organic fertilisation and intercropping. Intercropping had no effect on the soil changes around the root zones of all the wild mustard species but increased plant K content compared to sole cropping. Total K and P generally increased with organic fertilisation showing values above the initial values in the soil during four seasons of the year. Similar trends were observed for Cu and Zn. The study indicated that wild mustard is capable of building up the soil mineral nutrient concentration with or without fertilisation.

Keywords: Wild mustard, green beans

SMALL-FARMER PARTICIPATION IN SWEET POTATO (*Ipomoea batatas*) VARIETY EVALUATION IN LIMPOPO PROVINCE

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To enable horticultural advisors to recommend the best adapted and taste- preferred sweet potato varieties for small farmers in the Limpopo province of South Africa, a trial was conducted with a number of sweet potato varieties and new breeding lines during the 2004/05 season. The aim of the study was to evaluate the production potential of different sweet potato varieties and new breeding lines for small-farmer selection of best-tasting varieties/lines in Limpopo province.

Sweet potato varieties and lines were planted and grown under sub-optimal input levels at the experimental farm of the University of Limpopo for approximately five months. In an attempt to simulate small-farmer growing conditions, lower than recommended irrigation and fertilizer levels were used, while no weed, pest and disease control took place. Fifteen treatments (varieties/lines) were evaluated in a randomized complete block design with three replications. At harvesting, storage roots were graded as marketable or unmarketable yield, while small-farmers chose the preferred varieties/lines in-field. Storage roots were cooked and taste preference data gathered by means of a structured questionnaire. All data were analyzed with the Genstat statistical software package. Results of the 2004/05 season will be presented. Marketable storage root yields ranged from 66.1 $t.ha^{-1}$ (Ndou) to 15.3 $t.ha^{-1}$ (A15). Significant differences in yields ($p=0.05$) were found between most varieties/lines. The most promising new orange fleshed breeding line was 1999-6-1, with a yield of 39.9 $t.ha^{-1}$. The main causes of unmarketable storage root yields were cracking, and insect, rodent and mechanical damage. Farmers selected “Resisto”, “Amasi”, “Monate”, “Mafutha” and “Excel” as best tasting. New sweet potato breeding lines performed well in this environment. Small-farmers selected cultivars and lines of preferred taste and storage root characteristics. Satisfactory yields were obtained even when grown under sub-optimal conditions, indicating the good potential as a crop under small-farmer conditions in Limpopo. The results of varieties “Ndou”, “Monate” and “1999-6-1” (to be released as “Khano”), were promising after one season and final recommendations will be made after two season’s results.

Keywords: storage root yield, quality, taste panel, environmental adaptability

EVALUATION OF PLANT GROWTH ON DEGRADED MINE SOILS AMENDED WITH FLY ASH AND ANIMAL MANURES

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Due to the large production of coal combustion by-products (CCBs) and animal manures in the Mpumalanga Province, a study on the combination of CCB fly ash with cattle and chicken manure as alternative soil amendments was conducted. These amendments could potentially be used in the rehabilitation of many surface coalmines in this province, to establish more sustainable production systems. This study includes the production of Winter Rye (*Secale cereale*), Japanese Millet (*Echinochloa sp.*) and Forage Sorghum (*Sorghum sp.*) in a phytotron pot trial, which simulated the post-mining land capability class used for pastures and fodder crop production. Treatments included combinations of agricultural lime, fertilizer, chicken and cattle manure, and class F fly ash in cover soil and acid mine drainage (AMD) impacted soil from a surface coalmine. Winter Rye, Japanese Millet and Forage Sorghum data showed very significant interactions of the treatments at different levels on the average dry matter production, root development and seed germination rate. The effects of different treatment levels were the highest on the initial production of Winter Rye and decreased with time for the subsequent cropping cycles of Japanese Millet and Forage Sorghum. Chicken manure treatments, however, had the highest average dry biomass production, relative to the fly ash and agricultural lime treatments. All treatments which served as a source of macronutrients performed better on average. The results therefore indicate that fly ash and animal manures can serve as alternative or supplemental amendments for conventional commercial lime and fertilizer use on degraded mine soils.

Keywords: fly ash, animal manures, plant production, soil amendments

CHALLENGES FACING SUSTAINABLE CROP PRODUCTION IN SA

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Food security stands at the core of our country and region's health, prosperity and stability, and crop production fulfils a key function in creating that security. To this end The Grain Strategy Plan was drawn up by the key role players within industry to provide an implementable set of long term strategic initiatives at all levels of the value chain to bring about a united, prosperous and competitive grain industry. To achieve these goals and ensure the successful implementation of the Strategic Plan for the South African Grain Industry, three broad-based action plans were drawn up:

I. Broadening participation in the grain industry

II. Improving competitiveness and profitability of the industry

III. Food security

Various strategies were developed within each of the broad-based action plans to address these key objectives.

Keywords: food security, grain strategy plan, prosperity, crop production, security

GROWTH AND DEVELOPMENT OF SUGARCANE AS AFFECTED BY TRASH MULCHING: PRELIMINARY RESULTS

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Retention of a sugarcane mulch blanket, following green cane harvesting could increase moisture conservation, soil health (organic matter content and micro-organism activity) and soil nutrient status. However, less is known about the effect of such a mulch layer on sugarcane crop growth and development. To study the latter, an experiment was carried out in Komatipoort at the South African Sugarcane Research Institute's Experimental Station. Row spacing arrangement was either 1.5 m or 1.2 m x 0.6 m. N14 was planted as a fast canopy growing cultivar and N26 as a slow canopy growing cultivar. Plots were either covered by a mulch layer or left as bare soil. Stalk population, stalk height and radiation interception were measured every second week. Soil temperature readings were logged hourly at one depth (0.15 m). Preliminary results indicate that early growth and development of sugarcane was delayed under mulch treatments. Stalk length of N26 was reduced more than that of N14. Stalk population of both cultivars were significantly lower under the mulch treatment. Fractional interception of solar radiation was only 50% at 150 days after planting for the mulch treatment, compared to 70% for bare plots. Slow initial growth and delayed canopy development in mulch treatments were associated with low soil temperatures in the period leading up to full canopy closure. Soil temperature in the mulch treatments remained between 3^{o}C to 4^{o}C lower than the bare soil treatments. Early indications are that the presence of a mulch layer may reduce early growth and development of sugarcane.

Keywords: mulch layer, sugarcane, soil temperature

THE EFFECTS OF CLIMATE CHANGE ON AGRICULTURE

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The linkages between agriculture and climate are quite prominent, often complex, and not always well understood. Major uncertainties remain regarding the influence of climate change on agriculture, mainly due to the lack of precise forecasts of climate change at geographic and time scales relevant to agriculture.

This paper gives a literature overview of possible effects and impacts of climate change on agriculture with specific reference to South Africa. Estimates illustrate the possible consequences of climate change. These studies have been based on average predicted changes in the various weather elements. It is, however, difficult to quantify what the joint effect of the different factors will be.

Climate change can affect among others crop suitability and potential, the quantity and quality of forage for livestock, the prevalence and distribution of pests and diseases, the severity and occurrence of extreme events and food security. General predictions for South Africa include an increase in the intensity of extreme events; biome shifts that will favour horticulture over plantation forestry; and it is projected that the malaria risk areas will expand southward. Model predictions also show an increase in potential yields, generally by as much as 5 t/ha, over most of the country.

South Africa's ability to respond or adapt to climate change will depend on many factors. These include the capacity to organize and sustain the institutions that produce and transfer scientific and technical knowledge, the ability to embody new knowledge in equipment and materials, the level of farming and education among farmers, the efficiency of markets for inputs and products, and the effectiveness of public policy in easing adaptation.

Keywords: Climate change , Agricultural production

THE EFFECTS OF PLANT GROWTH REGULATORS ON AGRONOMIC AND QUALITY CHARACTERISTICS OF SOUTH AFRICAN WHEAT

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Lodging in wheat (Triticum aestivum) under irrigation in South Africa leads to severe yield and quality losses. Plant growth regulators (PGR's) that reduce plant height and lodging have not been evaluated on commercial wheat cultivars under local conditions. The objective of this study was to assess the effects of PGR's on plant height, lodging, yield and yield components and quality parameters of three wheat cultivars under irrigation in the field. A water control and two PGR's, chlormequat chloride and ethephon, were applied individually (1.575 kg chlormequat ha^{-1} and 0.6 kg ethephon ha^{-1}) and in combination with each other (1.75 and 0.375 kg ai ha^{-1} of chlormequat and ethephon respectively) at either the tillering, stem elongation or the flag leaf stage of growth to the cultivars Kariega (lodging susceptible), Olifants (lodging tolerant) and SST 876 (lodging tolerant) at Vaalharts and Bethlehem. The 4×3^2 factorial treatment combinations were planted in a RCBD with 4 replications in the 2003 and 2004 seasons at both sites. Chlormequat only reduced plant height by approximately 4.5% when applied at the flag leaf stage and had no effect on lodging with any cultivar. Yield and yield components and quality parameters were generally not affected by chlormequat. Ethephon and the PGR combination significantly reduced plant height (by 8.6 and 17% respectively) and lodging (by 84 and 94% respectively) of the cultivar Kariega when applied at the flag leaf stage, while lodging was not reduced with the lodging tolerant cultivars. Yields were either improved or reduced by ethephon and the PGR combination, depending on the cultivar, time of application (TOA) and environment. The yield reductions were primarily attributed to reductions in mass $grain^{-1}$ and grains $spike^{-1}$. Differential hectolitre mass, protein content, falling number and preharvest sprouting score responses were observed depending on the environment, cultivar and TOA of ethephon and the PGR combination. Generally, the results of the study suggest that chlormequat is not suitable as an anti-lodging tool in wheat production, while ethephon and the PGR combination may successfully control lodging and occasionally improve grain yield and quality, and should therefore be used as an insurance measure against lodging losses.

Keywords: chlormequat chloride, ethephon, lodging, yield components

GRAIN YIELD, GRAVIMETRIC MOISTURE CONTENT AND CHLOROPHYLL PRODUCTION OF MAIZE IN MAIZE-LEGUME INTERCROP UNDER MINIMUM AND CONVENTIONAL TILLAGE SYSTEMS.

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Maize is a dominant crop in the dryland smallholder farming system in the Limpopo province of South Africa , generally cultivated as intercrop with grain legumes. The major constraint in this cropping system is inadequate soil moisture during a growing season, which also limits nutrient availability to the component crops. The minimum tillage system, where the soil is generally left undisturbed from harvest to planting has been reported to improve soil moisture availability on farmers' fields but this has not yet been verified in an intercropping system in the province. The objective of this study was to quantify grain yield and chlorophyll production of intercropped maize, and to assess seasonal moisture availability under minimum tillage (MT) and conventional tillage (CT) systems. Dryland field experiments were conducted at two locations in the province namely, a farmer's field at Dalmalda in 2002/2003 and 2003/ 2004, and at the University of Limpopo Experimental farm at Syferkuil during the 2003/04 growing seasons. The experimental design was a randomized complete block in split plot arrangement at all locations and seasons. Tillage systems consisting of conventional tillage and minimum tillage were the main plot treatments, whereas five different cropping systems namely, maize only, and maize intercrop with Bechuana White, Agripers, Lablab bean and Velvet bean were assigned as sub-plot treatments. Maize grain yield in 2002/03 at Dalmada was significantly lower, 357 kg/ha under CT relative to 755kg/ha under MT. In 2003/04 at Dalmada, grain yield under the two systems was similar, 1557 for CT and 1436 for MT, but at Syferkuil, grain yield under MT was 15% higher than that under CT. At Dalmada, significantly higher soil moisture was recorded under the MT system only at 81days after planting (DAP) at the 0-150mm depth, and 63DAP at the 150-300mm depth in 2002/03 while in 2003/04, the difference occurred at 74DAP at the 0-150mm depth. No differences were recorded at the other sampling dates and depths. At Syferkuil, soil moisture was higher under MT at 126 DAP at both the 0-150mm and 150-300mm depths. Chlorophyll content of the youngest fully expanded leaves of maize was generally higher under MT than CT, but this was observed only at the later stages of growth. The minimum tillage system has shown the potential of being a superior system for dryland maize production, but further research involving additional locations is required to establish this.

Keywords: Maize, minimum tillage, conventional tillage, moisture content , grain yield

A REVIEW OF THE GREEN MANURING WORK CONDUCTED AT THE SOUTH AFRICAN SUGARCANE RESEARCH INSTITUTE OVER THE PAST 80 YEARS

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In order to focus future green manuring research at the South African Sugarcane Research Institute (SASRI) and avoid duplicating trials, a review was conducted of the work carried out at this institute since 1925. Trial reports, both published and unpublished, were reviewed and collated. In the early days of the South African sugarcane industry, inorganic fertilizers were not widely available, and legumes and other crops were the only means of returning nutrients to the soil via green manuring. The earliest published discussion of green manuring work in South Africa's sugar industry was presented in 1925. The author underlined the importance of maintaining sufficient organic matter levels in the soil, especially during dry conditions. Other researchers recognised the decrease in organic matter in sugarcane-growing soils of South Africa, and promoted green manuring to try to combat this decline.

Trials conducted in the early days were rather basic – a few species of crop were grown, and results presented in a subjective manner. Researchers did, however, identify promising varieties for use in the industry, and promoted the practice of green manuring to break the sugarcane monocrop. As manufacturing industries progressed and chemical fertilizers became more easily available and economically viable to buy and apply, so the practice of green manuring gradually declined, and from the 1950s until the 1970s it was practiced very little in the industry. Research at SASRI declined accordingly, and little green manuring research was conducted during this period. A sugarcane yield decline first identified in the 1970s, however, prompted farmers and researchers alike to question the viability of long-term monocropping. This yield decline, defined as 'the loss of productive capacity of sugarcane growing soils under long term monoculture', kick-started researchers into once more exploring the benefits of crop rotation and fallow cropping in the sugar industry. Once again, green manuring became an important aspect of SASRI's research programme. Since 1998 a fair volume of research has been conducted into green manuring and its benefits. Researchers hoped to develop a strategy for amelioration of yield decline in sugarcane through the use of green manures. Although researchers experienced periodic setbacks, several positive results ensued. Various green manure crops were found to grow very well without fertilizer, and it was found that fertilizer could, in some cases, be reduced in the following cane crop. More recently, green manures have been tested for other properties such as weed suppression, pest and disease control and overall soil health improvement. Current work continues to focus on the best green manure species for various seasons and areas within the sugarcane industry, and the most efficient and practical ways to establish and manage these crops. Soil biology and soil health are receiving increased attention from sugarcane growers and researchers alike, and green manuring forms part of a system of maintaining soil health and biodiversity. Future work at SASRI needs to reflect the changing nature of the sugarcane growers of South Africa.

Keywords: green manuring, sugarcane, soil health, SASRI

VISUALISATION OF INFILTRATION AND SALT ACCUMULATION PATTERNS IN CLAY SOILS OF SWARTLAND

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The experiment was inspired by field observations of cracks on the soil surface in some parts of the catchment and multiple instances of termite activity. Both processes (cracking and termite burrowing) resulted in formation of macropores in the soil. The influence of these pores on infiltration was not clear and it was decided to attempt to quantify their effect on distribution of water and salts in soils of the Goudertrou experimental catchment in the Swartland. KI (potassium iodide) was added to irrigation water as a tracer at 7% concentration. A standard double ring infiltrometer and a rainfall simulator were used to monitor infiltration rates. On completion of the infiltration experiment the sites were excavated and treated with bleach for more complete KI release, and subsequently with starch to develop highly visible patterns of water infiltration. Both vertical and a sequence of horizontal sections were examined and photographed with a digital camera. The degree of macropore conductivity was determined from the analysis of digital photographs. The experiment showed substantial increase of water penetration in the rows of the minimum tillage application, which may be attributed both to cultivation and the effect of wheat on water interception and channeling.

Keywords: Infiltration, salinity, tracer

INFLUENCE OF PLANTING DEPTH OF MAIZE ON PHYTOTOXICITY OF TWO GRAMINICIDES AND FOUR SEED DRESSINGS

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This study was prompted by maize producers reporting phytotoxicity to occur when graminicides were used on maize planted on sandy soil. The study comprised a greenhouse experiment in which four seed dressing treatments and seven herbicide treatments were applied to maize planted in pots filled with soil with less than 5% clay. Before planting, maize seeds were treated with seed dressings of thiametoxam, carbofuran A, imidacloprid and carbosulfan B. Two acetochlor herbicides were applied at both registered, double and triple dosage rates. The herbicides were applied directly after planting. An untreated control treatment was included. Experimental layout was a completely randomised design with four replicates per treatment. One pot was used per treatment-replicate. The maize seed used in this study was coded and of one seed size. Six maize seeds were planted per 4 litre plastic pot, filled with soil with a clay content of less than 5%. Maize seed was planted at three depths *viz* at 6, 8 and 10 cm. The trial was conducted at 15°C night and 25° C day temperatures. Thirty days after planting and herbicide application (DAP) the above ground plant parts of four plants per pot were cut and dried at 55°C for a week for determination of dry mass. Other variables recorded were mean time to emergence in days, the total number of seedlings emerged and visual symptoms of phytotoxicity. Throughout the observation period, it was difficult to distinguish between the effects of the different seed dressing treatments. It appeared that the effect of both planting depth and herbicide treatment were similar on the various seed treatments. Symptoms of phytotoxicity increased with an increase in planting depth. In contrast with the other assessed variables, where planting depth caused an increase in phytotoxicity, the percentage folded leaves was highest at the 6 cm planting depth, followed by 8 cm. The least folded leaves were recorded with the 10 cm planting depth. With regard to phytotoxicity, it seemed that the application of acetochlor 700 EC at double and triple dosages and acetochlor S 840 EC at triple dosage rate were responsible for phytotoxicity, especially at the deeper planting depths.

Keywords: graminicides, phytotoxicity , maize, planting depth

UNDERSTANDING SOUTH AFRICAN SOILS

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There is a need among non-soil scientists (engineers, environmentalists, botanists, etc) in South Africa, who are in some way or another involved or interested in land use or land degradation, for information on soils and the role of the soil in land use as well as land and water care.

High school and college students also experience a scarcity of non-technical publications and materials on soils. Soil science handbooks, soil classification books and Land Type memoirs are of a technical nature, and require a prior knowledge of the subject.

There is also a scarcity of interpretive publications, informing the extension officers, for example, as to what renders soils susceptible to erosion, or what fertile soils look like and where they are found.

South Africa is currently embarking on its own LandCare movement, which aims at empowering communities to use land in a sustainable way. Many land users, and also officials serving them with information, are lacking in understanding and the interpretation of soil characteristics.

The aim is to address the above needs by providing a non-technical, user-friendly, illustrated guide to, and map of South African soils, their origin, identification, suitability for various land uses and susceptibilities to degradation. The diversity of soil types of the country and the implication for land use and land care are illustrated. It is aimed at agricultural extension officers, college and high school students as well as persons in disciplines other than soil science who need a basic knowledge of soils. An attempt is made to explain concepts without using specialized technical language.

The methodologies followed to compile the map will be briefly discussed.

Keywords: Non-technical soil information, extension officers, students

THE AGGREGATE STABILITY OF SHORTLANDS SOILS

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Shortlands soils cover an es timated area of 700 000 hec tares in South Africa. They are commonly derived from basic parent materials. The presence of uniformly red subsoil colours, high clay content, moderately strong to strong blocky structure, aggregates that easily fall apart into shiny flat edged elements and diffuse horizon boundaries are characteristics of these soils. Kaolinite is the dominant clay mineral in the B horizons of 81 out of 117 Shortlands soils (nearly 70%). Although minor amounts of swelling clays are generally present in these soils, the strongly developed structure is more likely related to ”nitidization” or alternating micro-swelling and shrinking processes.

Examination of thin sections showed that the secondary iron oxides (hematite, goethite) act as cementing agents that lead to the aggregate stability counteracting clay dispersion and eluviation, resulting in a gradual or diffuse transition between topsoil and subsoil horizons. The ratio of water-dispersible to total clay is very low, also reflecting a high aggregate stability. The stable structure coupled with a deep and por ous solum, that permits deep rooting, make these soils very resistant to erosion, as was proven in several erosion studies.

The Shortlands soils are commonly classified as Nitisols in the World Reference Base for Soil Resources (WRB). The red-structured B horizon in these soils is equivalent to the “nitic” horizon in WRB or the “rhodic” concept of the Soil Taxonomy. The WRB “Introduction” describes them as “*much sought after for smallholders' farm and plantation crops*” and refers to their “*good tilth and easy workability and other physical attributes that have contributed to the presence of sustainable low-input agriculture on these soils*”.

Keywords: aggregate stability, thin sections, water-dispersible clay

ENERGY BALANCE CLOSURE

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The 1998 Republic of South Africa National Water Act refers to the possible prescription, by government, of methods for making a volumetric determination of water for purposes of water allocation and charges in the case of activities resulting in stream flow reduction. Given this scenario and the demand on water resources it is important to consider how evaporation, one of the main components of the water balance, is to be measured or estimated routinely with reliable accuracy and precision. Increasingly, energy balance methods are being used to estimate evaporation. Two energy balance approaches are used. Energy balance methods make use of the shortened energy balance: $R_{net} + LE + H + F_{soil} = 0$ W m^{-2} where R_{net} is the net irradiance, LE the latent heat (evaporation), H the sensible heat and F_{soil} the soil heat. The simplified energy balance is used either for checking the validity of the measurements or for estimating a particular energy balance component as a residual amount. The one method, using eddy covariance, involves independently measuring each component term of the simplified energy balance from which closure is estimated using $R_{net} + LE + H + F_{soil} = c$. Closure is said to be satisfied if $c = 0$ W m^{-2}. Implicitly, for the Bowen ratio method, $c = 0$ W m^{-2}. A non-zero value for c may be due to measurement errors in one or more of the component energy balance terms, although a near-zero value for c may be due to two or more of the component terms with incorrect value tending to cancel each other. A near-zero value for c only increases confidence in the energy balance component measurements but does not necessarily verify them. Eddy covariance methods for determining sensible and latent heat components of the energy balance of a surface are often regarded as the standard measurement method. There is however some belief that eddy covariance methods underestimate latent heat LE and sensible heat H, for example, so that energy balance closure does not occur ($LE + H < -R_{net} - F_{soil}$ or $c < 0$ W m^{-2}). Careful net radiometer usage and calibration ensure that net radiometers correctly measure net irradiance. Our measurements show that eddy covariance sensible heat flux density compares favourably with sensible heat measurements using: surface layer scintillometry, aerodynamic technique; surface renewal technique, radiometric technique; Bowen ratio technique for bare soil, short grass surface and for a vineyard. There is also reasonable agreement between the available energy flux density and the eddy covariance available energy flux density for a pine canopy. We could find no evidence for an underestimation in sensible heat H when using the eddy covariance method. There is however some evidence that eddy covariance latent energy measurements are underestimates. This underestimation may also apply to eddy covariance carbon dioxide flux measurements.

Keywords: energy balance closure, eddy covariance, evaporation measurement, Bowen ratio

SURFACE LAYER SCINTILLOMETRY AS AN OPERATIONAL TOOL FOR THE ESTIMATION OF SPATIALLY-AVERAGED EVAPORATION

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The 1998 Republic of South Africa National Water Act refers to the possible prescription, by government, of methods for making a volumetric determination of water for purposes of water allocation and charges in the case of activities resulting in stream flow reduction. Given this scenario and the demand on water resources it is important to consider how evaporation, one of the main components of the water balance, is to be measured or estimated routinely with reliable accuracy and precision. A dual-beam surface layer scintillometer (SLS), for the estimation of sensible heat flux density every two minutes for a pathlength of 101 m, was used in a mixed grassland community in the eastern seaboard of for 30 months. The scintillometer relies on the Monin-Obukhov stability theory, the correlation between the laser beam signal amplitude variances and the covariance of the logarithm of the beam signal amplitude measured using two detectors. Procedures for checking data integrity in real-time are highlighted as are the post-data collection rejection procedures. In addition to the SLS sensible heat flux density measurements, an energy balance system was used to measure the soil heat flux density and the net irradiance from which the latent energy flux density was calculated as a residual. A sensitivity analysis was used to determine the relative importance of SLS data inputs of air temperature, atmospheric pressure, beam path length and beam height on sensible heat flux density estimates. In addition, errors in soil heat flux density and net irradiance measurement also affected the estimated latent energy flux density. Worst-case errors in atmospheric pressure, air temperature, beam path length and beam height resulted in fractional errors in sensible heat flux density within 0.013, 0.015, 0.03 and 0.04 respectively. Clearly, the effective beam height needs to be accurately known as the error in beam height contributes the most to the overall error. Overall, the worst-case total fractional error in sensible heat flux density is within 0.054 and the typical fractional error is within 0.032. The SLS estimates of sensible heat flux density are compared against those obtained using the Bowen ratio, eddy covariance, and surface renewal methods. The influence of wind direction, in particular winds perpendicular and parallel to the SLS beam, on these measurement comparisons is examined. Confidence in the SLS path-averaging measurements is very good since the theoretical framework of the Bowen ratio, eddy covariance and surface renewal point estimates of sensible heat are very different from that of the SLS method.

Keywords: Evaporation measurement, scintillometer, Bowen ratio, eddy covariance

FACTORS OF CROP YIELDS AS AFFECTED BY FERTILISER SOURCE AND WEED CONTROL METHOD

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Small-scale farmers obtain relatively low grain yields, when compared to their commercially oriented counterparts, because of shortages in production finances and knowledge. Use of manure as a fertiliser source and use of a proven weed control method might increase these farmers' grain yield and profit margins. A study was conducted in Mooifontein, near Mafikeng, and treatments were 1) Control without application of fertiliser in any form, 2) Custom inorganic fertiliser as practised by farmers in the study area, 3) Recommended inorganic fertiliser according to soil analysis, 4) Recommended manure application rate, and 5) Combination of half recommended manure rate supplemented with half recommended inorganic fertiliser. Treatments were replicated six times. Recommended manure treatment was at a 10 t ha^{-1} rate on fresh matter basis, while the custom fertiliser treatment was at the rate of 75 kg ha^{-1} 3:2:1 (25). Maize was planted in November 1999 with mechanical weed control (MWC) conducted just before tasseling. Maize was again planted in October 2000 with pre-emergence herbicide weed control (HWC). Plant available soil moisture (PASM) was measured in July 1999. Soil moisture content (SMC) was measured in the topsoil (0-30 cm) during the MWC season (1999 / 2000), and in the topsoil and subsoil during the HWC season (2000 / 2001). SMC was measured at harvest time during both seasons. Grain yield was higher for all fertilised treatments compared to the control treatment during the MWC season ($P<0.05$), 2515 vs 1453 kg ha^{-1}. However, grain yield was lower in the two treatments with manure than in all other treatments, including, the control treatment, 1665 vs 2731 kg ha^{-1}. PASM was not different among treatments (284 g kg^{-1}). Recommended manure treatment had significantly lower SMC than the control, custom fertiliser and recommended fertiliser treatment (41 vs 49 g kg^{-1}) during the MWC year. During the HWC season, the SMC in the topsoil did not differ among treatments (44 g kg^{-1}). However, the subsoil during the HWC season had the lowest SMC in the recommended manure treatment (60 g kg^{-1}); while custom fertiliser, recommended fertiliser and combination of manure / fertiliser treatments had higher SMC (87 g kg^{-1}), and control treatment had the highest SMC (101 g kg^{-1}). The use of herbicides may increase grain yields, though it deceased yields in manure treated plots. Yield decrease could be due to weed competition in manure treatments, as seen in lower SMC measured at harvest time in these treatments. However, since weed quantities were not measured, lower yield might be due to effects of herbicide on microbial activity and nutrient release timing. Further research on herbicide application timing and on herbicide that is more effective to control weeds in soils treated with manure are imperative for better crop yields.

Keywords: manure, custom fertiliser practice, plant available soil moisture, soil moisture content, mechanical weed control, herbicide weed control

MEASURING SPECTRAL REFLECTANCE OF WHEAT AT DIFFERENT NITROGEN APPLICATION RATES, USING VARIOUS REMOTE SENSING TECHNIQUES.

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Remote sensing data can be used to predict photosynthetic rates and biomass production of agricultural crops using methodologies relating spectral vegetation indices to light absorption or to maximum photosynthetic capacities which are also closely related to leaf chlorophyll and nitrogen contents. Reflectance measurements can detect changes in leaf colour before visual detection is possible.

A wheat trial was conducted at the University of Limpopo experimental farm, in which nitrogen (N) was applied in the form of urea at four different rates (N0 = 0 kg N ha^{-1}, N1 = 60 kg N ha^{-1}, N2 = 120 kg N ha^{-1}, N3 = 180 kg N ha^{-1}). Colour infra-red images were obtained, using radio controlled aircraft as the aerial platform. Chlorophyll content of leaves was measured by a Minolta chlorophyll meter, and Normalized Difference Vegetation Index (NDVI) values were obtained using a Green Seeker hand-held optical sensor. The sensor was also connected to a blue tooth GPS receiver. The data was logged into the iPAQ using the GPS coordinates.

NDVI values corresponded well with the leaf chlorophyll content, as well as the stress classes obtained from the supervised classification of colour infra-red images.

The Green Seeker hand-held optical sensor unit can be a useful tool for crop research and consulting, and provides precision measurement and data logging of the NDVI and red to near infra-red ratios of plant material.

Keywords: Chlorophyll meter, Green Seeker, spectral reflectance, wheat

CONSERVATION FARMING UNDER SMALLHOLDER FARMERS IN SOUTH AFRICA: CASE STUDIES FROM LIMPOPO AND EASTERN CAPE PROVINCES

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Studies were carried out to investigate conservation farming methods practiced by smallholder farmers in Limpopo and Eastern Cape provinces of South Africa. In Eastern Cape, the survey was carried out in five districts namely: Middledrift, Sada, Keiskamahoek, Zwelitsha and Seymour while in Limpopo province a total of twelve villages in Vhembe district were investigated. Both study areas have a semi-arid climate with mean annual rainfall ranging from 400mm to 700mm. Participatory methods were used to collect various information such as: Socio-economic issues, labour and farm power availability, land management issues and conservation measures in use. Crop practices and yields was recorded using informal interview techniques and a semi-structured questionnaire which was designed for this purpose.

In Eastern Cape, the study showed that more than 80% of smallholder farmers in the study area own and use draft animals as the main source of farm power. Twenty (20%) of farmers hire tractors for opening new land and during winter fallowing. A total of eight conservation farming practices were identified. These include: Earth contour bunds (practised by 82% of all farmers interviewed); manuring (82%); Crop rotation (77%) and Mulching (25%). Other practices identified were the use of vegetation barriers, stone bunding and open furrow ridging which is used as drainage ditches. In Limpopo province, the study identified a total of seven soil-water conservation farming practices in the Vhembe district. These include: Stone bunds and the use of stone lines (practised by 28% of all farmers interviewed); terracing (24%); ridging and tie-ridging (24%) and intercropping (12%). Other practices identified were the use of water harvesting techniques (including the use of vegetation barriers) and infiltration pits. In both provinces, On-farm trials were conducted to assess the performance of various soil water conservation methods. These included: animal drawn ripper planter, pot holing, stone bunding and the use of tied ridging techniques. The tied-ridging method was found to conserve more soil and water and produced more yield per hectare as compared to other methods. Most of the farmers interviewed were unaware of minimum tillage techniques such as ripping. One of the main constraints in promoting conservation tillage practises was found to be the unavailability of crop residues and cover crops that can be used as mulch. The paper concludes that the promotion of conservation tillage systems that enhance soil fertility and water use efficiency, improve peak labour constraint and sustain the environment should be given due consideration and high priority for the improvement of agricultural productivity of small-holder farmers in low rainfall areas.

Keywords: Conservation farming, Smallholder farmers, Soil-Water conservation

THE EFFECT OF ROW SPACING ON RADIATION INTERCEPTION AND YIELD IN IRRIGATED SUGARCANE

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Sugarcane (*Saccharum* spp of tropical origin) yield is a function of stalk number and mass. Stalk number can be increased by means of narrower row spacing (RS) but studies reported in the literature have met with mixed success. RS also affects canopy closure and the green leaf area per unit of land area (LAI). The latter is a measure of the crops' photosynthetic and consequently yield potential. These relationships were investigated in a field experiment with a 1st ratoon crop of NCo376 sugarcane at Mount Edgecombe. Tiller population (TPOP), intercepted radiation and cane yield were recorded over the duration of growth cycle. The crop was drip irrigated and fertilized to avoid water or nutrient stress conditions.

Narrow RS significantly increased the number of final stalk population and cane yield per unit area. The rate of decrease in TPOP after peak population was, however, greater for narrow RS. Peak TPOP was reached at the same time for all RS treatments and coincided with maximum intercepted radiation within the row. Narrow RS reached 50% intercepted radiation earlier than wider RS (326 ^{o}Cd m^{-1} reduction in RS) and also produced a higher LAI for all sampling events. LAI increased at a rate of 1.33 m^{-1} reduction in RS and remained relatively constant across samplings. Radiation use efficiency was the same for all five RS treatments at 1.62g MJ^{-1}. Results indicate that intra-row, rather than inter-row, intercepted radiation determined the time of peak population. They also suggest that factors other than intercepted radiation are the cause of the greater reduction in TPOP experienced by narrow RS.

Keywords: Radiation use efficiency, Leaf area index, Fractional interception, Tiller population

EFFECT OF PRE-EMERGENCE HERBICIDES ON SORGHUM CULTIVARS UNDER HEAT STRESS

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Sorghum producers reporting phytotoxicity when graminicides are used on cultivars, grown under detrimental environmental conditions, prompted this study. A greenhouse trial was conducted, using ten sorghum cultivars grown in sandy soil (15 - 20 % clay). Seeds were treated with Concept, a safener. Treatments included s-metolachlor/terbutylazine mixture, s-metolochlor, atrazine/s-metolachlor mixture, acetochlor/atrazine/propazine mixture and alachlor. Herbicides were applied at registered dosage rates using a specially designed pot sprayer. The trial was conducted under optimal temperature regimes (18° / 28° C, night/day) and repeated where heat stress (18° / 35° C) was applied for four days. Total number of seedlings, mean time to emergence in days, visual symptoms of phytotoxicity and dry mass of seedlings 32 days after planting, were recorded. Data were subjected to factorial analysis, using cultivar as factor 1, treatments as the second factor, and heat stress as the third factor. Cultivars and heat stress had a significant effect on total number of seedlings (%), mean time to emergence (days), mesocotyl elongation (%) and dry mass per plant. Herbicide treatments had a significant effect on mesocotyl elongation and dry mass per plant. The mean number of emerged seedlings was less than 60% for all the cultivars. A significant cultivar x heat stress and herbicide x heat stress interaction were observed with regard to mesocotyl elongation and dry mass per plant. Mesocotyl elongation occurred only in cultivars subjected to heat stress. Although differences in percentage mesocotyl elongation were observed between herbicide mixtures, it was not significant when compared to the control treatment. The elongation of mesocotyls in all treatments, including the control, proved that it was not herbicide related. It is concluded that heat stress caused the elongation of the mesocotyls and is a physiological response rather than due to damage caused by the chemicals.

Keywords: sorghum, herbicides, mesocotyl elongation, heat stress

CAN VEGETATION BE USED TO EFFECTIVELY MANAGE WATER AND SALT ON A COARSE ASH DUMP?

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Coal ash is an inevitable co-product of the gasification process employed by Sasol Synfuels to produce gas from low-grade, high ash coal. The Sasol Secunda coarse ash disposal site is continuously growing and will eventually cover hundreds of hectares. A soil cap is normally required on such disposal sites to minimise the infiltration of water into the dump. The cost of an engineered soil cap is, however, very high.

An alternative way of manipulating the water balance of the dump to reduce percolation and salt movement, is through vegetation. Trees may be useful in order to obtain maximum exploitation of the available water and mineralized nutrients because of their deep root systems and low water holding capacity of the coarse ash medium. The selection of appropriate trees is important to ensure sustainability.

Several grass and tree species are being screened for survival and production on various coarse ash and sludge substrates. Coarse ash has been shown to provide a good growing medium for vegetation. Preliminary Soil Water Balance (SWB) model simulation results, indicate that water can be efficiently used by trees and therefore minimizing water and salt leaching through the coarse ash profile.

The water balance of a full forest canopy was simulated over a period of sixteen years using historic weather data. Root lengths were varied from 3 – 7 m. Over this period 10560 mm of rainfall occurred, typically 69 – 75% of the precipitation was transpired by the simulated vegetation while 26% evaporated. Recharge of 1.1 - 6% occurred and depended on the root lengths. Longer root systems for example 7 m, are possible and provided recharge of 1.1 %. This recharge includes 174 mm drained during an extreme rainfall event where 218 mm of rain fell over 4 consecutive days. These findings bodes well for the possibility of negating the need for an expensive soil cap to manage the water and salt balance of this ash disposal site.

Keywords: coarse ash, sludge, vegetation, water consumption, modelling

MEASURING THE IMPACT OF CONSERVATION AGRICULTURE ON RESOURCE-POOR FARMERS IN THE BERGVILLE DISTRICT OF KWAZULU-NATAL: WHAT DID WE LEARN ABOUT SUSTAINABILITY?

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Soil erosion, nutrient depletion, soil acidity and low soil organic matter are major soil productivity and agricultural production-limiting problems in large parts of KwaZulu-Natal, especially around the foothills and plains of the Drakensberg. There are also huge problems with human (i.e. skills, knowledge and health), physical (i.e. infrastructure), financial (i.e. money) and social (i.e. groups and networks) 'capital' among the communal farmers in the area. These farmers mostly use mixed-maize cropping systems on approximately 1 ha of arable land. For the above reasons it is imperative to follow a holistic, systems approach, involving and empowering key stakeholders over the long term. A Landcare project was launched in the Emmaus area in 2000 aiming to develop and implement conservation agriculture (CA) practices among the local farmers. CA includes the following principles: No ploughing, disking or soil cultivation (using specialized implements); Multi-cropping, including crop rotations and intercropping using cover crops; Mulching; and Integrated soil fertility, acidity, pest and weed management. The Landcare project followed a sound development approach, using a family of research methodologies that aim to pursue action (change) and research (better understanding) outcomes. In the Landcare project, action research (AR) methodologies were organised into a core process model based on the common-sense experiential learning cycle of planning, acting, observing and reflecting. One of the main methodologies used was monitoring and evaluation (M&E), which assisted to continuously focus and improve the project. A number of impact indicators were measured to determine the sustainability of the project. Since 2000 around 400 farmers have started to use CA practices. Results of farmer-led trials using CA practices have demonstrated an average maize yield increase of around 3 ton ha^{-1}, i.e. from 1 ton ha^{-1} to above 4 ton ha^{-1} between the 2000 and 2005 seasons. Gross margins have shown similar sharp increases from net losses to around R3000 ha^{-1}, mainly due to the increased productivity, as well as a reduction in external inputs, such as agro-chemicals and mechanization. Soil health has increased sharply, indicating the bio-physical feasibility of the technology. These results have shown that a shift to CA brought substantial social, economic and environmental benefits to farming communities over the short to long term. They also showed that the CA technologies could be successfully used to design low external input sustainable agriculture (LEISA) systems, which were found to be essential for resource-poor farmers. Finally, the use of AR methodologies proved to be fundamental in view of sustainability.

Keywords: Conservation Agriculture, Sustainability, Action Research, Landcare

INFLUENCE OF SOIL COMPOSITION ON MINERAL FOOD COMPOSITION IN THE OR TAMBO DISTRICT MUNICIPALITY, EASTERN CAPE PROVINCE, SOUTH AFRICA

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The extent of the impact of nutrient deficiencies on crops, animals and humans is progressively being realised. In South Africa, nutrient-deficient soils are widespread. Further, some of the poorest areas in the country are characterised by widespread soil degradation as a result of poor agronomic practices and overgrazing. In the OR Tambo district municipality, situated in the Eastern Cape province of South Africa, high nutrient element deficiency rates are found. These deficiencies, coupled with high poverty rates in rural communities, are cause for concern. Socio-economic factors, together with monocropping of maize and poor agronomic practices, have caused high food insecurity, with 83% of people in the Eastern Cape experiencing hunger. To find sustainable solutions for areas such as these, agriculturalists should undergo a paradigm shift, with the focus not only on improving the yield and variety of food crops used, but also on improving the nutrient quality of food through implementing sustainable agronomic practices.

The objective of this study is to determine the composition of food crops produced in the area and how it is related to soil composition. Once this has been determined, interventions can be planned and tested for their suitability.

To determine the food composition a number of food crops (orange fleshed sweet potatoes, spinach, butternut, pumpkin leaves, carrots, beans and maize) were sampled from a variety of soil types. Together with the food crops, soil samples were collected and their composition was determined.

Data of food composition and how it relates to soil composition are presented. In general, it was found that food composition in the OR Tambo district significantly differs from food purchased at the markets in Pretoria. It was further found that the soil composition and fertiliser practices have a significant influence on food composition. Therefore, during nutrient intake studies, the food composition data used must be evaluated against the soil composition and fertiliser practices of the study area. General food composition data should not be used if specific areas have been identified. Risk areas for nutrient deficiencies can also be identified by using soil composition. As a result of these findings it is important that the effect of agronomic practices, including fertilisers, on food composition should be considered when implementing rural development projects.

Keywords: food composition , soil composition , nutrient deficiencies

MODELLING THE SOIL WATER BALANCE OF POTATOES FOR IMPROVED IRRIGATION MANAGEMENT

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In South Africa, potatoes are produced in fourteen different geographic areas with diverse climatic conditions. This ensures a year-round supply of freshly harvested potatoes, which eliminates the need for long term storage, but requires cultivar and area specific production programmes. The most important environmental factors influencing potato yield and quality are water supply, temperature and photoperiod. The Soil Water Balance model has previously been calibrated for the irrigation management of potatoes. However, one of the limitations identified was the fact that the model did not perform well for different growing seasons. A study was initiated to examine the effect of growing season on potato growth and water use. A further objective was to calibrate and evaluate the SWB model for potato under well-watered and deficit irrigation conditions for improved irrigation management. Ultimately, it is hoped that this study will also provide valuable insight into the effects of photoperiod on potato growth and development, which could help make improvements to SWB. Experiments were carried out in spring and autumn plantings under different water regimes. The collected data were used to re-parameterise and re-calibrate the model.The model was then validated against independent spring and autumn data for tuber dry mass (HDM), total dry mass (TDM), leaf area index (LAI) and fractional interception of solar radiation (FI). Root mean square error (RMSE), mean of the measured values (MAE) and coefficient of determination (r^2) were used to analyse the degree of confidence between simulated and observed values.

Results obtained from irrigation treatments based on water stress imposed at the vegetative stage (SNN), tuber initiation stage (NSN), maturity stage (NNS) and from the unstressed control (NNN), showed that the potato crop is very sensitive to water stress. Water deficit imposed at tuber initiation and tuber bulking stages appeared to have the most dramatic negative effect on LAI, TDM and HDM. The treatment fully irrigated throughout the growing season (NNN) gave the highest yields, irrespective of planting season. SWB calibration showed reasonable agreement between observed and predicted LAI and FI for both seasons, but TDM and HDM values deviated from the measured values, especially towards the end of the growing season. Estimation of tuber initiation date was carried out and results showed that the time of tuber initiation varied with planting season. In spring, the time between emergence and tuber initiation was the longest. Autumn plantings have a shorter period between emergence and tuber initiation. Thermal time required to reach tuber initiation stage was computed, using seven methods. The SWB method corrected by a relative day length factor showed the smallest standard deviation and coefficient of variation values, when used to compute thermal time for tuber initiation in different data sets. This strongly suggests that the SWB method, corrected by relative day length factor is the appropriate method for computing the required thermal time from emergence to tuber initiation. Future photoperiod correction would hopefully improve SWB simulation of crop growth in different seasons.

Keywords: potatoes, soil water balance, modelling, irrigation management

CHEMICAL ANALYSIS OF SOILS SUPPRESSIVE AND CONDUCIVE TO FUSARIUM WILT IN SOUTH AFRICA

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No detailed studies have yet been conducted in South Africa on the chemical properties of suppressive and conducive soils to Fusarium wilt of banana. Suppressive soils are defined as soils in which disease severity is reduced, despite the presence of the host, the pathogen in sufficient concentration, and favourable environmental conditions. Conducive soils, on the other hand, are soils with no ability to reduce disease severity. Previous investigations internationally have indicated that suppressive soils had, amongst others, a higher cation exchange capacity, soil solution pH and soluble Na, and lower levels of exchangeable NH^{4+} than diseased areas or conducive soils. It was also found that suppressive soils had higher concentrations of calcium, magnesium and potassium, as well as a higher electrical conductivity (EC), and lower concentrations of available Fe than conducive soils. As a pilot study in South Africa, representative samples were collected from three suppressive and three conducive sites in the Kiepersol area and analyzed for extractable NO^{3-}N, NH^{4-}N, P, Ca, Mg, K, Na, Fe, Cu, Mn, Zn, and pH (H^2O) and pH (KCl) to determine possible trends. Definite trends were often observed for two of the three fields, with the opposite trend observed in the third. A rearranging of the data for the three fields from low to high values yielded interesting, although not statistically significant, trends. These trends have in most cases been reported previously in literature for other crops internationally and hold promise for future research on Fusarium wilt of banana in South Africa.

Keywords: Fusarium wilt, Banana, Suppressive soils, Conducive soils, Chemical soil properties

SOIL FERTILITY CONSTRAINTS IN NORTH-WEST ZAMBIA

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Along the Congo-Zambezi watershed in north-west Zambia, highly leached sandy soils have developed on Kalahari sands under *miombo* woodland and *dambo* grassland and annual rainfall of 1500mm. The extent of acidification and nutrient depletion is not well documented. Top- and subsoil samples were taken from soil pits dug in 35 lands cropped by subsistence farmers. Most topsoils (57% of those sampled) and subsoils (68%) had a pH (KCl) of <4.5, with a decrease in pH with depth being common. Subsoil acidity and Al toxicity therefore pose a serious challenge to the farmer. The majority of subsoils have acid saturation of 20–70%. Most of the soils have suboptimal levels of K (<50), P (<20), Ca (<250), Mg (<80) and Zn (<1 mg/kg). The more acidic samples have low levels of Mn suggesting that it may have been depleted through natural leaching and may also be limiting in some cases. Opportunities for improving crop production with imaginative fertilizer programmes are therefore considerable. The subsoil acidity is especially serious given the sandy but luvic nature of the soil profiles, meaning that crops must rely more than usual on deep rooting not just for water in an environment of unreliable rainfall but also for nutrients such as K which are scarce in the more sandy topsoil. The possibility of using gypsum for subsoil amelioration needs to be considered carefully since none of the subsoils have pH (KCl) > pH (H_2O) although some do have a small value (<0.5) for this pH difference, suggesting that "self-liming" associated with sesquioxide surfaces could develop in response to gypsum treatment. Imaginative use of waste products from copper processing may be feasible for soil amelioration. The presence of dolomite as the country rock in parts of this region implies a huge potential for crop production.

Keywords: tropical soils , African agriculture, gypsum , subsoil acidity , Al toxicity

ASSESSMENT OF LONG-TERM PHOSPHATE DESORPTION FROM SOILS AND ITS RELATIONSHIP WITH PLANT GROWTH

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The assessment of phosphate (P) bioavailability in soils is important especially for soils of long-term fertilization history. Soil phosphorus can rapidly increase when fertilizer or manure is continually applied at rates exceeding crop removal. In such soils, it is of economic and environmental importance to determine how long high P soils will remain above the crop sufficiency level. The current P status is due to indigenous (native) P present in the soil, and P from previous fertilizer P application (residual P). The amount of available soil P has been more frequently evaluated than the rate of its release when studying the P nutrition of plants. The availability of a nutrient to plants depends, among others, on the rate at which it is released to replenish the soil solution. There can be a significant residual effect due to desorption of phosphate from the soil of long term fertilization history, and this can lead to an underestimation of the benefit of phosphate fertilizer if not taken in to account. In order to characterize P forms in soils, a wide variety of methods have been proposed. One of the objectives of this paper was to investigate the optimum shaking procedure for the method employed, and the other objective was to study the dynamics of P in relation to plant parameter especially for soils of a long term trial. Thus, surface soil samples (0-20cm) were collected from one of the long-term trials at the University of Pretoria, South Africa (established in 1939; the soil is Hutton form; l loamy, mixed, thermic, Rhodic Kandiudalf). The soil samples collected were treated with different levels of P (NK, NPK, MNK, and MNPK). Optimization of the shaking procedure was carried out by taking in to account parameters such as shaking speed, amount of soil, amount of the ferric hydrate solution, and the length of the dialysis membrane tube itself. Best results were obtained for the following combination (110-120 rpm, 1g soil, 10 ml ferric hydrate solution and 15 cm membrane tube). The dialysis membrane tubes can be shaken without physical damage for an effective two weeks (14 days) at this shaking speed. A sequential P extraction procedure using a dialysis membrane tube filled with ferric hydrate solution (DMT-HFO) was carried out on each treatment combination to determine the changes in soluble, labile, non-labile and residual P pools. The DMT-HFO-Pi fraction increased significantly with increased period of extraction. The amount of P extracted in fractions (HCO_3-P_o, OH-P_o, D/HCl-P_i, C/HCl-P and residual P) decreased with increased period of shaking with the DMT-HFO. The inorganic fractions such as HCO_3-P_i and OH-P_i appeared to decrease at a slower rate in contrast to the former fractions. The increase in the yield of maize can be accounted for by the involvement of the less available P forms in replenishing the labile and solution P fractions.

Keywords: Phosphorus release rate., Dialysis membrane tubes, Soil test methods, Desorption of P, Phosphorus release rate

EVALUATING THE GENETICS OF RESISTANCE OF RICE (*Oryza sativa*) TO BLAST BY MICROSATELLITE MARKERS

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Reaction of several Iranian local and standard cultivars of rice (*Oryza sativa*) to the agent of rice blast disease (*Magnaporthe grisea*) was evaluated in a complete random block design under greenhouse and field conditions. There was a significant difference in resistance to blast among the cultivars in the field. Some cultivars were resistant, whereas others rated semi-susceptible. All of the cultivars tested were susceptible. Two isolates of M. grisea, IF-1 (clone E) and IA-81 (clone C), were used in the greenhouse. Some of the cultivars appeared to be resistant, whereas the others were either susceptible or semi-susceptible. Cultivars Sange-Tarom, Ahlami Tarom, Tarom Mahali and Ghashangeh were resistant to isolate IF-1 and Salari, Hassan Saraee and Hassan Saraee Ashka were resistant to isolate IA-81. The results indicate prevalence of different virulance groups or races of the causal fungus in the area that is compatible with genotypes of all local and some bred cultivars. There appear to exist some resistant genes, incompatible with some isolates in the local cultivars. Based on the results of greenhouse and field evaluation, the bred cultivars tested carry a specific broad spectrum blast resistant gene. Two SSR markers, RM224 and RM25, located on chromosomes 11 and 8 , respectively, and linked to the blast resistance gene, were used in PCR to detect the presence of resistance genes in the cultivars. The PCR products generated of the RM224 primer pair were highly polymorphic, whereas no polymorphism was observed when the RM25 primer pair was used for amplification. It appears that the resistance gene detectable with RM25 does not exist or operate in the Iranian land varieties. The genetic distance, number of alleles and heterozeagosity in populations of the local, bred and imported cultivars were estimated. The longest (0.791) and the shortest (0.148) distances were found between the bred and the local cultivars, and between the bred and the imported cultivars, respectively.

Keywords: Rice, blast disease, Microsatelite markers, Resistance gene

MODELLING AND MONITORING N AND P BALANCES IN SEWAGE SLUDGE AMENDED AGRICULTURAL SOILS

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The growth of population in cities and the expansion of industries are resulting in a rapid increase in municipal and industrial sewage waste products, which need to be utilized efficiently, or disposed of in an environmentally sound way. Although there are different disposal methods, using municipal sewage sludge on agricultural lands is attracting the attention of many countries. This is due mainly to its potential to replenish soil organic matter, in addition to supplying N, P and other macro and micronutrients. Taking into account these benefits, South Africa has developed guidelines on sewage sludge classification and utilization in agriculture. According to this guideline, class D sewage sludge can be applied according to the crop demand to a maximum annual application rate of 8 ton ha^{-1} a^{-1} for 25 years. However, this norm could be too restrictive to satisfy the demand of crops under highly productive agricultural systems. Therefore, the aim of this study is to evaluate and refine the current norm for different farming systems, using a mechanistic crop growth, water and nutrient balance model as a tool. As an example and to develop and validate the model, the following cropping systems were monitored: dryland maize, irrigated maize/oat rotation and dryland pasture. Each cropping system received three levels of sewage sludge, namely according to the norm (8 ton ha^{-1} $a^{-1)}$, half of it (4 ton ha^{-1} a^{-1}) and double the norm (16 ton ha^{-1} a^{-1}). The sludge treatments for the irrigated maize/ oat rotation, dryland pasture and turf grass production were split , so that half was applied to the first crop (harvest) and the remaining half to the second crop (harvest). The study is in progress at East Rand Water Care Works (ERWAT), 40 km south of Pretoria, with annual average rainfall of 700 mm on a sandy clay loam soil. The total N uptake from the dryland maize treatments was 169 – 172 kg ha^{-1} and 24 – 38 kg ha^{-1} P. However, the uptake was very high for the 16 ton ha^{-1} a^{-1} irrigated maize treatment, namely 492 kg ha^{-1} N and 108 kg ha^{-1} P. Similarly, oats utilized 250 kg ha^{-1} N and 70 kg ha^{-1} P. The annual N supply from the 16 ton ha^{-1} a^{-1} (446 kg ha^{-1} a^{-1}) was far less than the irrigated maize/oat uptake (742 kg ha^{-1} a^{-1}). Therefore, the crop utilized additional N from the soil. However, the total P applied seemed sufficient, although its availability is questionable. The total N uptake for the 8 ton ha^{-1} dryland pasture treatment (191 kg ha^{-1}) was higher than the supply (131 kg ha^{-1}); however, the P uptake (20 kg ha^{-1}) was far less than the supply (78 kg ha^{-1}). Since sludge applied on permanent dryland pastures is not incorporated into the soil, there is a risk of surface water pollution from surface runoff if more than the demand of the crop is applied. Preliminary model simulations with fair results were obtained for N. The P model is still being developed.

Keywords: Sludge, nitrogen, phosphorus, modelling

THE INFLUENCE OF ROW WIDTHS AND FERTILISER PLACEMENT ON GRAIN YIELD OF WHEAT WHEN SOWING MACHINES WITH KNIFE-POINT OPENERS ARE USED IN THE WINTER RAINFALL REGION OF SOUTH AFRICA

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The use of knife-point openers on no-till sowing equipment has escalated tremendously in the Western-Cape wheat producing regions. Such machines allow the producer much better soil water management options through stubble retention and by preventing water losses through cultivation before planting. To increase stubble flow under no-till planting conditions, row widths wider than the traditional 180mm rows need to be used. A minimum row width of 250mm is recommended in this regard, but producers would like to increase row widths to 300mm in order to apply the herbicide triflurilan safely and to save on machine, running and maintenance costs. Although some planters can place fertiliser away from the seed, others can only apply fertiliser with the seed. This study was done to investigate the effect of fertiliser placement on grain yield when moving from 250mm to a 300mm row width with a no-till planter. Trials were conducted at Riversdale, Swellendam, Caledon, Moorreesburg and Hopefield in 2003, 2004 and 2005. Treatments included fertiliser placements, wider row spacings, different nitrogen levels and different nitrogen sources. Results in 2003 indicated that using different placements and wider row widths did not influence grain yield negatively at any of the localities. Seedling burn occurred in 2004 and 2005 and influenced yield at some localities if N-levels exceeded 30-40 Kg N/ha. Nitrogen sources differed in the amount of seedling burn caused.

Keywords: Fertiliser placement, no-till, wheat, nitrogen sources

THE SUCCESSFUL VEGETATION OF A COARSE ASH DUMP

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In order to rehabilitate a waste disposal site, authorities insist on it being capped with an extremely expensive engineered soil cap to minimize the infiltration of water into it, which could pollute the environment. A coarse ash dump in Secunda that has also been used as a salt sink and depository for other waste products is seen as such a site. This research concentrates on using vegetation to consume as much rainwater falling on the dump as possible, to limit percolation through the coarse ash that may lead to contamination of surface and groundwater resources in the region. Studying the physical and chemical characteristics of the various waste materials co-utilized in this experimental trial and matching them with the growth requirements of the vegetation established was attempted. Initial fieldwork has highlighted a few interesting results regarding the handling and application of sludge and other waste materials to the coarse ash. This initial fieldwork entailed a screening trial, which focussed on the establishment, survival and adaptability of various grass species for future reference. This coarse ash was treated with materials such as sludge (10% solids), sludge (1% solids), fine ash, synthyl material and inorganic fertilizer. To date, the data that have been collected are promising. The different substrates were analysed and the establishment success of the vegetation and initial dry matter production of the grasses were also measured. A general approach is followed initially because we are working with an unstudied system, to determine which species are adapted to our substrates and climate. This will enable us to focus on a more in depth study of water and nutrient balances within the co-disposed sludge / coarse ash heap in future.

Keywords: coarse ash, plant production, sludge, vegetation, water consumption

EFFECT OF SURFACE APPLIED PRESSURE ON PROPERTIES OF A VIRGIN SOIL

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Soil compaction is a major problem in the South African sugar industry, especially in the northren irrigated areas. It is a well documented phenomenon in agriculture and one of the suggested solutions to overcome this problem is to improve or to maintain the buffer capacity of the soil against degradation. The results for this paper were taken from a trial, established on a virgin site near Komatipoort under drip irrigation. The soil form was a shallow Basalt derived Hutton/Glenrosa containing 32% clay, 22% silt and 4% organic matter. The trial was planted to a lodging resistant variety, N32, in July of 2002 and the first compaction treatments applied after harvesting in 2003 and again in 2004 and 2005. Yields reflecting the effect of compaction were obtained in 2004 and 2005. Various measurements were made after harvest before soil compaction and again after compaction. Soil compaction was induced by driving a laden 30 ton haulage vehicle over selected plots. The compactive effects of two types of tyres were tested – conventional radials and high flotation tyres. Pressures in the radials were 800 kPa in the front and 700 kPa in the back dual tyres. Pressures in the high flotation tyres were 650 kPa in the front and 350 kPa in the wide back tyres. Results quantifying changes in soil properties revealed significant changes to infiltration rates for both tyre types but not to bulk density, porosity and penetration resistance. Pressure applied by the front wheels was far more damaging compared to the back wheels. However, yield responses showed that the high flotation tyres were potentially less damaging.

Keywords: Sugarcane, compaction, yield, soil water content, row spacing, soil properties

SCENARIOS FOR AGRICULTURAL PRODUCTION AND RURAL DEVELOPMENT: THE EURURALIS EXPERIENCE

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Over the coming decades, agricultural production will be affected by a multitude of changes in the physical, social and political domains. These include, climate change, environmental legislation, international trade regulations, technological development, economic growth and demographic developments. Some rural areas will be subject to urbanisation; others face depopulation and land abandonment. People also change, for example regarding dietary habits and food quality concerns. Forces driving the changes act at several spatial and temporal levels and are often impossible to control. Policy makers and private sector agents must be prepared for new challenges and opportunities, but the rates, and in some cases even the direction, of changes are highly uncertain. Extrapolating trends, or studying a particular factor in isolation will, therefore, give a very deficient picture of how the future might unfold.

Scenario studies form an attractive alternative to deal with future uncertainties. A sensible way to develop scenarios is to construct plausible yet contrasting narratives, which are then fleshed out in an internally consistent way using quantitative models.

The objectives of this presentation are to give an overview of scenario studies and to discuss the utility and feasibility of a similar approach to South(ern) Africa. Special attention is given to EURURALIS, a study to stimulate discussion about the future of rural areas in the European Union (EU), and the role of policy instruments therein.

EURURALIS, was carried out by Wageningen University and Research Centre and the Netherlands Environmental Assessment Agency. Its four scenarios have a time horizon up to 2030. They were structured along two axes: (1) from increasing globalisation to a world of economic and cultural blocks and (2) from a future of lean governments to one with ambitious regulation. The scenarios were quantified with a chain of models, ranging from a global trade model, to a spatially explicit model simulating EU land use on a 1 x 1 km^2 grid. Apart from the narratives' assumptions, the models used data at several geo-referenced levels, on e.g. actual land use, yields, soils and macroeconomics. Results of the analyses were expressed in terms of sustainability indicators, addressing "people", "planet" and "profit". Methodology and outcomes were published on an interactive CD, as well as in scientific papers.

The analyses indicate that, even in the free-trade scenarios, the EU would still produce most domestic needs for agricultural products, but with great differences between regions. Results for Southern Africa (as a single region in the global analyses) show a strong increase of agricultural production in all scenarios, which would largely be realised by conversion of (semi-)natural areas. This raises questions, such as the viability of such changes, hot spots of pressure, social, economic and environmental implications, and the possibility to attain higher yield levels by boosting technological development.

Keywords: Scenarios, Land use, Rural Development, Agriculture, European Union, Southern Africa

THE USE OF A BASIN PLOUGH TO ENHANCE WATER CONSERVATION IN DRYLAND AGRICULTURE IN THE NORTH WEST PROVINCE

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Food insecurity and unemployment are two serious problems associated with resource-poor rural households in areas where water is the scarcest natural resource. The situation is aggravated where rainfall is highly variable in time and space and soils are difficult to manage. In semi-arid and sub-humid areas, water is the main factor limiting the productivity of this system. It is therefore the main factor determining the "people-carrying capacity" of agricultural land. In large areas of the North West Province, the rainfall is marginal for food production without irrigation. In these areas, such as the Bafokeng District, most of the rainfall occurs in the form of storms that result in considerable runoff on, specifically, the vertic soils. On these high clay soils, water losses due to evaporation are also very high. By making use of an in-field water conservation technique, which combines the benefits of micro-basins, mulch and fallowing, crop-available water can be increased to produce higher yields.

Micro-basins were mechanically prepared with a basin plough (originally designed for veld rehabilitation), which works as follows: A basin attachment pivots on the rear of a three-point hitched ripper. A scraper blade at the rear of the attachment creates basins and a ripper tine operates directly in front of the attachment to break up the compacted soil. Downward movement of the attachment is limited by a chain, thus enabling the tractor to lift the whole machine clear of the ground. When the ripper tine is engaged, the diamond shaped control wheel controls the movement of the scraper blade, resulting in a row of basins being created.

The between-row basin spacing was such that the tractor operation followed on the tracks on the return trip. Planting had to be done as close as possible to the edges of the basins and virtually on the side ridges. A suitable planting row width would be about 1 m, but taking the tractor wheel width of 480 mm into account, the wheels would trample on planted rows on the return trip. A planting row width of 900 mm offered a compromise.

The soil has a clay content of 57% and an organic carbon content of 0.87%. The soil nitrogen and phosphate contents are very low and the pH (KCl) is 6.2. Results from the 2004/2005 season indicate that the sunflower seed yield for the conventional tillage with fertiliser treatment was 564 $kg.ha^{-1}$ compared to 819 $kg.ha^{-1}$ for the micro-basins with mulch and fertiliser applications.

Keywords: water conservation, basin plough, vertic soils, dryland agriculture

PROPERTIES OF BADLAND SOILS FROM THE ALIWAL NORTH AREA, SOUTH AFRICA

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Badlands are areas transected by a dense network of deep and steep gullies. Key conditions for badland formation comprise unconsolidated parent material, downslope positions, semi-arid climate, complex pedological patterns and dispersive soils. South Africa has its share of badlands, particularly prominent ones being situated in the Aliwal North and Rouxville areas. The objective of the study was to prioritise factors or combinations of factors that are critical to the vulnerability of these soils to gully erosion. Two soil profiles have been described in the field and ten horizons sampled and analysed for selected textural, chemical and mineralogical properties. One profile was situated on the lower midslope, the other on the lower footslope. The soils formed from colluvium, derived from Molteno and Tarkastad sedimentary rocks. Annual precipitation is about 460 mm and the whole area has a sparse grassveld cover. Both profiles were classified as Valsrivier. The clay content in the A horizons varied between 15% and 19%, while both B1 horizons had 36% clay. The organic matter content was below 0.7% in the uppermost layers and the secondary iron fraction < 0.6%. All soil horizons were alkaline [$pH_{(H20)}$ = 7.5 – 8.7]. The exchangeable cation population was dominated by Ca, while the Na percentage ranged below 5. Mica and swelling clays dominated the clay fraction, i.e. minerals which are highly susceptible to dispersion under alkaline conditions.

Badlands in the study area are associated with a combination of factors that reportedly trigger gully formation: unconsolidated parent material, downslope position, arid climate, sparse vegetation and marked textural differences between the A and B horizons, which promotes piping. Alkaline conditions, a clay mineral suite dominated by 2:1 layer silicates, low amounts of secondary iron and a low humus content are not conducive to soil stabilization and are therefore assumed to contribute to the high susceptibility of these soils to gully erosion. Sodicity and silt content seem to play a minor role.

Keywords: gully erosion, pH, ESP, clay mineralogy, texture, badland soils

CASE STUDIES IN THE WOCAT DATABASE

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WOCAT (World Overview of Conservation Approaches and Technologies) was launched by the World Association of Soil and Water Conservation (WASWC) in 1992, organised as a consortium of international institutions. It was accepted as a global programme by the 9th International Soil Conservation Organisation (ISCO) Conference in 1996, and is currently co-ordinated by the Centre for Development and Environment (CDE) at the University of Bern, Switzerland.

The goal of WOCAT is to contribute to sustainable use of soils and water through collection, analysis and presentation of Soil and Water Conservation (SWC) technologies and approaches worldwide, to promote improved decision making and land management.

Since the start of WOCAT in South Africa in 1999, there are some 55 Approach and 59 Technology questionnaires included in the South African database. From these, 10 questionnaires on each were included in the International CD-ROM Version II. For the International CD-ROM Version III (released in 2004), more than 20 questionnaires of each were included. This also includes more than 400 photos/figures in the Image database. Four questionnaires were also chosen to be part of an International Overview Book to be published in 2006 by the CDE. This include technologies on Vetiver grass, water-runoff control, reduced/minimum tillage, veld reclamation, gabion structures, wetland rehabilitation and mine rehabilitation.

WOCAT is fast becoming the reporting mechanism of choice and will be required in all degradation related reporting by the Department of Agriculture.

Keywords: WOCAT, soil and water conservation, soil and water management, technology, approach, land management

HEAVY METAL UPTAKE BY WHEAT FROM TWO SACRIFICIAL BIOSOLIDS DISPOSAL SOILS AT DIFFERENTIAL LIMING RATES

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In previous studies it has been shown that intensive liming of sacrificial biosolids disposal soils leads to an increase in many EDTA extractable metals. This aspect is a cause for concern in that many studies have indicated that plant metal levels could be correlated with EDTA extractable metal levels in soil. To determine the influence of intensive liming of sacrificial soils on plant metal content, a dedicated trial was conducted. A new bulk sample of the two soils used in the previous studies was collected and incubated with $CaCO_3$ (AR) in pots at lime application rates equivalent to 0, 12, 24, and 36 tons ha^{-1}. Spinach and wheat were planted and harvested before flowering. The spinach plants did not grow in the 0 lime application treatment and grew poorly in the lime treatments, and the wheat plants were therefore the only ones analysed for their metal content. The soils from the pots were sampled and analysed for NH_4NO_3 and NH_4EDTA extractable metals. The NH_4NO_3 extractable metals decreased with increasing lime rate whereas the NH_4EDTA extractable metals generally increased, especially in the one soil. Plant metal levels were better correlated with NH_4NO_3 than with NH_4EDTA metal levels. This indicates that liming leads to a decreased risk of plant metal uptake from sacrificial soils and that it should be introduced into the management of these soils. The use of EDTA in guideline metal levels as well as to determine “potentially plant available” metals is discouraged.

Keywords: Heavy metals, Wheat, Biosolids, Sacrificial soils, Intensive liming

DISTRIBUTION OF GROUNDNUT LEAFMINER (*Aproaerema modicella* (Deventer) (Lepidoptera: Gelechiidae) IN AFRICA AND FARMERS' PERCEPTIONS IN LIMPOPO PROVINCE, SOUTH AFRICA

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The groundnut leafminer (GLM), *Aproaerema modicella* (Deventer) (Lepidoptera: Gelechiidae) is an important pest of groundnut and soybean (*Glycine max* (L.) Merr.) in South and South-East Asia . Previously it has only been reported from the East African countries of , and . An outbreak of GLM was first noticed in on groundnut at the Vaalharts irrigation scheme (27°50'S 24°50'E) in the Northern Cape Province during 2000. The next year the pest was observed over the entire groundnut production areas of the Free State , Northern Cape , North West , Limpopo and Mpumalanga provinces, causing severe damage to groundnut crops. Since then, GLM is a major pest of groundnut in Mpumalanga and the Limpopo province annually, resulting in severe losses by small-scale farmers. A survey was conducted to determine the farmers' perceptions of GLM in Limpopo province. The majority of the small-scale farmers cannot afford chemical control of the insect. In an attempt to develop control mechanisms affordable to these farmers, research is currently aimed at determining the host plants of GLM in , determining it's biological control agents and breeding for resistance to the insect.

Keywords: groundnut , leafminer

THE INFLUENCE OF ROW SPACING, AZOBACTER AND MOLYBDENUM ON THE GROWTH AND YIELD OF SOYBEANS (*Glycine max*. L. Merr.) IN DIFFERENT PRODUCTION AREAS IN SOUTH AFRICA

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The influence of row spacing, azobacter and molybdenum on the growth and yield of soybeans (*Glycine max.* L. Merr.) was evaluated in different production areas in . Ten field trials, three of which were irrigated, were planted at 90cm (WR) and 45cm (NR) row spacing. Trial lots were split for seed treatments with combinations of *Bradyrhizobium japonicum* azobacter, *Azospirillum brasilense* azobacter, sodium molybdate dihydrate ($Na_2MoO_4.2H_2O$) micronutrient and an unt reated control. A constant plant population of 400 000 pl ants per hectare was maintained across all treatments and localities. Seed yield was significantly (P = 0.05) higher in the WR for the moisture-limited Bethlehem and in the NR for the irrigation trial at Bloemfontein . Seed mass tested meaningfully higher for the WR at Bethlehem , Lichtenburg and Naboomspruit. A cultivar x row spacing interaction tested meaningfully for seed yield and seed mass at Bethal. Seed treatments with sodium molybdate resulted in a meaningful (P = 0.05) increase in seed mass at Bergville, and a significantly decrease in harvest index and seed yield at Lichtenburg. Also at Bethlehem , the addition of sodium molybdate resulted in a meaningfully lower seed yield in the NR. A cultivar x molybdenum interaction for yield at Bethlehem pointed to sensitivity differences between cultivars. *A. brasilense* did not significantly influence seed yield. The conclusion was drawn that wide row spacing can increase yield in lower rainfall areas, that narrower rows planted under irrigation or in higher rainfall areas can increase yield, that the presence of *B. japonicum* is essential for successful cultivation, that *A. brasilense* has no influence on yield, and that seed treatment with molybdenum significantly increases yield in acid soils but significantly decreases yield in soils with a higher pH.

Keywords: Azobacter, growth, row spacing, yield, molybdenum

THE EFFECT OF CERTAIN SOIL AND CLIMATICAL FACTORS ON THE QUALITY AND YIELD OF SOYBEAN SEED (*Glycine max* L. Merr.)

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The objective of this study was to determine the effect of the environment on the quality and yield of seed from different seedlots. Localities with different soil types, soil structures and climates were chosen to grow seedlots of the soybean *(Glycine max* L. Merril*)* variety Prima. After harvesting by hand, the seed was analysed for oil, protein and mineral content. Physical quality, germination and vigour tests were also done. There were big differences in the growing conditions and precipitation. Rainfall varied from a high of 956mm for the Komatipoort locality to a low of 149mm for the Delmas locality. The percentage defects varied from 0.5% for Delmas to 78% for Komatipoort and the germination percentage from 94% for Klerksdorp to 16% for Komatipoort. Suitable temperatures and rainfall lead to the infection of the disease *Phomopsis longicolla* at the Komatipoort locality. This was the reason for poor germination results and high percentage defects in the seed. Vryheid had the highest protein percentage of 38.53% and Delmas the lowest of 33.34%

The harvested seed was planted at Greytown first on the Redgates and Chailey farm in a randomized block design in order to determine germination, vigour and yield for seed from different seed lots multiplied in different soil types and climatic conditions, and now planted under similar climatic conditions. The analyses and comparisons in terms of leaf area index at the early flowering (R2) stage, plant height at harvest mature (R8) stage, pod height at R8 stage and eventual yield, did not reveal any significant differences (P=0.05). No significant differences were recorded for seed yield The average yield of the Chailey locality however was 1021.9 kg/ha higher than the average yield of the Redgates locality. Growth conditions did dominate the effect of different seedlots. Poor germination and stand also had very little effect on seed yield as demonstrated by the Komatipoort treatment. Although plant population was 150000 plants per hectare lower than the average for both trials, final seed yields were not significantly different (P=0.05) Therefore plant population had no influence on the yield.

The author concludes that for soil types, soil structures and climatic conditions typical of this study, no effect of seed lot on yield could be demonstrated.

Keywords: Soybean seed, vitality, germination, growth environment

INTERPRETATION OF DIGITAL SOIL PHOTOGRAPHS TO AID IN SOIL CLASSIFICATION

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Soil classification systems around the world extensively use soil colour in the definition of diagnostic horizons and materials. The application of soil colour in national classification systems is influenced by the regional climates. In countries with high rainfall, land users are more sensitive to water saturation than to plant available water, as is the case in arid countries. The ability of soil to drain or store water is, however, important in all climatic regions. In drought prone South Africa all indicators of the soil water regime therefore contribute to better interpretation and thus improved land-use. In Soil Classification – A Taxonomic System for South Africa, the determination of soil colour relies on the user's perception of colour, employing the Munsell soil colour charts colour matching system. This paper proposes a computerised methodology for the determination of soil colour through spatial analysis. To achieve this, soil colour definitions had to be converted from the Munsell colour notation to the RGB colour notation, employed in digital cameras. The conversion also aided in the mathematical manipulation of colour data during spatial analysis. In this study the relationships between photographed (observed) and actual RGB values were as follows: Calculated Red = 0.9238 x Photographed Red − 37.24 (R^2 = 0.986) Calculated Green = 0.9975 x Photographed Green − 38.96 (R^2 = 0.985) Calculated Blue = 0.9841 x Photographed Blue − 35.74 (R^2 = 0.987) The following equations can be used to differentiate between diagnostic grey, yellow and red: Between grey and yellow: Green = 0.88 * Red − 5 Between yellow and red: Green = 0.79 * Red − 11 The methodology showed a 19% misclassification, although the number of classified chips equalled the number of defined chips, when tested on photographed Munsell sheets. This was attributed to the discrete nature of the diagnostic colour definitions.

Keywords: GIS, photo, RGB, soil classification, soil colour

THE DEVELOPMENT OF AGRICULTURAL APPLICATIONS WITH THE USE OF MSG SEVIRI DATA

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Remote sensing data have been widely used in agriculture throughout the world. The latest developments in this regard focus increasingly on hyperspectral remote sensing and precision farming. Coarse resolution remote sensing has, however, been proven as an important information source in agriculture, with the focus being on drought monitoring, crop modelling and disaster management.

Data have recently become available from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on-board the Meteosat 8 (Meteosat Second Generation – MSG 1) satellite. It produces data with a 15-minute temporal resolution for the entire African disk. Over South Africa the spatial resolution of the data is in the order of 3 km. Application of these data could benefit the agricultural sector. The potential for the development of products from the data for application in agriculture was investigated with the emphasis on drought monitoring, crop yield estimation, and animal and plant pest and disease indices.

The Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST) and cloud cover products were some of the initial products derived from the MSG SEVIRI data. However, with crop estimation, animal, plant pest and disease indices in mind, further input data were needed to develop products relevant to these disciplines. Weather data from a network of 250 automatic weather stations were combined with MSG SEVIRI data to derive such products. These derived products include air temperature, air humidity and solar radiation.

The accuracy of the products exceeds that of interpolating between recording stations. The products have also successfully been tested as valuable input data layers into GIS-based pest and disease monitoring, drought monitoring and crop modelling algorithms. While the MSG SEVIRI data covers the entire South Africa, the automatic weather station network of the ARC-ISCW has provided useful and timely data to develop products that are partially derived from MSG SEVIRI data. The accuracy of these combined products can be improved with the additional incorporation of automatic weather station data from other sources like the South African Weather Service and further improvements to the derivation of input products from MSG SEVIRI data.

Keywords: remote sensing, NDVI, drought monitoring, crop yield estimation, disease indices

EXPLORING THE SPATIAL RELATIONS BETWEEN PLANT ELEMENT UPTAKE OF A LUCERNE STAND AND SOIL PROPERTIES

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There are several factors affecting the nutrient requirements of lucerne (*Medicago sativa* L.) of which yield level, cutting schedule, climate and management practices are the most important. Successful lucerne stands are obtained on deep, well-drained soils with pH(H_2O) = 6.2-7.8, P(Bray1) ≥25 mg kg^{-1}, K ≥80 mg kg^{-1}, Ca ≥600 mg kg^{-1} and Mg ≥600 mg kg^{-1}. This study was designed to quantify the spatial variability of the soil and plant properties and, consequently, to explore the spatial relations between plant element uptake and soil properties using geostatistical procedures. Seventy-two sampling points (nodes) were laid out on a 20 m square grid, with an additional 90 sampling points laid out on a 2.5 m square grid at six randomly selected node points to ensure that the total spatial structure would be identified. Plant and soil samples (0-300 mm layer) were collected in June 2001 and analyzed for several plant and soil properties. Linear regression analyses, in general, showed poor correlation between plant element uptake and soil properties. Geostatistical analyses of plant and soil variables produced considerable variation and highly variable autocorrelation lengths. When comparing spatial maps of plant Ca, Mg and P contents with their soil counterparts, no resemblance could be found, while for K some spatial agreement between plant and soil values was noticeable. Making use of a multiple regression equation, very good agreement was found between the spatial distribution of measured and predicted plant K. This emphasizes the fact that the uptake of elements by plants is not solely dependent on the concentrations thereof in the soil solution, but on other factors as well.

Keywords: spatial variation, plant element uptake, soil properties

USING APSIM FOR SOIL FERTILITY STUDIES AND RISK MANAGEMENT IN SMALLHOLDER FARMING SYSTEMS OF SOUTHERN AFRICA

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Using computer simulation models that represent crop and animal production processes to assist farmers, researchers and agricultural managers in making farm management decisions is a platform for achieving change in a farming system. APSIM (Agricultural Production Systems sIMulator) is a software system that provides a flexible structure for the simulation of climatic and soil management effects on the growth of crops and changes in the soil resource (www.apsim.info/apsim/). Simulation models such as APSIM are proving useful to capture the interactions between climatic conditions, soil types and nutrient dynamics in the climatically variable cereal based farming systems found throughout Africa and Australia (Keating et al. 2003).

APSIM has been used in a range of research contexts; as a research tool for investigating soil nutrient dynamics and responses or water use efficiencies, in testing crop rotation systems, or assessing seasonal climate forecasting to name a few. Systems simulation models may also provide an opportunity for interfacing and facilitating the integration of hard biophysical systems and soft systems approaches to intervention in social management systems. In this context, APSIM has enabled scientists, extension offices and farmers to explore the consequences on the farming system (e.g. grain yield, gross margin, soil fertility, etc) of management actions and strategies and seasonal and long-term climatic conditions. This can lead to a series of 'what if' scenario analysis sessions and information on trade offs. Such approaches are being used in collaborative R,D&E projects in the Limpopo province of RSA to help emerging cropping farmers become more profitable and sustainable.

Keating *et al.* (2003) An overview of APSIM, a model designed for farming systems simulation. European Journal of Agronomy 18, 267-288.

Keywords: APSIM, Simulation modelling, soil fertility, climatic risk, nutrient management

USING AGRICULTURAL WASTES ON SMALL AND DEVELOPING FARMS FOR THE PRODUCTION OF ORGANIC FERTILISERS AND COMPOSTS

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This paper concerns the use of agronomic wastes as a composted soil ameliorant for the sandy soils of the northern coastal region of KwaZulu-Natal. There are two aspects to this paper: the increase in the soil fertility potential of the sandy soils (Fernwood Form) of the coastal region of Northern KwaZulu/Natal; and to find some way of alleviating the waste problem of Mondi Kraft at Felixton. The University of Zululand Department of Agriculture (UZDA) was asked by the community to help with agronomic advice.

The first objective was to find a method of increasing the soil fertility in a sustainable manner so that vegetables could be grown for household use and the excess sold to increase household income. A soil survey was undertaken at Mandlazini Agri-village, Richards Bay, with 209 samples, one per household plot of 4000 m^2, out of a total of 570 household plots in the Agri-village. These were analyzed and found to be deficient in all the basic nutrients and with a very low water holding capacity. To increase and maintain soil fertility it was decided to use organic inputs; the problem was obtaining the materials needed in the amounts necessary. The UZDA was contacted by Mondi Kraft at Felixton, who had a problem with getting rid of their organic waste as their own landfill site was full. The waste from Mondi was tested and found to be suitable for use as a carbon source in the basics for the organic amendments for the soil. The source for the nitrogen came from the use of bio-solids from the local sewage works, which had also been tested and found to be acceptable. The organic compost project could solve both problems at once: increase the soil fertility while resolving Mondi Kraft's waste problem.

Soil samples were taken from 209 sites in the study area. A pilot study was set up mixing the three products, wet pith bagasse, filter cake and bio-solids, to obtain the correct C:N ratio of 30:1. An area was laid out (adjacent to the Agri-village) with 12 replicates and catchments for the leachate. Temperatures were taken daily until 60ºC was reached; then the compost was turned every week until it reached an ambient temperature of about 30ºC. This took eight weeks. The compost was then tested to determine the nutrient content, cation exchange and water holding capacity of the compost. The leachate was also tested for use as a compost tea. The compost was then used in pot trials to see how it performed on vegetables. The results will be presented in tables and graphs at the conference. This project was successful and has led to further projects with Mondi and the use of organic inputs in other areas with sandy soils.

Keywords: Composting, Fernwoods, wate disposal, Coastal KZN, small farmer, soil fertility

QUANTIFYING RAINFALL-RUNOFF RELATIONSHIPS ON A REGOSOL IN ETHIOPIA

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A large part of Ethiopia is semi-arid. In these areas crop production is low due to low precipitation use efficiency (PUE), low and erratic rainfall, and high water losses by runoff (R) and evaporation from the soil (E_s). Many of the soils in these areas have a high silt content which enhances crust formation and promotes R. This decreases PUE. It is therefore possible to boost crop production in these regions by employing suitable water conservation techniques such as in-field rain water harvesting (IRWH). With this technique R = 0 and E_s is reduced considerably. It is hypothesised that it will be possible to make a reasonably reliable prediction of the beneficial effect of IRWH on maize yield by comparing runoff responses on conventionally tilled plots with plots on which an essential feature of the IRWH technique is simulated, i.e. a bare crusted runoff surface. The rainfall-runoff relationships on a representative ecotope, were quantified and used to calibrate and validate a runoff model. The runoff model could then be used on other ecotopes, enabling extrapolation of results to other parts of Ethiopia. The Morin and Cluff runoff model was selected. The main input parameters are rainfall intensity (P_i), final soil infiltration rate (I_f) and soil storage and detention (SD). A runoff experiment was conducted at Dera, a representative semi-arid ecotope. It is located in the central Rift Valley of Ethiopia. The annual rainfall is 765 mm and the annual aridity index (AI) is 0.5. The soil is classified as a Calcic Fluvic Regosol (WRB classification). It covers about 10 % of Ehtiopia. The texture of the Ap horizon (0-200 mm) is a fine sandy loam with silt and clay content of 30.6 % and 17.5 % respectively. The experiment consisted of 2 m by 2 m runoff plots with two treatments and three replications. The treatments were conventional tillage (CT), and an artificially smoothed soil surface (NT). It was conducted for two years (2003 and 2004) during the main rainy season. Rainfall intensity (P_i) was measured at one minute intervals and runoff was measured after each rainfall event. I_f was measured using a sprinkler infiltrometer on a separate plot on which a crust had already formed. The infiltration rate measurement gave an I_f value of 6 mm hr^{-1}. Runoff, expressed as a percentage of the total rainfall for the season, during the 2003 and 2004 seasons was 46 and 32 for CT and 53 and 39 for NT, respectively. The Morin and Cluff model simulated the observed runoff on both treatments in a reliable way, with D indices ≥ 0.98. A simplified procedure for predicting R was also investigated. It consisted of measuring the area above the P_i = 6 mm hr^{-1} line on P_i vs time graphs for each storm. This procedure predicted R:P = 39 % over the two seasons, i.e. the same value as that measured for CT. These results show application of IRWH could increase the water available to the crop by at least about a third of the seasonal rainfall. This should increase maize yields significantly.

Keywords: Rainfall-runoff model, Soil crusting, Infiltration rate, In-field rain water harvesting, Ecotope

STUDY ON HERBICIDAL WEED CONTROL AND HAND WEEDING IN WINTER SOWING DATE OF CHICKPEA

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The presence of weeds in winter sowing chickpea is a s erious threat to crop yield. The conventional hand and mechanical weed controls are not economically effective in chickpea. Therefore, the use of other weed control methods such as chemical control is necessary. More effective herbicides with broader spectra of weed control and wider adaptability in chickpea are sought. The effects of herbicides including pyridate, pendimethalin, oxyflourfen, trifluralin and paraquat on chickpea weeds were evaluated at the Research Farm of Tehran University, Karaj, during the growing season of 2002-2003. The experiment design was a Randomized Complete Block (RCBD) with four replications. Weed control treatments included the pre-emergence applications of pendimethalin (1320 g a.i./ha), oxyflourfen (600 g a.i./ha), and post-emergence applications of pyridate (1200 g a.i./ha), oxyflourfen (480 g a.i./ha) and paraquat (200 g a.i./ha). Different combinations of pre-plant applications of trifluralin (960 g a.i./ha) and pendi methalin (1320 g a.i./ha) were made, each with post-emergence applications of pyridate (1200 g a.i./ha) and oxyflourfen (480 g a.i./ha) plus one hand weeding, and finally a weed free and w eed infested plot were used as checks. The results showed that chickpea seed and bi ological yield were significantly affected by weed control treatments ($p<0.05$). The results also showed that pre-emergence application of oxyflourfen effectively controlled early season weeds. The combined treatments of pendimethalin + oxyflourfen, pendimethalin + one hand w eeding, trifluralin + one hand w eeding and trifluralin + oxyflourfen effectively controlled total broadleaf weeds by 93.4, 92.2, 90 and 88.5%, respectively. Post-emergence applications of oxyflourfen and paraquat resulted in crop injury. Thus, the integrated treatments of trifluralin + one hand weeding, pendimethalin + pyridate, trifluralin + pyridate, pendimethalin + one hand weeding and application of pendimethalin alone, with good weed control and high yield, were the best treatments to use in chickpea under conditions similar to those in this experiment.

Keywords: Chickpea, Weed, Chemical weed control, Hand weeding, Winter sowing

NEUPROBDB: A DATABASE APPLICATION FOR PROCESSING NEUTRON WATER METER DATA

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Accurate and timely information is necessary for planning and decision making regarding water resources, especially in water poor countries like South Africa. Long-term soil water content measurements, using instruments such as a neutron water meter (NWM), are an important source of such information. Calibration and utilization of NWM data is, however, often time consuming and error prone, especially when long-term and spatially varied data are considered. A computer application was developed for the input, storage, processing and output of NWM data. The application was developed in MS Access using the Visual Basic for Applications (VBA) programming language. A database that consists of 10 tables was designed and developed. The front-end (graphical user interface) of the application enables the user to import NWM readings to the database, and to specify the site, soil information, and the reading dates at the beginning and the end of the period considered. The calibration equation can be entered by the user or it can be selected from the available options depending on soil and instrument information. The application is usable at any time and for any site, depending on the user input and preferences. Provision is made for the use of a single linear equation, two linear equations, or an exponential equation. Resulting count ratio or soil water content data can be displayed for the period considered in the form of tables or in the form of graphs. The application also allows for exporting the results into other applications such as MS Excel. The application will facilitate easier and more accurate interpretation of NWM data. Therefore it is believed that it will promote reliable hydrological modelling and agricultural and environmental applications of soil water data.

Keywords: Soil water, neutron water meter, database application, data processing

DEGREES OF WETNESS OF SELECTED DIAGNOSTIC HORIZONS IN THE WEATHERLEY CATCHMENT

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Quantitative description of the wetness of soils in the landscape provides valuable information for agricultural, environmental and hydrological studies. The degree of water saturation (s) of the soil is a suitable parameter for this purpose. This study compares long-term mean daily s values for diagnostic horizons using cumulative distribution functions (CDF). Daily s values were calculated for 70 diagnostic horizons in the Weatherley catchment (Eastern Cape) over a period of six years based on measured and estimated soil water content data. This dataset enabled the generating of CDF graphs of mean daily s values for each type of diagnostic horizon. The diagnostic horizons included 21 orthic A (ot), 6 neocutanic B (ne), 3 red apedal B (re), 3 yellow brown apedal B (ye), 4 soft plinthic B (sp), 3 E (gs), 12 unspecified material with signs of wetness (on), and 18 G (gh) horizons. The ot horizons were subdivided into 8 wet (ot_w) and 13 dry (ot_d) ones. Results showed that the diagnostic horizons considered could be roughly sub grouped into three wetness classes: the ne, re, ye and ot_d horizons at the dry end; the gs, gh and on horizons at the wet end; and the sp and ot_w horizons about midway, on the wetness spectrum.

The s value of 0.7 is provisionally assumed to be the lower threshold value for redox reactions to occur. The CDF graphs of long-term mean daily s values showed that the probability of exceeding s = 0.7 was close to 0 for ne, 0.04 for re, 0.13 for ye, 0.15 for ot_d, 0.45 for ot_w, 0.60 for sp, 0.93 for on, 0.95 for gh, and 0.96 for gs.

These results are according to expectation in relation to morphological characteristics.

Keywords: degree of water saturation, diagnostic horizons, cumulative distribution functions, Weatherley catchment

EFFECTS OF EXTERNAL CA CONCENTRATION ON THE VEGETATIVE GROWTH OF PEANUT (*Arachis hypogaea* L.) IN FLOWING SOLUTION CULTURE

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Calcium (Ca) deficiency is an important problem in commercial production of peanut (*Arachis hypogaea* L.), with lines from the sub-species *A. hypogaea hypogaea* (Virginia type) considered more susceptible to Ca deficiency than those of *A. hypogaea fastigata* (Spanish and types). Fifteen peanut lines comprising Virginia bunch (5 lines), Virginia runner (1), Spanish (6), and types (2) plus 1 x Spanish cross were grown for 30 d in continuously flowing solution cultures at constant external Ca concentrations ranging from 9 to approx. 2500 µM. Two lines, required < 9 µM Ca for near-maximum dry matter yield of tops, whereas 5 lines required 15 – 20 µM, 6 lines required 25 – 50 µM, and 2 lines required > 75 µM Ca for near-maximum yield. It was concluded that, although peanut lines differed markedly in the external Ca concentrations needed for near-maximum yield, these differences did not coincide with broad botanical groupings of lines. However, Virginia type peanut lines had consistently lower Ca concentrations in youngest fully expanded leaves (YFEL) than the Spanish or other lines studied (the difference in means increased from 1 g kg^{-1} Ca at the lowest external Ca concentration to 4 g kg^{-1} Ca at the highest). Increases in external Ca concentration decreased the concentrations of Mn, Mg, P, Fe, and K in the YFEL. It seems probable that yield reductions observed at above-optimum Ca concentrations were due to induced deficiencies of P, Mg, or possibly Fe.

Keywords: Calcium deficiency, Calcium excess, Groundnut, Magnesium deficiency, phosphorus deficiency