Abstracts:

Oral Presentations

EVALUATION OF ZINC OXIDES AS A SOURCE OF ZINC FOR PLANT GROWTH

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INTRODUCTION

Zinc oxides are often produced as by-products of a number of industrial processes and there have been concerns that they may differ in terms of soluble zinc depending upon their origin. With this in mind a pot trial was implemented using wheat as an indicator of the ability of different zinc oxides to supply soluble zinc for growth.

MATERIALS AND METHODS

Wheat was grown in perlite and irrigated with a hydroponic solution free of zinc. Zinc oxides of different origins were band placed at planting at a rate that supplied equal amounts of elemental zinc. Five sources of zinc oxide and two controls were included in the trial, the first control receiving no zinc and the second was a treatment of zinc sulphate which is known to be readily soluble and hence available for plant uptake. The trial was laid out using a Completely Randomised design on a rotating table and the seven treatments were replicated five times. Plants were harvested just prior to flowering and dry root and shoot mass measured and their zinc concentrations analysed.

RESULTS AND DISCUSSION

Marked differences were found in the response of the wheat to the different sources of zinc. As anticipated, the control receiving no zinc performed poorly in terms of shoot and root biomass and the concentration of zinc in the tissues. Amongst the treatments, statistically significant differences were measured ($P<0.05$) in all parameters. The general trend observed was that treatments with higher biomasses tended to have lower concentrations of zinc in their tissues and vice versa. In terms of total zinc uptake, treatments with high concentrations of zinc were shown to have taken up significantly more zinc than the control ($P<0.05$) and the uptake was also statistically equal to that of the zinc sulphate treatment.

CONCLUSION

It is important to screen zinc oxides for their ability to supply plants with zinc before taking the decision to use them as a source of zinc for plant growth. Zinc oxides were shown to be as efficient as zinc sulphate at supplying zinc under the conditions tested.

Keywords: Micronutrients, zinc, zinc oxide

ACETOCHLOR INJURY TO MAIZE AS AFFECTED BY PLANTING DEPTH

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INTRODUCTION

Acetochlor containing an antidote is registered for pre-emergence use on maize for the control of mainly annual grasses. It is normally applied at rates of between 0.49 to 1.89 kg ai ha^{-1} on soils with a clay content ranging from <10% to 55%. There is a tendency emerging for farmers to plant maize at greater depths, up to 10 cm, in order to place the seed in moist soil. This increases the time to emergence, which influences the amount of herbicide that can be absorbed by the plant, and can lead to increased herbicide phytotoxicity. An experiment was conducted in order to establish if maize sensitivity to acetochlor was increased with an increase in planting depth.

MATERIALS AND METHODS

Pipes (16 cm diameter and 30 cm deep) were filled with a sandy loam soil (15 % clay) to the required planting depth (25, 50, 75 and 100 mm). This soil was wet to field capacity and six seeds (DKC73-76R) placed on the wet surface, after which the pipes were filled with soil. Five rates of acetochlor (0, 0.74, 1.47, 2.94 and 5.88 kg ai ha^{-1}) were applied and leached into the soil using the equivalent of 12.5 mm of rainfall. The trial was laid out in a randomised complete block design in a glasshouse set to 28/18°C day/night. Time to emergence (first and last) and phytotoxicity were monitored, and plants were harvested 28 days after treatment. Data on seedling emergence, plant height and mass of seedlings were collected and subjected to standard statistical analysis.

RESULTS AND DISCUSSION

Characteristic symptoms of acetochlor phytotoxicity were noted at the higher rates of application (2 and 4X) and shallower planting depths (25 and 50 mm). Time for seedling emergence also increased with increasing depth and acetochlor application rate, being significantly delayed at the 100 mm depth and the 4X application rates. A highly significant interaction effect between the herbicide application rate and planting depth was obtained for plant height, while all other parameters showed highly significant effects due to both planting depth and herbicide application rate. Acetochlor had an inhibitory effect on seedling mass at the recommended rate of application, and seedlings from the shallowest plantings had the greatest mass. Greatest reduction in mass was found in seedlings planted at 50 mm, possibly due to less leaching taking place. It is possible that these results could differ depending on the soil type used, or the amount of water used to leach the herbicide into the soil.

CONCLUSIONS

Both planting depth and acetochlor application rate affected the growth of maize seedlings. Acetochlor at the recommended rate of application significantly reduced the mass of maize seedlings. Planting at an intermediate depth on this particular soil type, rather than at the deepest depth, resulted in the greatest reduction in seedling mass.

Keywords: Acetochlor, corn, maize, phytotoxicity, planting depth

BIOREMEDIATION OF POLYCHLORINATED BIPHENYLS (PCBS) CONTAMINATED SOIL BY PHYTOREMEDIATION WITH *Chromolaena odorata* (L) KING AND ROBINSON

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INTRODUCTION

PCBs are toxic and recalcitrant pollution in the environment which founds its use in several human appliances as a result of its physico-chemical properties (Anyasi and Atagana, 2011). The most effective methods of PCB remediation has been incineration (Aken et al., 2010). However, with the aim of discovering an alternative approach, phytoremediation were harnessed. Till date, no plants have proffered a complete remediation of PCB from the environment. This study however, involves the use of alternative plant type (*Chromolaena odorata*) in the greenhouse for the removal of PCB from a PCB-contaminated soil.

MATERIAL AND METHODS

Soil samples initially analyzed below detection (soil 1) were contaminated with PCBs in the form of pure Aroclor and transformer oil (T/O) through the method of sprout culture adopted by Suzuki et al. (1977). The soil samples were spiked with 100, 200, and 500mg/kg soil^{-1} of Aroclor, and 100, 200, and 500ml/kg soil-1 of T/O co-contaminated with 100ppm Aroclor (soil 2). Five weeks old *C. odorata* plants that were pre-cultured in soil 1 housed in cellophane bag of dimension (30x25x30) cm^3. Plants were harvested after 6weeks and the plant and soil samples were extracted and analyzed using GC-MS.

RESULT AND DISCUSSION

GC analysis showed a total PCB concentrations of 6.4, 11. 7 and 55.8 µg/g in plants tissues, given a total percentage reduction in soil PCB concentration to 2.1, 1.5, and 1.1 among the three treatments respectively. There was no detection of PCB in plants of the T/O in Aroclor samples, though soil total PCB recorded percentage reduction of 0.32 and 0.87 among the treatments respectively; this could be attributed to microbial action. Relative growth rate (RGR) in Aroclor amended samples was higher than that in T/O with Aroclor. This means that in an optimal condition, phytoremediation of PCB with *C. odorata* could be optimized.

CONCLUSIONS

The result of this study has proven that *C. Odorata* is capable of remediation of PCB contaminated soil and should be optimized under field condition.

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Keywords: bioremediation, biological remediation, PCB, phytoremediation

DOES CLIMATE HAVE AN EFFECT ON LOW FALLING NUMBERS OF WINTER WHEAT?

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INTRODUCTION

Pre-harvest sprouting (PHS) has been recognised as the primary cause of low falling numbers (FNs) in wheat. Recent research however, revealed a number of additional causes of low FNs. FNs of certain cultivars have varied considerably from year to year and across environments in the wheat producing areas of the Free State Province. In this study we aimed to determine whether climatic conditions could contribute to these unexpectedly low FNs.

MATERIALS AND METHODS

Trials were planted at five localities in the Free State Province of South Africa between early May and late July during 2004, 2005, 2006, 2007 and 2008 to ensure that a wide spectrum of climatic conditions was covered. Eleven commercially released cultivars from three breeding institutions were included in the trials. The trials were planted according to a randomised complete block design (RCBD) with four replicates. Weather data from plant to harvest were collected from neighbouring meteorological stations. FNs of each of the cultivars at each of the localities were determined according to the AACC Method 56-81B (American Association of Cereal Chemists, 2000). Data were analysed using the statistical program GenStat®.

RESULTS AND DISCUSSION

Certain cultivars had low FNs in environments where there was no evidence of sprouting and in which other cultivars had high FNs (>250s). Individual correlations showed that rainfall just prior to harvest, and therefore PHS, were not responsible for the low FNs that occurred from time to time but that rainfall during the later stages of maturity was more important in determining low FNs in four localities and in at least eight of the cultivars. Minimum temperatures were also a critical factor in determining FNs in certain cultivars. Principal component analysis (PCA) identified three groupings of cultivars varying in the frequency of low FNs experienced over the five years of the study. It is clear that low FNs are not always associated with cultivars without PHS resistance, such as PAN 3349. On the other hand cultivars such as Betta-DN and Elands that are known for their excellent resistance to PHS (Barnard, 2001) experienced low FNs from time to time.

CONCLUSIONS

Rainfall during the later stages of grain filling and maturity had a negative effect on the FNs of seven of the eleven cultivars, while maximum temperatures during these growing periods were positively correlated with FN in eight of the eleven cultivars. Minimum temperatures just prior to harvest could also determine the FNs of certain cultivars. Rainfall just prior to harvest, and therefore PHS, was not the major factor responsible for the low FNs obtained during this study.

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Keywords: falling number, pre-harvest sprouting, rainfall, temperature, wheat

AN AUDIT AND SUBSEQUENT MONITORING OF NON-PARASITIC AND PLANT-PARASITIC NEMATODES IN SYSTEMS OF ACCEPTED CONSERVATION AGRICULTURAL PRACTICES

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INTRODUCTION

One of the primary focuses of conservation agriculture (CA) is to promote soil quality by stimulating an increase in the numbers and diversity of beneficial soil organisms. In terms of nematodes' role in agriculture three aspects are critically important, viz. i) how CA could benefit soil organisms, especially non-parasitic nematodes; ii) why non-parasitic nematodes are important in crop production and iii) how soil quality could be defined in terms of the ratio between population dimensions of different nematode trophic groups in the same soil community. The objective of the study is to investigate and monitor nematode communities over time in CA systems to determine whether and how they could be instituted as indicators of soil health status.

MATERIALS AND METHODS

Nematode community composition was determined and population dynamics were monitored over two seasons at a trial site in North West in an existing CA programme. The trial consisted of four treatments, viz. monoculture maize under conventional cultivation and three treatments where minimum soil disturbance, different crop rotations and permanent soil cover were applied in different combinations, with four replicates. Soil samples for nematode analyses were taken before planting in each season, while crop roots and rhizosphere samples were collected at 60 and 100 days after planting. Non-parasitic as well as plant-parasitic nematodes were extracted, identified and counted.

RESULTS AND DISCUSSION

Data show strong tendencies in nematode dynamics in different cropping and cultivation regimes, with non-parasitic population levels increasing between seasons 2009/2010 and 2010/2011. Thus far population levels of plant-parasitic nematodes did not show any significant changes.

CONCLUSIONS

The study needs to be carried out for a considerable period before significant conclusions can be drawn. A survey is needed to establish a benchmark against which the trials can be compared in order to monitor their progress towards more stable, diverse systems as can be found in natural or undisturbed fields.

ACKNOWLEDGEMENTS

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Keywords: CA, non-parasitic nematodes, plant-parasitic nematodes

POTASSIUM UPTAKE OF GRASS ON GOLD MINE TAILINGS

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INTRODUCTION

Vegetating mine tailings mitigates some environmental impacts like dust pollution, water contamination, acid mine drainage and erosion. Gold mine tailings are generally dominated by silt size particles with very low cation exchange capacity, very low levels of ammonium acetate extractable potassium and magnesium but very high levels of ammonium acetate extractable calcium. Amelioration and fertilization guidelines for gold mine tailings are not well developed and in some cases guidelines developed for natural soils are used.

MATERIALS AND METHODS

Results from soil, tailings and grass (*Cynodon dactylon*) analyses from several monitoring projects were used to establish correlations between potassium availability and uptake parameters. Samples were taken from ameliorated gold mine tailings facilities and nearby natural soils such as ameliorated footprints, spillage areas and uncontaminated natural veld. A range of soil analyses were done on the soils or tailings but in this study only cation exchange capacity (CEC), ammonium acetate extractable potassium and water extractable potassium are given. Grass samples were taken at most sites where soil or tailings samples were taken and analyzed for several nutrient- and metal concentrations including potassium after dry ashing and acid digestion.

RESULTS AND DISCUSSION

Cynodon dactylon grass growing on soil and on tailings accumulated average potassium concentrations of 0.97% and 1.03% respectively, despite average ammonium acetate extractable potassium concentrations of 121 mg kg^{-1} and 37 mg kg^{-1} in soil and tailings, respectively. This could be explained by the water soluble potassium in the tailings samples contributing 51% on average of the ammonium acetate extractable potassium, compared to 13% in the soil samples. The high proportion water soluble potassium in tailings might be expected when considering the very low CEC (0.8-2.4 cmol kg^{-1}) and extremely high Ca levels thereof. Reasonable correlations were found between potassium in grass samples and potassium concentrations in soil/tailings samples only when data was separated between soil and tailings. Threshold concentrations, below which potassium might be deficient in grass samples, were calculated from regression equations. The threshold ammonium acetate extractable potassium concentrations were 77 mg kg^{-1} for soil and 24 mg kg^{-1} for tailings, indicating that amelioration guidelines for soils and tailings might differ substantially. These trends were also found by other researchers who recorded no response to potassium fertilizer of turf grass growing on alkaline sandy golf greens despite low ammonium acetate extractable potassium.

CONCLUSION

Threshold soil concentrations, below which potassium might be deficient in grass samples, was much lower (24 mg kg^{-1}) on gold mine tailings compared to surrounding natural soil (77 mg kg^{-1}) indicating that amelioration guidelines for soils and tailings might differ substantially.

Keywords: gold mine tailings, grass, potassium, soil

TILLAGE PRACTICES IN CROP PRODUCTION AND THE IMPACT ON BASIC SOIL PROPERTIES

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INTRODUCTION

Over the last three decades soil conservation through tillage practices became an important aspect of conservation agriculture. These tillage responses can be positive or negative in terms of soil conservation, depending on the tillage practice, the type of soil and the climatic conditions (Martinez *et al*., 2008). Little research has been done on the long-term effects of tillage on soil properties in the Western Cape other than the long term research at Langgewens. The aim of this study therefore was to evaluate the effect of different tillage practices on the soil physical and some chemical properties.

MATERIALS AND METHODS

The research was conducted on the Langgewens experimental farm, 18 km north of Malmesbury in the Western Cape. The soil form is a Glenrosa in with gravelly sandy-loam texture. The experiment started in 1975 with four main tillage treatments; conventional- , tine-, minimum- and no-tillage. The coarse fragments, electrical conductivity and total organic carbon were analyzed for the 0-100 mm and 100-200 mm soil depths for each site. Dry bulk density (0-100 mm) was determined with a Troxler surface gamma-neutron meter for in-situ measurement.

RESULTS AND DISCUSSION

Conventional tillage had a significantly higher EC comparing to other tillage treatments in the 0-100 mm soil profile. Total soil carbon of the 0-100 mm soil profile depth showed that conventional tillage had a significantly lower total carbon content compared to the other tillage treatments. At 132 and 146 days after planting, minimum- and no-tillage had significant lower bulk densities than tine- and conventional tillage.

CONCLUSIONS

This research highlights the use of conservation tillage practices, which buffers compaction that can have a negative effect on crop yield and had a marked effect on infiltration.

REFFERENCES

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ACKNOWLEDGEMENTS

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Keywords: Long-term effects, soil properties, tillage

HYDROPEDOLOGY: INTEGRATING PEDOLOGICAL EXPERTISE IN HYDROLOGICAL STUDIES IS BENEFICIAL FOR BOTH

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Hydropedology combines the field experience of pedologists and soil surveyors with quantitative process-knowledge of hydrologists and soil physicists. As many modern applications of soil science increasingly require quantitative expressions of land qualities to be obtained by simulation modeling, soil survey databases can provide useful data , e.g. in terms of pedotransferfunctions and physical boundary conditions for complex flow systems in anisotropic, heterogeneous field soils. Modern land use issues require *transdisciplinary* approaches and every discipline has to define its specific “niche” that makes it an interesting partner in the team. Focusing on the seven soil functions, defined in the European Soil Protection Strategy of 2006, represents an effective approach when defining the “niche” and in this context, hydropedology scores better than the two separate disciplines. Four examples will be discussed: (i) measuring the hydraulic conductivity in structured soil, illustrating the effect of sample volume and distinction of K(sat); (ii) bypass flow in soils with macropores, (iii) water accessibility in coarse structured soils, and (iv) determining hydraulic characteristics of particular soil horizons, using a spodic and an argillic horizon as an example. The benefit of hydropedology for pedology and soil survey is the improved functional characterization in terms of water regimes in soils and watersheds, that is needed for modern applications. The benefit for hydrology and soil physics is the opportunity to get away form the implicit assumption in flow models that soils are isotropic and homogeneous, which, of course, they are not.

HYDROLOGICAL RESPONSE MODEL OF A COMPLEX SOILSCAPE IN THE WEATHERLEY CATCHMENT, EASTERN CAPE

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INTRODUCTION

The hydrological response of hillslope soils (soilscape) is critical in hydrological modelling. Soilscape response is mainly controlled by soil (upper vadose zone) and its interaction with the fractured rock (lower vadose zone). The control mechanisms, flowpaths and storage mechanisms are grafted in the soils as signatures of pedogenesis.

MATERIALS AND METHODS

A soilscape in the Weatherley catchment was selected. Soil observations were made in a transect consisting of three soil profiles with morphological, chemical, tension and daily neutron water meter data and 15 auger observations with morphological data. The lithology is sedimentary rocks of the Molteno and Elliot formations and a dolerite dyke. Three steps were used to identify the factors (mechanisms) and processes (flowpaths and storage) controlling hillslope hydrology. (i) Interpret soil morphology, (ii) interpret soil chemistry to improve the interpretations and (iii) interpret data of long-term soil water measurements.

RESULTS AND DISCUSSIONS

The soil morphology indicates a variety of soil water regimes varying between leaching (recharge), interflow and storage. Chemical parameters differ according to these hydrological conditions. Soil water contents vary accordingly. The hydrology of the soilscape is controlled by recharge in the Hutton soils of the crest. Water moves vertically through the soil to the bedrock were it splits and some water infiltrates the bedrock and some moves on top of the bedrock laterally in the Bloemdal soils. Bedrock water interflow in the bedding planes of the sedimentary rocks is stored behind the dyke. Stored water returns to the subsoil in the midslope maintaining saturation in the G horizon of the Katspruit soil.

CONCLUSION

Although designed by ancient soil morphology the conceptual hydrological response model was confirmed by recent soil chemistry and active hydrometrics.

Keywords: Chemistry, morphological indicators, hydrometrics, hillslope hydrology, flowpaths, storage mechanism

DEVELOPMENT OF HERBICIDE SELECTION AND CALIBRATION TABLES FOR EMERGING SUGARCANE FARMERS

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INTRODUCTION

Emerging farmers (EFs) frequently request assistance with the selection of appropriate herbicides and the calculation of required application rates. Consequently, SASRI hosts field days to assist Efs with knapsack calibration and herbicide selection. In addition, a training manual containing user-friendly tables has been developed to assist Department of Agriculture, Environmental Affairs & Rural Development Extension Officers. This manual has simplified the SASRI Herbicide Guide and calibration calculations, and rendered treatments readily accessible to Extension Officers and EFs (Anon, 2011; Boevey, 1993). The objective of this paper is to explain the content and step-wise use of these user-friendly tables.

MATERIALS AND METHODS

Nine steps have been specifically tailored to meet the needs of the EFs with respect to appropriate selection and application of herbicides.

RESULTS AND DISCUSSION

Nine steps were developed for herbicide selection and calibration: the first five steps are measurements to determine the required height of water in a 210 L mixing drum. Steps 6 and 7 provide a guide to select herbicides appropriate to the region of the SA sugar belt. The tables provide an overview of all recommended treatments. Treatments can be 'deselected' according to whether the crop is plant or ratoon cane, weed growth stage (pre-early post emergence, post-emergence and escaped weeds), soil moisture and availability of small herbicide quantities. Step 8 provides the required amounts of each herbicide for addition to the mixing drum, and is adjusted for different soil clay contents. Step 9 provides the required amounts of suitable adjuvants according to the height of water initially added to the mixing drum. In addition, a second set of tables was developed to calibrate a 15 L knapsack, for areas less than 0.5 hectares. These methods could potentially increase the success of weed control in the EF sector, thereby promoting increased yields.

CONCLUSIONS

· The developed technology transfer intervention will promote effective calibration and herbicide selection by emerging sugarcane farmers.
· With effective calibration and herbicide selection, followed by good crop husbandry, the potential for increased yields amongst EFs might be realised.

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Keywords: calibration, emerging farmers, herbicide selection, sugarcane, weed control

COPPER DEFICIENCY AND TOXICITY IN WHEAT AND MAIZE

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INTRODUCTION

Cereals especially wheat are sensitive to copper deficiency which is manifested by drooping, purplish ears devoid of grain. Deficiency is mostly associated with sandier soils low in organic matter in Southern Africa. For instance, granite sands in Zimbabwe have had to have copper application where irrigated wheat is grown in rotation with maize and tobacco. High Zn and P applications for wheat and these preceding crops were suspected of aggravating copper deficiency. Cu deficiency and Zn and P antagonism were examined in pots and Cu deficiency in field trials with wheat. In a separate investigation high Cu outcrops in maize fields were tested to evaluate the threshold and the mechanism of Cu toxicity.

MATERIALS AND METHODS

Farmer's reports during the 1982-83 seasons indicated a wide spread problem manifesting as patches in fields of barren wheat ears. Plant and soil samples were collected for analysis. These indicated a possible copper deficiency and bulk samples were collected from a number of sites for pot trials. Two sites were identified for field trials. Pot trials comprised 2 x 2 x 2 factorials with copper, zinc and phosphate and all combinations as treatments. Field trials tested levels of soil applied copper and concentrations of copper leaf sprays. Severe leaf chlorosis of maize was investigated at a site near a copper mine where copper anomalies occurred in fields and soil and leaf samples were taken.

RESULTS AND DISCUSSION

All pot trials had a grain response to Cu but no response to or suppression of Cu uptake by Zn or P treatments. Wheat yield was increased by copper application at one field site. Yield however, was repressed at double the recommended rate of soil Cu application. At another site soil copper was adequate and yield was repressed by copper application to soil and in most cases as spray application to leaves. It was also observed in the field, that soil applied copper sulphate inadvertently applied at twice the intended rate (20 kg $CuSO_4$/ha instead of 10 kg $CuSO_4$/ha), induced what appeared to be Fe-chlorosis in a strip where an overlap during application occurred.

In two Cu anomalies where maize was growing, soil EDTA-Cu levels above 300 mg/kg caused severe chlorosis and reduction in leaf and node size (compared to Fe or Mn deficiency) and suppressed leaf Mn below the sufficiency level of 20 mg Mn/kg.

CONCLUSIONS

Copper deficiency in maize grown on granite sands on farms and in pot and field experiments was the cause of discoloured, barren wheat heads without evidence of antagonism from zinc or phosphate. Copper toxicity in maize was confirmed on copper anomalies; Cu did not accumulate excessively in leaves but Mn deficiency was induced.

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Keywords: Copper, deficiency, maize, toxicity, wheat

GGE-BIPLOT ANALYSIS OF YIELD AND SELECTED EPIDEMIOLOGICAL PARAMETERS ASSOCIATED WITH NORTHERN CORN LEAF BLIGHT RESISTANCE IN MAIZE

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INTRODUCTION

Northern corn leaf blight (NCLB; causal organism *Exserohilum turcicum*) could result in yield reductions of 2-8% in maize for every 10% increase in disease severity (Pataky, 1992). Resistance is the most effective control measure. The study was conducted to establish whether GGE-biplot analysis (Yan *et al.,* 2000*)* could be utilised for evaluation of epidemiological parameter stability and whether stability for one or more epidemiological parameters could contribute to obtaining resistant genotypes with greater yield stability.

MATERIALS AND METHODS

Five trials were selected from NCLB resistance cultivar evaluation trials conducted over four seasons. Six genotypes were selected for analysis (five resistant and one susceptible). Trials were planted as randomized complete block designs with three replications each. Inoculations, assessments, total disease severity (y_t), standardised area under the disease progress curve (sAUDPC), we*ighted mean absolute* rate (ρ) and yield were evaluated and calculated according to Craven and Morey (2011). GGE biplot analysis was performed for y_t, ρ, sAUDPC and yield.

RESULTS AND DISCUSSION

The susceptible genotype obtained y_t that varied between 11.76% and 53.5% over environments. Stability for y_t, sAUDPC, ρ and yield varied between resistant genotypes. Genotypes that demonstrated sAUDPC stability were less stable in their yield as opposed to genotypes with stable ρ, which also demonstrated yield stability.

CONCLUSIONS

GGE biplot analysis indicated genotypes could be selected based on stability for y_t, sAUDPC, ρ and yield. Genotypes that demonstrated a stable ρ parameter also had stable yield, suggesting that screening genotypes for ρ stability in maize breeding programmes could contribute more to achieving yield stability that using either y_t or sAUDPC alone.

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Keywords: Exserohilum turcicum, resistance, maize, yield stability

THE BERG RIVER BASIN DRYLAND SALINITY AND LANDUSE

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INTRODUCTION

Research conducted over the past 8 years in the Berg River catchment led to a new understanding of the manner in which agricultural systems impact on the water resources of the region. Any change in the land use of the region has an impact on the salt balance of the region and ultimately the water in the Berg River (de Clercq *et al*., 2010).

MATERIALS AND METHODS

The research was conducted on at least 6 localities within the Berg River catchment of the Western Cape. Various soil forms were investigated in this research and the crop production systems were compared with renosterveld systems in terms of their differences in water related characteristics (de Clercq *et al*., 2010).

RESULTS AND DISCUSSION

A marked difference was found in the soil water responses between renosterveld and the adjacent wheat production systems. The renosterveld system had much faster infiltration of water and had a larger subsurface flow component. The conventional wheat production systems showed slow infiltration with a larger overland flow component. The investigated long term no-till sites however, showed soil water responses comparable to the renosterveld system. It was indicated that in the renosterveld system, the water table was much deeper than below the conventional wheat production system. It was consequently also indicated that the no-till systems had even shallower water tables. The large difference therefore between the renosterveld system and the wheat production systems, indicated larger water storage in the wheat systems during winter, water that were not consumed and caused saline seep through summer months, affecting the quality of water in nearby streams.

CONCLUSIONS

The renosterveld of this region stores salts and utilize the stored winter water to the maximum. Winter crop productions systems of the Berg River catchment on the other hand caused the system to store more water and not utilize this resource during spring and summer, which in turn caused enhanced levels of saline seep during summer months. By utilizing this excess winter water resource during early summer may therefore impact positively on the Berg River water quality. The utilization of this water furthermore provides a number of attractive possibilities for further conservation aimed agricultural and biodiversity solutions to the saline seep problem.

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ACKNOWLEDGEMENTS

The Water Research Commission for funding of the research and the Elsenburg Department of Agriculture for using their facilities.

Keywords: soil salinity, conservation no-till

EFFECT OF TILLAGE-INDUCED COMPACTION ON PHYSICAL PROPERTIES OF AGRICULTURAL LOAMY SOILS

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INTRODUCTION

Soil degradation and structural deterioration by mechanistic pressure enhanced compaction due to agricultural practices is a global concern. Tillage and its associated compaction induces changes to the physical properties with consequent effects on crop production. An adverse effect of surface soil compaction on soil physical properties were reported to result in increased soil bulk density, decreased total porosity and soil aeration (Kim *et al*., 2010) and decreased amount of water available to plants (Abu-Hamdeh, 2004). We carried out the study in agricultural soils under intense tillage operations to assess influence of tillage-enhanced compaction on physical properties.

MATERIALS AND METHODS

Phyical properties of soils including soil texture, bulk density, porosity, infiltration rate and soil water retention were determined for tilled and non tilled soils. Soil texture was measured using hydrometer method while the core method was used for soil bulk density. Soil water retention and infiltration rate was measured using pressure chamber and double ring infiltrometer, respectively.

RESULTS AND DISCUSSION

The results shows that both sites are characterised by loamy sands although the tilled soils has experienced soil compaction compared to non tilled soils. This was indicated by the high bulk density in the tilled soils (1.68-1.77 g/cm^3) while the non tilled had lower density (1.42-1.56 g/cm^3). This was manifested by reductions in porosity lower in tilled than non-till areas. The results also reveal that tillage influences the infiltration rate, for instance the non tilled soils had a higher mean rate (16.5 cm/h) than that of the tilled soils (7.5 cm/h) due to compaction thus decreasing the pore spaces with restriction of air and water movement. Decreased water content (WC) at field capacity and increased WC at permanent wilting point was attributable to reduction of the pores.

CONCLUSIONS

The tilled area was more severely affected by compaction than non-till area. Deterioration of soil structure integrity due to the inability of structure to withstand compaction was observed. This form of soil degradtion has implications on soil productivity and hence crop production.

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Keywords: compaction, physical properties, tillage, loamy soils

AN ALTERNATIVE VIEW OF THE NEOCUTANIC B HORIZON

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INTRODUCTION

The concept of the Neocutanic B-horizon is interpreted very differently between pedologists and soil surveyors. The differences in interpretation are especially evident between the allowed colour variation, structure and the presence of cutans in either yellow-brown and red apedal B horizons on the one hand, and Neocutanic B horizon on the other.

THE CURRENT CONCEPT

The basic concept is that of young soils developing in unconsolidated material, recently deposited as colluvial or alluvial or even aeolian material in which little pedogenesis has occurred. Enrichment with organic material as an A horizon and absence of depositional stratifications that may originally have been present, are the most prominent evidence of pedogenesis.

RECOMMENDATIONS

Recommendations of materials that should be included into Neocutanic B horizons:

- Mixed alluvial deposits lacking prominent stratification due to pedoturbation.
- Brown or dark coloured alluvial and colluvial material.
- Alluvial, colluvial and aeolian materials without an overall red or yellow-brown colour.
- Unconsolidated brown coloured aeolian material, with an identifiable A horizon.

Recommendations of materials that should be excluded from Neocutanic B horizons:

- Red or yellow-brown aeolian material in which, except for an increase of organic material, little pedogenesis has occurred.
- Material in which the transition from the A horizon to the B horizon is distinct or abrupt.
- Material with a prominent red or yellow-brown colour.
- Material in which redistribution and localisation of iron in the form of iron mottles and/or concretions occur in or immediately below the horizon.
- Soils which have formed *in situ* from parent rock.
- Transition horizons with colour variation between the A and B horizons.
- Colour variation due to deep cultivation.
- Red or yellow-brown apedal B horizons with colour variation due to filling of root or faunal channels.

PROPOSED DEFINITIONS TO BE ADDED

(i) Has structure that is weaker than moderate blocky or prismatic in the moist state.

(ii) Except for the case of red or yellow-brown unconsolidated colluvium or alluvium, does not have red or yellow-brown colours as defined for the red apedal B or yellow-brown colours as defined for the yellow-brown apedal B.

(iii) Has not undergone in the horizon itself or a horizon below it, localisation and accumulation of iron and manganese oxides under conditions of a fluctuating water table to give rise to reddish brown, yellowish brown and/or black mottles.

(iv) The transition from the A horizon to the B horizon is not distinct or abrupt.

(v) Additional text descriptions to the definitions of both the red and yellow-brown apedal B horizons distinguishing these horizons from the neocutanic B horizon.

Keywords: Neocutanic horizon, Soil classification

THE UNDERLYING PHYSIOLOGY OF THREE *Eucalyptus* CLONES IN RESPONSE TO DROUGHT STRESS

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INTRODUCTION

Research derived from an intensively managed dendrometer trial in northern KwaZulu-Natal has shown that the diameter and height of *Eucalyptus grandis x E. urophylla* (GU) and *E. grandis x E. camaldulensis* (GC) hybrid clones is higher in higher rainfall areas and that the GU clone also has a greater diameter than the GC clone (Drew *et al*., 2009). The aim of the current study was to investigate the impact of watering regime on the morphology (height, diameter and biomass) and physiology (photosynthetic capacity) of three *Eucalyptus* clonal hybrids.

MATERIALS AND METHODS

Eucalyptus plants of three clones (two GU clones and one GC clone) were grown in a randomised complete block (RCB) design in large (80 L) planting bags of river sand (0.15 m^3 m^{-3} FC) for 18 months. The plants were subjected to three watering regimes (termed control (100% of FC), chronic (50% of FC) and acute stress (75% of FC long-term) which were monitored using a soil moisture probe. A 3^3 factorial design was adopted and replicated 12 times. Height and diameter were measured monthly and biomass was determined at two harvest periods after 9 and 18 months growth (5 plants per treatment per harvest, at soil level). Photosynthetic characteristics (J_{max}, E, g_s) were assessed at 6, 12 and 18 months (seasonally) after planting. A two-way ANOVA determined significance at $p < 0.05$ was used for data analysis.

RESULTS AND DISCUSSION

Chronic and acute water stress significantly reduced tree diameter by up to 10% in all three eucalypt clones. In terms of wood productivity, GU clones out-competed the GC clones, and WUE of GU clones was 5-10% higher than that of GC clones. Photosynthetic capacity was significantly lowered by acute water stress but was not reduced in the long-term. Leaf area was significantly greater in GU clones (compared with GC) and under control water conditions.

CONCLUSIONS

Results suggested that eucalypt genotype is an important determinant of the extent to which biomass accumulation is affected by water stress, and that leaf area is a critical genotype characteristic. The severity and duration of water stress, and plant age, are also important factors influencing biomass accumulation of this commercially important tree species.

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Keywords: Drought stress, photosynthesis, *E. grandis* × *E.camaldulensis*, *E. grandis* × *E. urophylla*

SOME POTENTIAL FIELD METHODS TO ASSIST WITH THE CORRECT IDENTIFICATION OF SOIL MATERIAL AND DIAGNOSTIC HORIZONS IN FUTURE SOIL CLASSIFICATION PROCEDURES

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INTRODUCTION

The Soil Classification Working Group (SCWG) is currently in the process of updating Soil Classification: A Taxonomic System for South Africa (1991). One of the reasons why the "Blue Book" is the most successful and practical system in use in South Africa is that it largely makes use of properties that can be identified in the field. This paper gives a review of that field indicators/test presently in use but also of a few very promising ones that may help with correct identification of soil materials and diagnostic horizons that are currently difficult to identify (e.g. high carbon topsoils under different hydromorphic conditions) in the field.

MATERIAL AND METHODS

Soil properties (e.g. colour, texture, consistence and structure) that form part of a normal soil profile description were revisited. Simple soil chemical field tests such as the application of diluted HCl for test of free carbonates were extended by field tests for the identification of podzol B horizons [e.g. NaF test with pH paper of Brydon & Day (1970) and measuring pH in the laboratory as a control] on high carbon topsoils collected from a variety of wetlands, melanic A horizons, "classic" humic A horizons and other high carbon topsoils in lower lying positions in traditional humic landscapes that was difficult to classify in the field. The methyl orange field test was used to test for presence of sepiolite and petrosepiolite in certain arid soils. Strong adherence of a fragment to the wetted tongue was also used to test for sepiolite. By heating a small sample on a metal spoon with a gas blow lamp the colour change of high carbon topsoils were determined in the field.

RESULTS AND DISCUSSION

A review is given of those field tests that are currently applied in the definitions of diagnostic horizons/materials used in the Blue Book. According to Francis *et al*, (2007) the pinkish colour that develops after wetting with methyl orange to a sample that contains sepiolite is a diagnostic test. Strong adherence of a fragment to a moist tongue is further evidence of sepiolite. The NaF pH test (medium to strong purple colour development) is an effective field test to separate high carbon topsoils with high concentrations of reactive aluminium (e.g. humic A horizon).

CONCLUSIONS

The blow test seems to be an effective way in separating high Fe containing topsoils (e.g. "classic" humic A) from topsoils containing lower Fe (e.g. wetland topsoils). A positive NaF on pH test paper and a reddening or yellowing of soil material using the blow lamp is suggested to separate "classic" humic topsoils from other high carbon topsoils.

ACKNOWLEDGEMENTS

Keith Snyman for selection and supplying humic topsoil samples. ISCW for supplying some selected melanic topsoil samples. Mico Stander for NaF analysis on samples.

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Keywords: Field tests, soil classification, high carbon topsoil, sepiolite

SOIL SOLARISATION IS USEFUL FOR SMALL SCALE WEED CONTROL IN THE WESTERN CAPE

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INTRODUCTION

A**gri**cultural chemicals are the corner stone of successful large scale crop production as it is used by farmers for weed, pest and disease control. However, resistance to agricultural chemicals, rising production costs, environmental pollution and human health concerns, necessitates the development of new control methods for crop protection. Solarisation is a simple non-chemical technique that captures radiant heat energy from the sun under plastic mulches, leading to the control or suppression of soil borne fungi, insects, bacteria, nematodes and weeds. This method was evaluated over three seasons with the aim of testing its efficacy for weed control.

MATERIALS AND METHODS

After seedbed preparation at two localities, namely Atlantis and Helderstroom, and irrigating with 10 mm water, transparent plastic strips of 50 µ mm thickness and 30 m long by 2 m wide, with edges covered with soil in shallow furrows were used for treatments of four, five or six weeks.

RESULTS AND DISCUSSION

Solarisation for four weeks was ineffective as this period was insufficient for weed control. The average maximum daily temperature in plots solarised for five weeks at Atlantis, was 51.7 °C. Compared to the control, significantly lower numbers of weeds emerged within four weeks after solarisation. Weeds which did emerge from plots solarised for five weeks at Helderstroom, were *Emex australis* (spiny emex), *Polygonum aviculare* (prostrate knotweed), *Chenopodium album* (white goose foot) and *Brachiaria eruciformis* (sweet signal grass). At both localities, it was evident that average maximum temperatures in solarised soil at or above 50 °C, ensured a relatively weed free seedbed for four weeks following solarisation, provided no soil disturbance occurred.

CONCLUSIONS

Soil solarisation is an alternative weed control method which is especially useful for small scale crop production.

Keywords: small scale farmers, soil solarisation, weed control

AN OVERVIEW OF RESEARCH ON FUMONISIN-PRODUCING FUNGI OF MAIZE IN SOUTH AFRICA

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INTRODUCTION

Maize is a staple food, with local consumption as high as 500 g per person per day (Shephard, 2008). Two *Fusarium* spp. pathogenic to maize produce fumonisins that are carcinogenic to humans and toxic to animals (Thiel *et al.*, 1991). Our research on *F. verticillioides* compliments various projects to better understand variables involved in the colonization of maize kernels by the fungus and fumonisin production.

MATERIALS AND METHODS

Studies include environmental and host plant effects, as well as the role of the pathogen in disease development and fumonisin production.

RESULTS AND DISCUSSION

Fumonisins in maize samples from subsistence farmers ranged from 0-21.8 ppm. In commercial cultivar trials at 26 localities, maximum biomass of *F. verticillioides* ranged from 15.7-31.5 pg and fumonisin levels from 2.1-12.3 ppm in 2007-9. Colonization of commercial grain and fumonisin levels were related to prevailing weather conditions at certain maize development stages. In a resistance study mean visual symptoms of Fusarium ranged from 0.2-26.5% at different localities. Fumonisin levels ranged from 0.5-61.1 ppm. Lines are being tested over various sites to determine stability of resistance. *F. verticillioides* isolates are phylogenetically separated in two clades and each clade into three lineages. *F. verticillioides* isolates are divided into five groups according to fumonisin levels *viz.* >0-2 ppm, >2-5 ppm, >5-10 ppm, >10-20 ppm and >20 ppm.

CONCLUSIONS

Distribution, incidence and severity of Fusarium ear rot and production of fumonisins have been related to environmental factors, which helps identify risk areas. Sources of resistance have been identified. Understanding *F. verticillioides* population dynamics will determine the variation in pathogenicity and fumonisin production and may help explain variation in an epidemiological model.

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ACKNOWLEDGEMENTS

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Keywords: mycotoxins, *F. verticillioides*, *F. proliferatum*

EVALUATING PLANT GROWTH AND NITROGEN FIXATION IN PROMISCUOUS AND NON-PROMISCUOUS SOYBEAN GENOTYPES PLANTED IN MOZAMBIQUE

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INTRODUCTION

Promiscuous soybean genotypes have been bred at IITA to encourage their widespread cultivation and adoption by small holder resource-poor African farmers, and to improve grain yield without inoculation. However the ability of these genotypes to freely nodulate and fix atmospheric N_2 with indigenous rhizobia differed in some locations and showed inconsistent responses to commercial inoculants at other locations (Pule-Meulenberg *et al*. 2010). The aim of this study was to assess the response of these promiscuous-nodulating soybean genotypes to inoculation.

MATERIALS AND METHODS

Four promiscuous and three commercial soybean varieties were planted at two IITA experimental sites in Mozambique (Ruace and Mutequelesse) using a randomized complete block design with four replications. The soybean genotypes were either uninoculated or inoculated with a peat based *Bradyrhizobium japonicum* inoculant strain WB74. Plants were sampled at flowering and processed for the analysis of ^{15}N and ^{14}N isotopes using mass spectrometry. Data was analyzed using Statistica software program.

RESULTS AND DISCUSSION

Plant growth, $\delta^{15}N$, %Ndfa, N-fixed, soil mineral N uptake and N-removed differed significantly ($p \leq 0.05$) between inoculation and among soybean genotypes. Inoculating soybean genotypes significantly increased growth. Low $\delta^{15}N$ values found in this study indicated higher symbiotic dependence of soybean on symbiotic N_2 fixation for their N nutrition. The actual amounts of N- fixed ranged from 111 to 212 kg N ha^{-1} at both locations following inoculation. Irrespective of inoculation, soybean genotypes at Ruace showed better growth and symbiotic performance relative to those at Mutequelesse.

CONCLUSIONS

The promiscuous soybean genotypes responded positively to inoculation, though they have the potential to show high symbiotic performance in certain locations without inoculation.

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Keywords: $^{15}N/^{14}N$ isotopes, *Bradyrhizobium japonicum,* promiscuous soybean, symbiotic N_2 fixation

INDUCING GENETIC VARIATION ON SELECTED VERNONIA LINES USING PREDETERMINED ETHYL METHYL DOSAGE, TEMPERATURE REGIME AND EXPOSURE DURATION

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INTRODUCTION

Vernonia galamensis is an underexploited potential oilseed crop. Profitability in vernonia is hampered by non-uniform seed maturity, problem of shattering, and lack of appropriate technologies for mechanical harvesting, seed cleaning (threshing) and processing and oil extraction. Mutations of a single or few genes possessing target traits are invaluable in crop improvement programs (Kim *et al*., 2005). The use of ethyl methyl sulfonate in inducing mutation is advantageous as it is both effective and affordable. This study was conducted induce genetic variation using predetermined optimal treatment conditions and select for mutants for further development of selected *V. galamensis* lines.

MATERIALS AND METHODS

Seeds of two selected lines of vernonia (Vge-1and Vge-4) were treated using previously determined optimum mutagenesis conditions. Vge-1 was treated at 0.372% EMS dose for one hour at 35^{o}C while Vge-4 was treated at 0.372% EMS dose for two hours at 32.5 ^{o}C. The treated seeds were field planted at the Ukulinga Research Farm of the University of KwaZulu-Natal along with the untreated controls in a randomised block design. Data on days to emergence, germination percentage, days to head formation, number of chlorophyl mutants, percentage of mutants sterile, days to flowering, days to maturity, number of seeds per head, number of sterile plants, plant height, thousand seed weight and plot yield was recorded. Principal component analysis was conducted to determine the phenotypic traits that accounted for most of the variability in yield.

RESULTS AND DISCUSSION

Ethyl methyl treatment significantly affected all eleven agronomic traits. Treatment significantly delayed days to emergence, days to head formation, days to flowering and days to maturity for both lines. Treatment also significantly reduced germination percentage, number of seeds per head, number of fertile plants, plant height and plot yield for both Vge-1 and Vge-4. Thousand seed weight significantly increased in treated seeds of all two lines. Chlorophyl mutants were observed for all vernonia lines with high count of sterile plants. Principal component analysis revealed that days to emergence, days to heading, days to maturity, percentage of sterile plants, number of chlorophyll mutants and percentage of mutants sterile explained most of the variation in yield of vernonia

CONCLUSION

The ethyl methyl sulfonate treatments successfully induced mutation in vernonia. Selected chlorotic mutants will be used in further development and breeding research of vernonia

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Keywords: ethyl methyl, *Vernonia galamensis*

CHEMICAL DEGRADATION OF BIOCHAR

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INTRODUCTION

The oxidative stability of black carbon has led to the assumption that biochar is chemically and biologically inert to such an extent, that its mineralization rate was thought to be negligible (Goldberg, 1985). However, a few studies have reported on the ability of various basidiomycetes to liquefy coal. It is known that white-rot fungi are able to produce extracellular hydroxyl radicals (OH•) (Backa, et al. 1993), which are the strongest reactive oxygen species occurring in aqueous systems able to oxidise almost any organic material (Enoki*et al.* 1997).We hypothesized that hydrogen peroxide (H_2O_2) would be able to facilitate the progressive oxidation of biochar through the Fenton reaction pathway as biochar contains metal catalysts to produce OH•, similar to the action of lignocellulose-degrading enzymes.

MATERIALS AND METHODS

The biochar used in this study was produced from pine sawmill waste by slow-pyrolysis (450˚C). Different concentrations of H_2O_2 (0.333, 0.166, 0.083 and 0.042 M) were used. The H_2O_2 can be catalysed to various free radicals by transition metals such as Fe^{3+}/Fe^{2+}, Mn^{2+} and Cu^{2+} present in the matrix of the biochar. The biochar was assumed to be exposed to an OH•-producing system due to the pH range used and the metal catalysts present in the biochar. The biochar's elemental composition (% C, H, O, and N), surface chemistry (FT-IR spectra, surface acidity/basicity and pH) and intermediates released upon degradation were determined.

RESULTS AND DISCUSSION

The oxidation of the biochar with H_2O_2 resulted in an increase in the O content and a decrease in the H and C content possibly due to H abstraction and C mineralization through the oxidation of aliphatics, volatile organic carbons and cleavage of benzene rings. The increase in O content can mainly be attributed to hydroxylation and carboxylation reactions. We concluded that the aromatic components of the pine wood structure (lignin) were also the most recalcitrant during oxidation of biochar. The surface acidity of the biochar reached a saturation point. However, the pH of the biochar still decreased significantly and it was attributed to the release and removal of basic cations. Extensive oxidation of biochar resulted in the release of various short-chained carboxylic acids. It was found that maleic acid was the initial and primary product released from biochar oxidation.

CONCLUSIONS

Biochar is H_2O_2 degradable via hydroxylation and carboxylation reactions resulting in aromatic ring cleavage and the release of carboxylic acids. Basidiomycetes should therefore be able to degrade the highly aromatic structure of biochar.

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Keywords: biochar, degradation, fenton reaction, white-rot fungi

PROPERTIES ASSOCIATED WITH TRANSVERSAL SAND DUNES IN SOUTH AFRICA

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INTRODUCTION

A layer of wind-blown sand, known as Kalahari sand, covers an area of more than of 2.5 million km² (Schlegel et al., 1989) of Southern Africa. It stretches from South Africa northwards to the Republic of Congo and Gabon and eastwards from Angola and eastern Namibia to western Botswana, Zimbabwe and Zambia. During the dry periods of subsequent wetter and drier periods seif dunes form lateral with the wind direction. Smaller transversal dunes form perpendicular to the wind direction. A prominent topographic feature of the areas covered by sand is the presence of small shallow pans, especially in poorly drained or waterlogged localities. Larger, older and deep pans are present where the sand is absent or thin. Smaller or younger pans are present on thicker sand. During the last decade the technology in satellite derived information has exploded and information can be gathered in a way we only could have dreamt of even ten years ago.

MATERIALS AND METHODS

Geology maps and land type information was used to illustrate the distribution of wind-blown sand in the interior of South Africa with the aid of the ArcGIS program. RSTM data was used to create hillshade images of localized areas to illustrate the presence of transversal dunes, as well as the distribution of pans and water tables in localized areas in the North West Province. 3D images are used to illustrate the position of the pans and water tables in the landscape. Cross sections through localized areas of the dunes are used to illustrate accumulation of the sand on the paleo slopes. Information derived from available precision farming surveys, was used to illustrate some soil physical properties of the dunes in the landscape.

RESULTS

The wind direction in the interior of South Africa is north-north-west. Transversal dunes lie perpendicular to this wind direction. These sand dunes are typical approximately 200 to 400 m apart and vary in depth. In the Schweizer Reneke district these dunes are typically approximately two meter deep and 1.5 m in the Lichtenburg area. Trying to evaluate the position of water table and pans from two dimensional maps is not easy. By converting the landscape of selected areas into 3D images, it becomes clear that water tables and smaller pans occur on the lowest lying areas of break lines in the landscape. The distribution of the pans, in some instances, is arranged in a manner which resembles relict drainage lines.

CONCLUSIONS

Analysis of RSTM and other satellite-derived information like Google Earth can help to understand the distribution of sand dunes, pans and water tables in the landscape. Transversal dunes lie in a NNE to SSW direction in the landscape with regular intervals.

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Keywords: Sand dunes, pans, water tables, Satellite derived information

RESPONSE OF SELECTED SOYBEAN GENOTYPES TO DIFFERENT SILICON CONCENTRATIONS

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INTRODUCTION

Soybean (*Glycine max* L.), is one of the major staple crops globally. Unavailability of improved cultivars, low soil fertility, recurrent drought and disease and pests are among yield limiting factors in soybean. A study was conducted to determine the responses of soybean genotypes to silicon applications. Silicon is an element found naturally in soils and would thus have little or no impact on the ecosystem making it ideal to enhance crop productivity.

MATERIAL AND METHODS

Two independent controlled experiments were conducted at the University of KwaZulu-Natal during 2010. Ten previously selected genotypes established in plastic pots were subjected to an application of three silicon (potassium silicate [KSiaq]) concentrations (0, 200 and 250ppm) using a randomized complete block design. The silicon concentrations, as selected from the previous year's results, were applied twice weekly over a period of 4 months. Data collected included number of days to 50% flowering, number of days to 50% maturity, plant height, number of pods per plant, number of seeds per pod, 100 seed weight, root mass, shoot mass, seed yield and harvest index. Data were subjected to the standard analysis of variance and principal component analysis using Gensat statistical program.

RESULTS AND DISCUSSION

There were significant interactions amongst genotype by silicon concentration for all the measured traits in both experiments. Silicon (Si) applied at 200 ppm was on average more effective in the growth and seed yield of the selected soybean genotypes than 250 ppm and 0 ppm Si and resulted in high harvest indices. The genotypes that produced the highest seed yield and harvest index in both experiments were Williams and Barc-2 at 200ppm Si. These genotypes produced a seed yield of 1.42 g/pot and 1.98 g/pot, respectively. Results from principal analysis (PCA) revealed high harvest index and seed yields for the 10 soybean genotypes used were generally associated with high plant height, number of pods per plant and 100 seed weight.

CONCLUSIONS

The use of silicon at 200 ppm may be effective in increasing the harvest index and seed yield as well as other agronomic traits in soybean. Genotypes Williams at 200 ppm Si and Barc-2 at 200 ppm Si performed the best compared to other tested soybean genotypes in many of the agronomic traits.

Keywords: Glycine max, harvest index, principle component analysis, silicon.

AN EPIDEMIOLOGICAL MODEL FOR FUMONISIN-PRODUCING *Fusarium* SPECIES ON MAIZE

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INTRODUCTION

Fumonisins are mycotoxins produced by *Fusarium verticillioides* and *F. proliferatum* and are carcinogenic metabolites occurring almost everywhere on various commodities (Plancinta *et al*., 1999). A disease prediction model to monitor and assess the risk of fumonisin contamination in maize grain could aid agronomic decisions during production and reduce risk of crop infection by *Fusarium* spp. (Schaafsma & Hooker, 2007).

MATERIALS AND METHODS

Maize grain samples were collected from 16 cultivar trials (2007-2009) at different localities in the local production areas. Grain colonization by *Fusarium* spp. and contamination with fumonisins were determined using real-time PCR and HPLC, respectively. Clusters of significant relationships between weather variables and *Fusarium* biomass were determined. Mean maximum temperature and minimum humidity had significant relationships with *Fusarium* colonization of maize grain. The non-linear, three-dimensional Lorentzian equation (Sigmaplot 10.0) was used to re-analyse these selected variables.

RESULTS AND DISCUSSION

Fusarium colonization of grain and fumonisin levels were related to weather conditions during early post-flowering and grain development stages, respectively. Colonization was significantly related to mean maximum temperature and minimum relative humidity during the early post-silking period (R^2>0.83), while fumonisin production was related to level of fungal colonization and mean maximum temperature during the dough stage (R^2>0.89).

CONCLUSIONS

The study is continuous and further data are needed to evaluate the prediction model. Testing under field conditions to determine the forecasting potential of the model is also required. The current model is based on an assumption that pathogen inoculum is present. Pathogen survival and spread parameters may need to be included in field calibration.

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ACKNOWLEDGEMENTS

The Maize Trust and ARC- GCI for funding of this research.

Keywords: environment, fumonisin, *Fusarium* spp., maize.

HUMAN-INDUCED SALINIZATION IN THE BERG RIVER CATCHMENT: MECHANISMS AND PROCESSES

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INTRODUCTION

The Berg river is a major source of water for the City of Cape Town and West Coast District Municipality, irrigated agriculture and the industries of Saldanha. The Department of Water Affairs has found increasing trends in salinity in the Berg river since the mid 1970's. Natural dryland salinity (predominantly NaCl salts trapped in Proterozoic Malmesbury shale sediments) has been identified as the source of some of the salts causing an increase in river salinity. The aim of this paper is to discuss the mechanisms and processes of dryland salinity based on 8 years of research in the Berg River catchment.

MATERIALS AND METHODS

The research approach included three intensive monitoring sites: i) Langgewens experimental station where the water and salt balances of different crop rotations were investigated; ii) Goedertrou small scale catchment where hydrosalinity fluxes were quantified; and iii) Voëlvlei Nature Reserve where evapotranspiration of endemic renosterveld vegetation was compared to an adjacent wheat field. The results obtained from the intensive monitoring sites served to inform hydrological modelling of salinity in the Sandspruit river, a seasonal tributary of the Berg river, which was identified to be particularly saline (maximum electrical conductivity EC ~ 2,000 mS m^{-1} at the end of the rainy season).

RESULTS AND DISCUSSION

Concentration of meteoric salts through evapotranspiration resulted in a gradient in groundwater salinity that was inversely related to annual rainfall (groundwater quality becomes increasingly saline from the recharge area at the top of the Berg River basin towards the bottom, semi-arid area of the basin). Salts accumulated in bulges in the regolith above groundwater, flushed downwards by infiltration and recharge, and transported upwards from the groundwater table by capillary rise. Seasonal perched water tables occur at the interface between the soil mantle and the Malmesbury shale, which has low hydraulic conductivity. Different land uses (e.g. indigenous vegetation, crop rotations etc.) affect greatly the water and salt balance of the system. Groundwater monitoring showed that groundwater tables in annual crop systems are likely to rise, mobilize salts trapped in the regolith and enhance salt discharge. Hydrological modelling was used to develop land use and management systems that would reduce salt loads in the Berg River.

CONCLUSIONS

The results of field investigations and hydrological modelling yielded new insights into the origin of salts and the behaviour of the system. These findings will be used to develop guidelines for regulating land use to reduce the risk of mobilising and transporting salts to the river.

ACKNOWLEDGEMENTS

Water Research Commission for funding and Friedrich Schiller University of Jena (Germany) for hydrological modelling support.

Keywords: Berg River, dryland salinity, hydrological modelling, land use, semi-arid climate

THE EAU4FOOD PROJECT: INNOVATION PROCESS AND PROBLEM DIAGNOSTICS

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INTRODUCTION

African agricultural productivity cannot keep up with population growth. At the same time, fresh water and soil resources continue to degrade. The EAU4Food project (European Union and African Union cooperative research to increase food production in irrigated farming systems in Africa) seeks to address these challenges. The aim of this paper is to present the innovation process of this research project, and the participatory approach adopted to identify constraints and opportunities in African irrigated farming systems.

INNOVATION PROCESS

EAU4Food is being executed in four irrigated zones in Africa (Mozambique and South Africa, Tunisia, Mali and Ethiopia) for comparative purposes. Many previous attempts to improve food production in irrigated areas resulted in poor uptake of scientific knowledge and technologies. EAU4Food utilizes a trans-disciplinary approach to involve stakeholders through the establishment of learning practice alliances (LPAs) and communities of practice (CoPs). Constraints and problems in irrigated crop production are first being identified, followed by opportunities and potential solutions. A list of potential innovations (institutional, irrigation management and technologies, soil fertility and management, agronomic, socio-economic) is presented to stakeholders (LPA) and practitioners (CoP). Existing or new innovations are then co-developed with practitioners to facilitate uptake, implemented and evaluated through monitoring of bio-physical and socio-economic indicators. Sustainable production thresholds are defined as upper limits to which a production factor can be increased without detrimental effects to the wider environmental system.

PROBLEM DIAGNOSTICS

The first phase of the research deals with problem diagnostics. The collection of baseline information, the dynamics and lessons learned from the establishment of LPAs and CoPs, the participatory identification of constraints and opportunities are discussed. One of the main problems identified at an emerging South African irrigation scheme was water shortage, due to competition for water and water allocation priorities. The importance of a holistic approach, farmers' participation, crop diversification to increase system resilience and mechanisms for market access are also stressed.

CONCLUSIONS

The trans-disciplinary co-development of innovations and capacity building programmes in EAU4Food are expected to have significant positive impacts on African agricultural production at farm level, and on policy processes at national and trans-national levels.

ACKNOWLEDGEMENTS

European Commission Framework Programme 7, Department of Science and Technology and CSIR for funding the research.

Keywords: Food security, irrigation management, soil fertility, trans-disciplinary approach

EXTRACELLULAR SECRETION OF LUMICHROME, RIBOFLAVIN AND INDOLE ACETIC ACID OF *Psoralea* NODULE BACTERIA IS ALTERED BY PHOSPHOROUS AND NITROGEN NUTRITION

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INTRODUCTION

Soils of the Cape fynbos in South Africa are very low in nutrients, especially P and N, which affect bacterial growth and metabolism. Strains isolated from root nodules of *Psoralea* species (Tribe Psoraleae, Family Leguminosae) have been reported to differ in their synthesis and extracellular release of some metabolites in response to soil factors such as pH, temperature and salinity (Kanu & Dakora, 2009). However, nothing is known about their response to mineral nutrition. Therefore, the aim of this study was to determine the effects of P and N as nitrate (NO_3^-) or ammonium (NH_4^+), on the synthesis and release of lumichrome, riboflavin and IAA by bacteria isolated from *Psoralea* root nodules.

MATERIALS AND METHODS

Eight young *Psoralea* plants were harvested from six study sites in the Cape Floristic Region of South Africa in 2005. Sixteen bacterial isolates from root nodules of *Psoralea* species were used and the bacterial growth media was prepared as described by Phillips *et al.* (1999) for quantifying lumichrome and riboflavin. Extraction, quantification of lumichrome and riboflavin, and bioassay for IAA production in bacterial culture filtrate were all done as described by Kanu and Dakora (2009).

RESULTS AND DISCUSSION

The data revealed marked variation in the secretion of lumichrome, riboflavin and IAA into culture filtrate. There was generally greater production of lumichrome, riboflavin and IAA by some strains compared to others, with much greater concentrations of lumichrome and riboflavin in culture filtrate at high P than low P. At low and high P, symbiotic strain TUT57pp produced 2.2-fold and 3.2-fold more IAA than TUT65prp and TUT33pap, respectively (also with greater IAA production). Although ammonium nutrition has no effect on riboflavin production, it altered lumichrome concentrations in culture filtrate. While ammonium feeding had no effect, supplying bacterial cells with high nitrate concentration significantly decreased bacterial production of lumichrome and riboflavin, two important symbiotic signal molecules. This negative effect of nitrate on the formation and release of lumichrome and riboflavin as symbiotic signals is in addition to its inhibition of nodulation and N_2 fixation in nodulating legumes.

CONCLUSIONS

Phosphorus and nitrate nutrition can alter the extracellular secretion of lumichrome, riboflavin and IAA into culture filtrate by *Psoralea* bacterial strains. These symbiotic signal molecules are major players in the rhizosphere of plants hosting bacterial interactions.

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Keywords: P & Nutrition, lumichrome, riboflavin, Cape fynbos

INFLUENCE OF SOIL TEXTURE, WATER MANAGEMENT AND NITROGEN FERTILIZER ON BIOMASS PRODUCTION AND ANTIMICROBIAL PROPERTIES OF *Mentha longifolia* L

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INTRODUCTION

It has been documented over a decade ago, that there has been a growing realization of the importance of traditional herbs. The use of indigenous herbs has remained a more feasible option due to affordability. Unfortunately, there is a clear decline in these herbs due to over-harvesting of wild resources; therefore, cultivation of these herbs is necessary to guarantee a continuing supply. The aim of this research was to determine the optimum cultivation conditions for obtaining maximum biomass production and antimicrobial activity of the widely-used, indigenous herb, *Mentha longifolia L.*

MATERIALS AND METHODS

In this research, we employed a two-way factorial experiment produced by 3 X 3 X 4 factors, viz. three different soil textures (loam, sandy loam and loamy sand soil) and three levels of irrigation water in trial 1 (0 %, 50 % and 90 % depletion of Plant Available Water [PAW]) and three levels of fertilizer N in trial 2 (0 kg ha^{-1}, 150 kg ha^{-1} and 250 kg ha^{-1} fertilizer N) replicated four times. The pot-trial experiment conducted using fertigation in a greenhouse tunnel. The biomass yield and antimicrobial activity (*Staphylococcus aureus*) of the dried leaves were determined.

RESULTS AND DISCUSSION

From trial 1, 0 % depletion of PAW treatments produced high biomass whereas 50 % and 90 % depletion matched each other at lower biomass production. Sufficient irrigation was beneficial for improving biomass production. Appreciable biomass was obtained from loamy sand followed by loam and sandy loam. From trial 2, significant biomass production was highest, intermediate and low from 250 kg ha^{-1}, 150 kg ha^{-1} and 0 kg ha^{-1} of fertilizer N, respectively. *Mentha longifolia* L revealed a minimal inhibition reaction against Staphylococcus aureus under MIC assay.

CONCLUSIONS

It is inferred and deduced that 0 % depletion of PAW on loamy sand fertilized at 250 kg ha^{-1} of fertilizer N could produce an outstanding biomass to alleviate over-harvesting done by collecting the herbs from the wild, thereby ensuring accessibility, sustainable utilization and conservation of cultivated and wild *Mentha*. *Mentha longifolia* L has minimal inhibition properties against *Staphylococcus aureus*.

Keywords: Peppermint, nitrogen, texture, water management

WHAT HAVE WE LEARNED FROM THE CASE OF RESISTANCE DEVELOPMENT OF *Busseola fusca* TO Bt MAIZE IN SOUTH AFRICA?

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INTRODUCTION

Since the first deployment of Bt crops there has been concern with regard to resistance development of target pests. Insect resistance management (IRM) strategies were developed and until recently proved effective. The large scale use of Bt crops puts considerable selection pressure on target species. Based on experiences with development of resistance by the African stem borer (*Busseola fusca*) to Bt maize (MON810), the following aspects are addressed: lessons learned; how to detect resistance in target pests; how to monitor for resistance; requirements for successful detection and monitoring.

Lessons learned

Resistance development of *B. fusca* was rapid and appeared within nine years after the first deployment. The compliance to refugia requirements was low, especially during the first 5 – 7 years after release of Bt maize (Kruger *et al*., 2009). Collaboration between farmers, seed companies and research/extension services is needed to develop methods to delay resistance development (Kruger *et al*., 2011). Furthermore stewardship programs are very important and were instituted by private industry and contributed significantly to improved management of GM technology.

How to detect resistance in target pests

Several complimentary methods should be used and could include: 1) Field surveys to assess unexpected damage on Bt maize and farmer reports of damage, 2) Confirmation of resistance should be done in controlled trials (laboratory and greenhouse studies) and additional important information should be collected on fitness costs through comparative studies on life history parameters.

Requirements for successful detection and monitoring

For successful detection and monitoring the development and spread of resistance infrastructure and skilled personal are required with knowledge on protocols for rearing insects, resistance evaluation and farmer surveys.

CONCLUSIONS

Seed and chemical companies as well as farmers should work together to make resistance monitoring and the IRM strategy work in order to experience economical advantages of GM crops and prolong the usefulness of biotechnology.

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Keywords: Insect resistance management, resistance evaluation, stewardship programs

HYDRAULIC PROPERTIES OF THE DIAGNOSTIC SOIL HORIZONS OF THE TWO STREAMS CATCHMENT

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INTRODUCTION

Soil plays an important role in the natural and agro-ecosystem. Hydraulic properties of diagnostic soil horizons differ. Arranged in a profile, they provide information about soil hydrology valuable for irrigation management and environmental studies. In catchment hydrology the hydraulic properties of horizons control flow paths and residence times of components of flow making up stream discharge. These properties are measured in the field and laboratory to parameterise hydrological models.

MATERIALS AND METHODS

In situ and laboratory measurements of hydraulic properties were made of the 5 horizons i.e. orthic A, yellow brown apedal B, red apedal B, neocutanic B, and organic O with clay content of 24, 28, 30, 28 and 32% respectively, of six profiles (Griffin, Hutton, Clovelly, Oakleaf, Pinedene and Champagne) representing the soils of the forested catchment. In the field a double ring and tensionin filtrometer were used to measure vertical saturated and unsaturated hydraulic conductivities. Core samples taken at each diagnostic horizon were subjected to the hanging water column and pressure plate techniques to measure the soil water retention (θ/*h*) curves. The (θ/*h*)data were processed using the RETC program to provide the parameters for the Mualem's and van Genuchten's model (van Genuchten *et al*., 1991), which was then used together with the field determined hydraulic conductivity (K) data to determine an unsaturated hydraulic conductivity (K*h*) curve for each horizon.

RESULTS AND DISCUSSION

The water retention curves of orthic A and organic O horizons differ. The organic O horizon exhibited a more rapid reduction in water content as tension increased. No significant differences were showed in the yellow brown apedal, red apedal B horizons and neocutanic B. For all measured sites, K*s* was generally greater for diagnostic B horizons than A horizons. The overall K*h* curves showed that K was greater in the B horizons than in A the horizons. This is due to water repellency prevalent in top horizons of soils beneath wattle trees (*Acacia* species) (Scott, 2000). These results indicate that similar hydrological response would be expected in the B horizons of Two Streams soils.

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Keywords: saturated hydraulic conductivity, saturated water content, water retention curves

CHEMICAL CHARACTERIZATION OF CATTLE AND GOAT MANURE-BASED PHOSPHO-COMPOSTS

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INTRODUCTION

Phosphorus (P) is unique among major plant nutrients due to its role in plant nutrition. However, reports of its widespread deficiency especially on smallholder farmlands are well documented (Mills and Fey, 2003; Mandiringana et al., 2005; Kutu, 2008). Unlike nitrogen, correction of P deficiency problem on farmlands is solely through an expensive P fertilization programme. The co-composting of non-reactive ground phosphate rock (GPR) typical of South Africa's Phalaborwa phosphate rock has been documented elsewhere as cheaper P-source in under-resourced communities (Sekhar and Aery, 2001; Sarr et al., 2009). Intrinsic chemical indices govern mineralization and P release patterns from different phospho-composts produced.

MATERIALS AND METHODS

Eight different phospho-composts were produced from cattle and goat manure-based organic materials using Phalaborwa GPR (36.5% P_2O_5). The ground rock was separately mixed with the wastes at ratios 7:3, 8:2, 9:1 and 1:1 (dry weight basis) and left in heaps outdoors on paved ground. Turning and water addition was done every two weeks. Moisture content of the composts was maintained below the water-holding capacity throughout the composting period. The thermophilic aerobic composting process was terminated after 4 months following curing. Samples of the phospho-composts and control (composts without GPR) were taken to the laboratory for detailed chemical characterization using standard procedures.

RESULTS AND DISCUSSION

The total P content of the phospho-composts increased with increasing proportion of GPR addition. The reverse was the case with the total N content. The content of total P ranged from 0.435 to 4.373% in cattle manure-based phospho-composts but varied between 2.514 and 4.779% in the goat manure-based phospho-composts. The lignin, cellulose and tannin contents for the various phospho-composts produced using both organic wastes were reduced after the co-composting process. The polyphenol content was reduced by up to 40% in cattle manure-based phospho-compost mixed at ratio 8:2 while in goat manure-based phospho-composts it was reduced by approximately14% and 32% in only 9:1 and 1:1 mix ratios, respectively.

CONCLUSIONS

Studies are on-going to determine the mineralization rates, P release patterns and quantification of bioavailability of P from these phospho-composts.

ACKNOWLEDGEMENTS

The project is been funded by National Research Foundation (Grant No 76215).

Keywords: Mineralization indices, organic wastes, P availability, phosphate rock, phospho-composts

SHORT TERM EFFECTS OF SOIL TILLAGE AND CROP ROTATION ON THE PRODUCTION POTENTIAL OF WHEAT ON SHALE DERIVED SOILS OF THE WESTERN CAPE

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INTRODUCTION

Tillage practice and crop rotation can be regarded as two important factors that influence sustainability of crop production. The aim of this study was to quantify the effect of tillage practice and crop rotation on wheat productivity during the wheat phases of the study.

MATERIALS AND METHODS

A long-term tillage/crop rotation trial was started in 2007 on the Langgewens Research Farm near Moorreesburg. Three crop rotations, continuous wheat (WWWW), wheat/medic/wheat/medic (WMcWMc) and wheat/canola/wheat/lupin (WCWL) were allocated to main plots replicated four times. Each main plot was subdivided into four sub-plots allocated to four tillage treatments namely zero till – soil left undisturbed, no-till – soil left undisturbed until planting and then planted with a tined planter, minimum till – soil scarified March/April and then planted with the no-till planter and conventional tillage – soil scarified late March/early April, then ploughed and planted with the no-till planter. Data recorded during the 2007-10 seasons are covered in this presentation. Due to difficulties with weed infestation (ryegrass) the zero-till data were omitted.

RESULTS AND DISCUSSION

No differences (P=0.05) in biomass production, grain yield and protein content were reported for the 2008 wheat production season at Tygerhoek. During 2009 the no-till treatment resulted in higher (P=0.05) mean wheat biomass (12587 kg ha^{-1}) compared to the minimum till treatment (11774 kg ha^{-1}). The no-till treatment in the LWCW (wheat after canola) system resulted in higher grain production (3332 kg ha^{-1}) compared to the minimum till treatment (2663 kg ha^{-1}) whilst no differences were recorded for grain protein content. The only difference recorded for 2010 was higher (P=0.05) grain yield (1307 kg ha^{-1}) for the conventional tilled treatment compared to the no- (951 kg ha^{-1}) and minimum till (912 kg ha^{-1}) treatments in the WWWW system. At Langgewens, biomass was not influenced (P=0.05) by treatment combinations in 2008. In the McWMcW system higher grain yields were recorded for the no-till treatment (5270 kg ha^{-1}) compared to the conventional treatment (4226 kg ha^{-1}). During 2009 biomass and grain yield were influenced by tillage practices only in the LWCW system. During 2010 biomass production was higher in the no-till (8883 kg ha^{-1}) compared to the conventional till treatments (7650 kg ha^{-1}) in the McWMcW system. Except for the LWCW system, no-till resulted in higher yields compared to the conventional systems. No differences in protein content were observed.

CONCLUSIONS

No definite trend regarding the effect of tillage and crop rotation was noted. The extra tillage operations in the minimum and conventional tillage treatments did not contribute to higher wheat yields and grain quality.

Keywords: crop rotation, soil tillage, wheat

RESPONSE OF WHEAT (*Triticum aestivum* L.) TO DIFFERENTIAL NITROGEN FERTILISER APPLICATION AND PREVIOUS CROP UNDER RAINFED CONDITIONS IN THE SWARTLAND SUB-REGION OF THE WESTERN CAPE

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INTRODUCTION

Inexplicable differences in wheat yields in long-term crop rotation system trials were observed. Seasonal variation in climatic conditions, the previous crop and the resultant effect on N mineralisation rate may have contributed to these observed differences. The aim of this study was to quantify the effect of fertiliser N management strategies as influenced by previous crops on wheat yield and grain quality.

MATERIALS AND METHODS

A trial was laid out at the Langgewens Research Farm near Moorreesburg to evaluate the effect of previous crops and differential nitrogen applications on wheat production and grain quality. The trial was laid out as a factorial arranged in a split plot design with previous crops (wheat, canola or medic) allocated to main plots and N treatments to sub-plots. Nitrogen fertiliser treatments were, either 0 or 30 kg N ha^{-1} at planting followed by various combinations of 0, 30 or 60 kg N ha^{-1}, 30 and/or 60 days after emergence. Fertiliser application rate was calculated as the sum of nitrogen applied during the growing season. Data were pooled as 0, 30, 60, 90 and 120 kg N ha^{-1}. For example, the 60 kg N ha^{-1} therefore included the 0 30 30, 0 60 0 and 30 30 0 treatment combinations.

RESULTS AND DISCUSSION

Although grain yields for the wheat (W) after medic (Mc) (McWMcW system) varied between 4803.0 and 5475.6 kg ha^{-1}(2008), 3092.7 and 3870.7 kg ha^{-1} (2009) and 3633.8 and 4099.3 kg ha^{-1} (2010), no differences (P=0.05) due to the effect of nitrogen application rate were recorded. Except for the 0 and 30 kg N ha^{-1} treatments in 2009 and 0 kg N ha^{-1} in 2010 for the wheat after canola (C) (WWCW system), that resulted in significantly lower yields, no differences in yield were obtained due to the different nitrogen rates tested. In the wheat after wheat (WWWW system), significantly lower yields were recorded at the 0 and 30 kg ha^{-1} application rates during 2008 and 30 kg N ha^{-1} rate in both 2009 and 2010. The protein content of grain produced in the McWMcW system was sufficient for most N treatments to qualify for B1 grading, the only exception being 2009 at 0 kg N ha^{-1}. Differences in grain protein content in the WWCW system were only recorded in the 2009 season with 90 and 120 kg N ha^{-1} producing grain with a higher (P=0.05) protein content compared to the other nitrogen treatments tested. In the WWWW system, 0, 30 and 60 kg N ha^{-1} resulted in very low levels of grain protein content that caused downgrading to B2 and lower quality grades.

CONCLUSIONS

Wheat that followed medic or canola produced higher grain yields compared to wheat a monoculture system and were more subjected to downgrading as a result of low grain protein content.

Keywords: grain quality, nitrogen, wheat

CHARACTERISATION AND CLASSIFICATION OF HYDROLOGICAL SOILSCAPES OF SOUTH AFRICA

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INTRODUCTION

Water distribution in the landscape is uneven ranging from freely drained upland, recharge, oxidised and acidic soils; periodically saturated midslope, interflow, redox and variable acid soils and waterlogged wetland, saturation excess responsive, reduced and less acidic soils. These hydrological soil types are topographically linked in a soilscape (hydrosequence, catena or toposequence). The hydrological nature of the soils is interrelated to soil properties including morphology used in soil classification and surveys. The variation in soil water regime is a window to the interaction between the upper and lower vadose zones. Systematic redistribution system implies that systematic hillslope mechanisms in the soil and fractured rock (factors) are controlling processes (flowpaths and storage mechanisms in the soil and fractured rock) which leave very specific signatures in the soil as properties. Therefore, soil maps based on these properties can form the basis for setting up hydrological models for prediction of the hydrological behaviour of catchments.

METHODOLOGY

Soilscapes (48) on varying geology and in climates varying from arid to sub-humid were surveyed as part of several projects. Soil properties (chemical, water regime and drainage) indicative of control mechanisms, flowpaths and storage mechanisms correlated well with soil and terrain morphology. Conceptual soilscape hydrological response models were developed, characterised and classified according to their measured and inferred hydrological characteristics.

RESULTS AND DISCUSSION

The relationship of soil properties to hydrology is useful to infer soilscape hydrology as it fit measured data. These soil properties include non-diagnostic properties (lime and base saturation), diagnostic horizons (E and G) and soil forms (Hutton, Cartref). The soilscapes are hydrologically grouped as i) soil flow dominant, ii) fractured rock flow dominant and iii) interactive soil/fractured rock flow. Conceptually group i) soilscapes contributes largely to hydrograph shoulder flow, group ii) more to hydrograph baseflow and group iii) to shoulder and to baseflow.

CONCLUSION

Hydrological response can be predicted from soil surveys done with the SA soil classification system. Soil maps can contribute significantly to the design of the hydrological response models and predictions in ungauged basins where models cannot be calibrated.

Keywords: Hillslope hydrology, hydropedology, soil forms, prediction in ungauged basins.

EFFECTS OF DIFFERENT CONTROL STRATEGIES FOR RUSSIAN WHEAT APHID, *Diuraphis noxia* ON GRAIN YIELD AND QUALITY OF DRYLAND WHEAT

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INTRODUCTION

Russian wheat aphid (RWA) biotype development poses a direct threat to dryland wheat production in the summer rainfall region. The potential impact and severity of losses require effective control strategies. With the objective of monitoring effects of seed dressing, foliar insecticide and host plant resistance on grain yield and baking quality, field trials were conducted in the eastern Free State.

MATERIAL AND METHODS

Field trials designed as split-split plots with four replications were established at Bethlehem and Reitz. Animidacloprid seed-dressing, foliar-application of chlorpyriphos, a combination of both strategies and an untreated check were applied in Matlabas (RWASA1 resistant), Gariep (RWASA1 resistant), Betta (RWA susceptible), PAN 3144 (RWASA2 resistant), PAN 3368 (RWASA2 resistant) and PAN 3118 (RWA susceptible).

RESULTS AND DISCUSSIONS

Infestation in untreated Betta at both sites exceeded the economic threshold for dryland wheat (46.6% at ARC-SGI and 81.5% at Weltevrede). Analysis of variance indicates that cultivar x treatment method influenced protein content at both Bethlehem and Reitz. At Bethlehem protein of Matlabas increased significantly through application of imidacloprid + chlorpyriphos and chlorpyriphos but protein of Gariep and PAN 3118 treated with imidacloprid was significantly lower than all the remaining treatments. Untreated PAN 3144 and PAN 3368 had significantly higher protein compared to imidacloprid + chlorpyriphos or chlorpyriphos. At Reitz conditions were conducive for crop development and treatments aided protein in Gariep and PAN 3118. Protein of untreated or imidacloprid-treated Gariep was significantly more than for imidacloprid + chlorpyriphos or chlorpyriphos treated Gariep. Protein of untreated PAN 3118 was higher than PAN 3118 treated with imidaclopridor chlorpyriphos. Data for 2005 to 2010 indicate grain yield was least influenced by chemical control and 46.7% of all Cultivar, Treatments and Cultivar x Treatment effects were significant. Chemical control in susceptible cultivars significantly increased hectoliter mass and may be associated with the presence of host plant resistance (86.7%). Protein content was influenced regularly by chemical control (58.3%) although the effects often had a negative impact on protein (20% for RWA susceptible cultivars).

CONCLUSIONS

The various reactions of the different control strategies warrants further research as it potentially can contribute towards better understanding of wheat–RWA interactions and provide insight on validity of the claims that adult host plant resistance exist in wheat against RWA.

Keywords: Triticum aestivum, dryland wheat, Russian wheat aphid, *Diuraphis noxia*, chemical control

CANOLA SEED QUALITY VARIATION IN RESPONSE TO TEMPERATURE CHANGE IN THE WESTERN CAPE

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INTRODUCTION

Canola (*Brassica napus*) is an important oil seed crop in the winter rain-fed cereal crop rotation systems in the Western Cape. Due to future expected weather changes, the focus of this study is to examine the relationship between temperature and the performance of canola in terms of seed quality (Johnston & Hewitson, 2009). Gunasekera *et al*. (2006) found in an Australian study a decrease in oil content of 0.27% for every 1ºC increase in mean post-50% flower temperature.

MATERIALS AND METHODS

Correlation analyses of canola seed quality components and corresponding temperature data during the growing period were done for data collected over five years at two sites, i.e., Langewens in the Swartland and Tygerhoek in the southern Cape under rain-fed conditions. Performance and quality data of the various canola cultivars were divided according to the period (days) from sowing till flowering, i.e. early and medium developmental groupings. Temperature data (maximum, mean, minimum) during the first 60 days following 50% flowering were used to determine its impact on oil and protein content of the two developmental groups.

RESULTS AND DISCUSSION

Oil content of cultivar groups did not differ across localities. At both localities, the oil- and protein content were affected by daily minimum temperature. A decline in oil content of between 1.01% to 1.85% was observed for every 1°C increase in the minimum temperature over the period for both locations. In the Swartland the protein content increased with 0.92% to 0.99% for every 1°C increase in the maximum temperature, whilst no such response was observed for the southern Cape.

CONCLUSIONS

Increasing minimum temperatures during the 60 day period following 50% flowering in canola crops will have a significant effect on the reduction of the oil content in the seed, in the Western Cape.

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Keywords: canola, oil, protein, temperature

BIOCHAR INCREASES RETENTION, AVAILABILITY AND UPTAKE OF PHOSPHORUS TO WHEAT CROPS UNDER LEACHING CONDITIONS

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INTRODUCTION

Phosphorus (P) fertilizers have long been applied to soils to enhance food production. However, due to high levels of P applied, leaching is experienced on coarse-textured soils which results in pollution of waterways and unavailability to plants. Biochar has been proposed as a soil amendment which will improve soil fertility and reduce leaching. Biochar is a product of pyrolysis of plant or animal feedstock in the absence of oxygen. Biochar can provide the required alternative to minimize P leaching while still enabling sufficient P availability to crops. We therefore hypothesised that biochar would a) increase P uptake and growth of plants b) decrease P leaching and c) increase arbuscular mycorrhizal fungi (AMF) colonisation of wheat roots.

MATERIALS AND METHODS

A glasshouse lysimeter leaching experiment was conducted to assess these hypotheses on wheat (*Triticum aestivum* L. var. Wyalkatchem). A factorial randomized block experiment was designed where two types of biochar (chicken manure biochar; CMB and wheat chaff biochar; WCB) with rates of 0, 10 and 20 t/ha and three P fertilizer rates of 0, 25 and 50 kg/ha were applied to a coarse-textured soil. Leaching events were conducted over a period of 8 weeks at 2 week interval. AMF colonization was determined by using a microscope.

RESULTS AND DISCUSSION

Chicken manure biochar increased shoot P uptake. Biochar increased total P leached, probably due to the high amount of P fertilizer applied as well as P contained in the biochar. However, biochar increased the percentage of P in fertiliser, biochar and available soil P that was leached. These were different between two of the biochar types. Biochar application to soil increased P availability in soil. Biochar application to soil increased AMF colonisation (up to 70%) of wheat roots at low rates of fertilizer P and declined at the P application rate of 50 kg/ha to about 35%.

CONCLUSIONS

We conclude that the high levels of applied P from fertilizer and biochar increased not only plant P uptake and growth but also P leaching. However, retention and availability of P in soil and plant P uptake and as well as microbial biomass increased. Studies using biochar with low levels of P content and lower rates of P fertilizer application warrant further investigation in coarse-textured soils.

ACKNOWLEDGEMENTS

Funds for this study were provided by the Australian Grains Research and Development Corporation (GRDC).

Keywords: arbuscular mycorrhizal fungi, chicken manure biochar, lysimeters, nutrient leaching, pyrolysis, wheat chaff biochar

RHIZOBIUM STRAINS ISOLATED FROM COWPEA AND BAMBARA GROUNDNUT ENHANCE MINERAL UPTAKE/CONTENT IN THEIR HOMOLOGOUS HOSTS

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INTRODUCTION

Symbiotic N_2 fixation in legumes has been shown to promote greater mineral uptake. Although this biofortification trait of nodulated legumes has potential to increase macro and micronutrient density in edible crops for improved human nutrition and health, little is currently known about this phenomenon in legumes. The aim of this study was to screen cowpea and Bambara groundnut root-nodule bacteria for their ability to induce nutrient uptake *in vitro.*

MATERIALS AND METHODS

Seeds of cowpea and Bambara groundnut were surface-sterilized, germinated in sterile Leonard jars containing ¼ strength Hoagland nutrient solution. Cowpea was inoculated with 7 broth cultures of its respective N_2-fixing *rhizobium* strains whilst Bambara groundnut was inoculated with 18 effective and 2 ineffective bacterial isolates. Each treatment was replicated four times. Four replicates of 0.5 mM NO_3-fed plants were also included as control. All plants were harvested 30 d after planting, separated into shoots and roots, and oven-dried (60°C). The shoots were weighed, ground into fine powder (0.85 mm) and analysed for P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B concentration using inductively coupled plasma mass-spectrometry.

RESULTS AND DISCUSSION

The data from cowpea revealed marked differences in bacterial strain effect on shoot and whole plant biomass. Furthermore, all cowpea plants nodulated by the test strains showed significantly higher concentrations of macronutrients and trace elements in shoots compared to 0.5 mM NO_3-fed plants. Strains TUT13d1vu and TUT26a1vu consistently showed increased concentrations of P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B in shoots of inoculated cowpea compared with other strains. However, strains TUT53b2vu and TUT33b4vu (which were the highest fixers) accumulated much greater amounts of P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B in cowpea shoots than any of the other strains. Bambara groundnut inoculated with its bacterial symbionts also revealed marked differences among strains in inducing mineral accumulation in shoots.

CONCLUSIONS

Inoculation with N_2-fixing bacteria and the subsequent N_2 fixation process could have positive effects on growth and nutritional quality of nodulated legumes.

ACKNOWLEDGEMENTS

The National Research Foundation, the Research Chair in Agrochemurgy and Plant Symbioses and Tshwane University of Technology are acknowledged for funding this study.

Keywords: Inoculation, legumes, mineral element

CARBON ASSIMILATION AND WATER-USE EFFIECINCY IN SOYA BEAN (*Glycine max* L. MERRILL) PLANTS GROWN IN FARMERS' FIELDS IN SOUTH AFRICA

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INTRODUCTION

Soya bean is a legume crop grown for its oil and protein. It is also a source of animal feed and biodiesel. In South Africa, it is grown as rainfed or irrigated crop. Water deficit in this crop leads to about 40% yield reduction. Water use-efficiency (WUE) is the ratio of dry matter produced per unit of water expended. Instantaneous or long term WUE can be determined through gas exchange measurements or isotopic analysis. The ^{13}C isotope technique for example, is a useful tool in studying plant-water relations, and can guide the choice of plant species and genotypes in breeding programs (Blum, 2005). This study assessed soya bean plant growth, carbon assimilation and plant-water relations in farmers' fields.

MATERIALS AND METHODS

Field trips were undertaken to farmers' fields in three Provinces of South Africa (i.e. KwaZulu-Natal, North West and Mpumalanga). A total of 37 farms were randomly sampled (thus KwaZulu-Natal, 15; North West, 12 and Mpumalanga, 10) and an experimental field at Potchefstroom. Soya beans in these farms and at Potchefstroom were under rainfed conditions and were inoculated with commercial Bradyrhizobia at or before planting. At pod filling (R6) stage, 10 soya bean plants were harvested, oven-dried (60 °C) for 72 hours, weighed and ground into fine powder (0.85 mm) for ^{13}C isotope analysis. Gas-exchange measurements were done on four young top leaves per plant at R6 stage, with a portable infrared red gas analyser. Measurements and conditions were as described by Makoi *et al*. (2010).

RESULTS AND DISCUSSION

Significant differences ($p \leq 0.05$) were shown for photosynthetic rates and WUE among the soya bean plants at different farms. Dry matter yield, %C, $\delta^{13}C$ and C content in KwaZulu-Natal and North West revealed significant differences among soya bean varieties from farms within a locality. The $\delta^{13}C$ values varied from -40.5 ‰ in Dundee to -20.4 ‰ in Heron indicating marked differences in plant-water relations at Potchefstroom. Lower discrimination of ^{13}C in Heron under experimental conditions at Potchefstroom indicated greater WUE.

CONCLUSIONS

Gas-exchange studies and the ^{13}C isotopic analysis complimented each other in identifying soya bean variety PAN538 planted in Winterton as being the most water-use efficient of all the varieties, while PAN737, Dundee and PAN1434 require further testing for enhanced water relations.

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Keywords: Plant growth, water-use efficiency, isotopic analysis, gas exchange measurements

RHIZOSPHERE ACID PHOSPHATASE ACTIVITY AS A MARKER OF P NUTRITION IN *Cyclopia* SPECIES IN THE CAPE FYNBOS OF SOUTH AFRICA

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INTRODUCTION

Cyclopia, a shrub legume, is endemic to the Cape fynbos of South Africa. Out of 24 species, only nine of them are used to produce honeybush tea. The soils of the Cape fynbos are sandy or gravely with low P concentration (Cramer, 2010). Although total phosphate is abundant in many soils, it is largely unavailable for uptake by plants because about 20 – 80% of soil P occurs in organic forms (Richardson, 1994). In low P soils, both plants and microbes adopt various strategies P including the secretion of extracellular phosphatases (Makoi *et al.,* 2010), to source P from such environments. Acid phosphatase for example, have been reported to hydrolyze and cleave P from organic phosphate esters in acidic and alkaline soils (Asmar *et al.,* 1995), thus making P more available in those soils. The objective of this study was to assess rhizosphere acid phosphatise activity as a marker of phosphorus nutrition in *Cyclopia* species indigenous to the Cape fynbos of South Africa.

MATERIALS AND METHODS

Rhizosphere soil, defined as soil around the test species, *Cyclopia*'s roots, up to a distance of 2 mm away from the roots and bulk soils as soils without roots of the test species, were sampled from 30 cm depth at two *Cyclopia* commercial farms, Koksrivier and Kanetberg in the Western Cape Province of South Africa. Shoots of 10 plants, were harvested at crown level, and processed for analysis of P using an inductively coupled plasma-mass spectrometry (ICP-MS). *Cyclopia* plants sampled from Koksrivier farm were each two years old and those from Kanetberg farm were each seven years old, these two farms had not been fertilized with any P fertilizer before sampling. Bioassay of acid phosphatase activity in the soils was done using a method described by Tabatabai (1994).

RESULTS AND DISCUSSION

There was significantly ($p<0.05$) higher phosphatase enzyme activity and P concentration in rhizosphere soils of all legumes relative to bulk soil. Acid phosphatase activity as well as P concentration, were also higher in the rhizosphere of older *Cyclopia* plants. Rhizosphere P and shoot P concentrations closely mirrored the enzyme activity in the rhizosphere of each species. Our data therefore suggest that the increase in acid phosphatase activity of *Cyclopia* rhizosphere resulted in greater P supply from organic sources relative to bulk soil. Again, where there was low acid phosphatase activity, P concentration was much reduced.

CONCLUSIONS

In conclusion, our results suggest that rhizosphere acid phosphatase activity can be taken as a good indicator of P availability and P nutrition in *Cyclopia* species of the Cape fynbos of South Africa.

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Keywords: Cape fynbos, *Cyclopia*, Phosphatase activity, P nutrition, Rhizosphere

DIGITAL TERRAIN MAPPING OF THE SANDSPRUIT CATCHMENT IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA

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INTRODUCTION

Land components boundaries frequently coincide with transitions in environmental land properties such as soil, climate and biology. Image segmentation has been found to be an effective method for delineating terrain morphological units from digital elevation models (DEMs). In this paper we evaluated DEMs for land component mapping at the Sandspruit catchment in the Western Cape Province, South Africa.

MATERIALS AND METHODS

The 90m Shuttle Radar Topography Mission (SRTM), the second version of the 30m Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER GDEM2) and two versions of the 5m Stellenbosch University DEMs were evaluated. As a reference, a 1m DEM was generated from the GeoEye stereo pairs. All the DEMs were resampled to 5m resolution for comparison purposes. Scale factors for the study area were determined using the reference DEM by the Estimation of Scale Factor tool in eCognition software. The slope and aspect DEM derivatives were used to segment the study area into land components by the multiresolution segmentation algorithm. The resultant terrain units were evaluated by the generalization ratio, Hammound's metric ratio, the mean absolute area index and the number of land components.

RESULTS AND DISCUSSION

The SUDEML2 yielded the best land component segmentation. While the SUDEML1 and ASTER GDEM2 over-segmented the terrain units, the SRTM under-segmented. The results are consistent with previous studies which found that higher resolution DEMs are necessary for delineating accurate morphological information. The SUDEML2 was slightly better than the SUDEML1. This supports the finding that the incorporation of SRTM data improves DEM quality in moderate terrains

CONCLUSIONS

The study confirmed that higher resolution DEMs are necessary for delineating accurate information from DEMs. Useful land component information can be derived from the SRTM and the ASTER GDEM2. The ASTER GDEM2 appears to be superior to the SRTM in delineating land components in the study area. With the availability of accurate soil information, DEMs can be useful for soil mapping.

ACKNOWLEDGEMENTS

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Keywords: Land components, multiresolution segmentation, terrain units, soil forms

EVALUATION OF DRY BEAN GENOTYPES FOR USE IN THE LIMPOPO PROVINCE

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INTRODUCTION

Dry bean (*Phaseolus vulgaris* L.) is an important protein seed crop in South Africa grown mostly for human consumption. Dry beans in both unprocessed and canned form, constitute a vital, palatable and nourishing part of the diet of many people, particularly for those in the low income groups. The aim of the study was to determine the genotype x environment interaction and yield stability of dry beans produced in the Limpopo province.

MATERIALS AND METHODS

Six varieties of dry beans were planted in the 2010 and eight in the 2011 seasons at four locations with different agro-climatic conditions in Limpopo. The locations were Trichardtsdal ($24^0$10`0S, $30^0$23`6E), Dalmada ($23^0$55`6S, $29^0$28`6E), Dzindi Irrigation Scheme (23^o 01` 45 S and $30^o$ 26` 30 E) and Phalaborwa ($23^0$55`0S, $30^0$59`4E). The varieties used were OPS-RS1, Jenny, Pan 148, Kranskop, DBS310, OPS-RS4, DBS 360, OPS-RS2 and OPS-RS5. A randomized complete block design with four replications was used at each location. The plots consisted of 4 rows of 5 meter long. The within row spacing was 7,5 cm and the between row spacing was 90 cm giving a population of 150 000 plants/ha. The trial was replicated three times. Data was collected from the two middle rows. Data was subjected to Analysis of Variance using General linear Model procedure of SAS to determine the interaction between genotypes and the environment. Means were compared using Least Significant Difference test at 5 % level (LSD = 0.05).

RESULTS AND DISCUSSION

Analysis of variance results for both 2010 and 2011 indicated that there was a strong interaction between location and varieties ($p<0.05$). The Dalmada site had an exceptionally low yield due to the fact that it was affected by frost during maturity. The combined analysis of variance for both years and all locations indicated that there was a highly significant interaction ($P<0.01$) between years, locations and varieties. Kranskop remained the highest performer amongst all varieties when the data was combined with the mean yield of 0.848 t ha^{-1}; the mean was lowered by the yield at Dalmada. The results are in line with the findings by Mekbib (2003).

CONCLUSIONS

The results indicated that OPS-RS4 and Jenny can replace Kranskop in Phalaborwa and Pan 148 at Dzindi irrigation scheme whereas at Maruleng and Dalmada the results indicated that there was no significant difference among the varieties. OPS-RS4 seems to be performing well in all the areas and could be recommended as the best variety for all areas. The study is ongoing and recommendations will be made after the 2012 growing season.

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Keywords: protein seed crop, dry bean variety

SOIL HEALTH (QUALITY) ASSESSMENT OF TOPSOIL CONDITIONS IN A LONG-TERM VINEYARD SURFACE MANAGEMENT TRIAL IN ROBERTSON, SOUTH AFRICA

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INTRODUCTION

This study evaluated the soil conditions of vineyards under different surface management practices (Robertson, South Africa) based on the current concept of soil health and soil quality. The effect of agricultural traffic on soil health (quality) was also evaluated. The objectives of study were to: (i) select suitable soil health (quality) indicators for vineyards; (ii) evaluate the effect of the management treatments and agricultural traffic on soil health (quality). The soil physical, chemical and biological properties which were selected as indicators of soil health (quality) were based on specific criteria similar to previous work done on the concept (Doran & Parkin, 1994).

MATERIALS AND METHODS

The surface management treatments included: mechanical weed control, chemical weed control, annual addition of straw mulch, annual cover crop and perennial cover crop. The soil was sampled to depths of 0-200 mm for initial characterization of soil and 0-50 mm to compare soil health (quality) *between* traffic tracks and *in* tracks of treatment plots. Properties analyzed included: soil texture, gravimetric water content, bulk density, soil aeration, water aggregate stability, soil pH, EC, available NPK, organic matter (OM) content, soil microbial biomass, mineralizable N and soil respiration.

RESULTS AND DISCUSSION

The soil properties that were most sensitive to the surface management; namely water content, bulk density, soil pH, EC, available NPK; OM, and soil respiration, showed significant differences in the first few centimetres of the soil. In most of the treatments, the *in* track and *between* track means for the various treatments showed significant differences within treatments and significant impact of traffic on a wide range of soil quality parameters.

CONCLUSIONS

The parameters showing significant differences are to be considered most sensitive and thus suitable as indicators of soil quality to used in future soil health (quality) studies for vineyards. The treatments that resulted in the most desirable soil health (quality) were the straw mulch and perennial cover crop treatments. Interestingly, the vehicle traffic in treatment plots seemed to have had a greater effect than the treatments applied.

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University of Stellenbosch, Soil Science Department; ARC Infruitec-Nietvoorbij; Wine-tech; Western Cape Department of Agriculture, Elsenburg College.

Keywords: soil health; soil quality; soil management

SOIL CARBON DISTRIBUTION AND STABILITY IN INTACT AND DEGRADED SPEKBOOM THICKET SOILS (E. CAPE, RSA)

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INTRODUCTION

Soils of semi-arid regions are known to have low organic matter (OM) content attributed to the prevailing climatic conditions. Yet, the Spekboom Thicket, which occurs in semi-arid Eastern Cape (South Africa) accumulates large amounts of soil carbon. To understand this remarkable accumulation, and to see whether it is solely as a result of spekboom's (*Portulacaria afra*) organic chemical properties, we carried out a detailed investigation of the soil carbon directly beneath spekboom and other "non-spekboom" species in intact thickets, and also compared soils from degraded (over-grazed), open (savannah-like) thickets. This involved examining the distribution of organic vs. inorganic carbon, general soil properties and the relative stability of the organic carbon at the different sites.

MATERIALS AND METHODS

Twelve fence-line transects of contrasting intact vs. transformed thickets were selected, from which foliage, litter and soils were sampled. Soils were collected at 0-5, 5-15, 15-25 and 25-50 cm depth intervals directly underneath canopies of *spekboom* and *non-spekboom* species, and also in the degraded *open* grassy areas at each transect. Soil organic carbon (OC) and inorganic C content was determined, as well as general soil chemical properties. Density fractionation was used to quantitatively isolate the particulate OC from the stable, mineral-bound OC in the 5-15 cm layer at each site. The relationships between stable OC and selected soil properties, hydrophobicity, aggregate stability, clay content, exchangeable Ca and Mg, Fe and Al oxide content, were examined in order to elucidate the organic C stabilization mechanisms operating in the soils.

RESULTS AND DISCUSSION

Degraded *open* sites displayed a significant decline in hydrophobicity, aggregate stability and OC. *Spekboom* soils tended to be more hydrophobic and contained significantly more exchangeable Mg, K and Na, than other sites. The majority (78-95%) of the soil C at all sites was found to be organic. There were no significant differences in the carbon content (organic or inorganic C) between *spekboom* and *non-spekboom* (intact thicket soils). Organic C stocks in the top 50 cm ranged from 19-34, 22-62, and 19-58 g C kg^{-1} for *open* area, *spekboom*, and *non-spekboom* sites, respectively. Inorganic C stocks were estimated to range from ca. 2-9 g C kg^{-1}, representing approximately 4-22% of total C. Stable, mineral-bound OC accounted for the largest fraction (60-66%) of OC in the intact (28 and 26 g C kg^{-1} for *spekboom* and *non-spekboom*, respectively) and degraded (17 g C kg^{-1}) for *open* thicket soils. Similar to previous studies of semi-arid soils, there were no strong correlations between the stable OC and soil properties investigated, suggesting that vegetation chemistry might play an important role in stabilization.

CONCLUSIONS

The particulate OC and mineral-bound OC stocks in the intact thicket soils are about three times higher than the values previously reported for other semi-arid ecosystems. It appears that both *spekboom* and *non-spekboom* vegetation in intact thicket leads to the accumulation of OC, in particular, stable mineral-bound OC. The mineral-bound OC stocks remain high in the degraded, *open* soils, indicating the stability of the OC derived from the original thicket vegetation. Our findings confirm the importance of the Spekboom Thicket restoration in promoting soil OC sequestration.

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Keywords: carbon stabilization, semi-arid, soil chemistry, spekboom (*Portulacaria afra*), ecology

SOIL SURFACE MANAGEMENT PRACTICES AFFECT MYCORRHIZAL AND MICROBIAL ENZYME ACTIVITY AND DIVERSITY IN AN APPLE ORCHARD SOIL

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INTRODUCTION

Microorganisms produce enzymes such as *ß*-glucosidase (C-cycle), urease (N-cycle) and phosphatase (P-cycle) that play important roles in the biogeochemical cycling of mineral nutrients. The functioning of these enzymes may be affected by soil surface management practices, as may rooting pattern and root exudate production. Since root colonisation by beneficial arbuscular mycorrhizal fungi (AMF) is mainly triggered by root exudates, the extent of AMF colonisation may be indicative of the efficacy of soil management practices. The aim of this research was to assess the effect of two different soil surface management practices on microbial diversity, microbial enzyme and AMF fungal activity in an apple orchard soil.

MATERIALS AND METHODS

The investigation was a factorial field trial on 8-year old Cripps Pink apple trees, and was carried out at Elgin Research Farm, Grabouw. Two management practices: chemical weed control (herbicide) and mulching with straw, were applied to the tree row, each in combination with treatments applied in the work row. All treatments were replicated four times. Soil samples were taken in the tree row at 15 cm and 30 cm depths during spring and summer over three seasons. Colorimetric assays were performed to measure *ß*-glucosidase, urease and phosphatase activities. Root colonisation by AMF was determined using a compound microscope, and metabolic (carbon source utilisation) profiles of the microbial communities (indicating diversity), were measured using BIOLOG microtiter plates.

RESULTS AND DISCUSSION

AMF root colonisation levels were higher under mulching than where chemical weed control was utilised. Mulching also increased the activities of microbial enzymes, and the diversity of the microbial populations. Probable contributory factors were the supply of carbon from the mulch, and the likelihood that soil moisture contents and temperatures were more stable under the mulch than where the soil surface was kept cover-free with herbicide. The soil pH, having been slightly lower under the mulch (pH 4.7) than in the chemical treatments (pH 5.2), may also have been a contributing factor.

CONCLUSIONS

Mulching has positive impacts on AMF colonisation of apple roots and promotes microbial enzyme activity and microbial diversity in the soil, relative to weed control by means of chemicals. Mulching is an environmentally safe practice that will probably continue to confer advantages in apple orchards for long periods.

ACKNOWLEDGEMENTS

The Deciduous Fruit Producers Trust and the Agricultural Research Council are gratefully acknowledged for their financial support.

Keywords: apple, arbuscular mycorrhizal fungi, chemical control, enzyme activity, mulch, soil surface management

CORRELATION BETWEEN GLOMALIN AND CHEMICAL PROPERTIES OF APPLE ORCHARDS SOILS

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INTRODUCTION

Apples account for about 65% of South Africa's total annual income from deciduous fruit. More than half of these apples are produced in the Western Cape Province, where numerous cultivars are grown in soils of varied texture and chemical composition. Creating conditions conducive to the growth of these cultivars is an important aspect of current research. The role of glomalin in creating and maintaining such conditions is largely unexplored. This glycoproteinaceous substance, which is produced by arbuscular mycorrhizal (AM) fungi, represents a potentially valuable pool of carbon (C) in the soil (Rillig *et al*., 2001), and is considered to be an indicator of soil health. The aim of this research was to examine the relationships between glomalin, organic C, pH and mineral nutrient elements in Western Cape apple orchard soils.

MATERIALS AND METHODS

Various areas, totalling 30 orchards and four scion/rootstock combinations, were included in a survey of Western Cape apple orchards. Composite soil samples were collected at 30 cm depth in spring and summer 2009 and 2010. Glomalin content was quantified using the Bradford assay method, and N, P, pH, exchangeable Ca, Mg and K, and total organic soil C, were determined by routine soil chemical analysis. The data, which represented all soils and apple varieties, were correlated.

RESULTS AND DISCUSSION

Glomalin concentrations were consistently and positively correlated with soil C during spring 2009 and spring 2010 (P = 0.0086 and 0.0467, respectively), indicating that glomalin may be affected by the same controlling factors as soil organic C. This finding supports that of Rillig *et al.,* 2003 (r^2 = 0.659; P < 0.0001). Soil N (r = 0.54062; P = 0.0025) also explained the glomalin concentrations, but only in spring 2009. Significant correlations were not found for the samples that were taken during summer. Correlations between glomalin and other soil parameters were inconsistent.

CONCLUSIONS

Glomalin concentration correlates with soil organic C. Because of its affinities with mycorrhizae, glomalin may nevertheless be a more informative test of soil health than that for total soil C; as when assessing the relative effects of different soil management practices.

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The Deciduous Fruit Producers Trust and the Agricultural Research Council are gratefully acknowledged for their financial support.

Keywords: apple, glomalin, mycorrhiza, nitrogen, organic carbon, soil

SYMBIOTIC FUNCTIONING AND RHIZOBIAL BIODIVERSITY OF BAMBARA GROUNDNUT (*Vigna subterranea* L. Verdc) GROWN IN FARMERS' FIELDS IN SOUTH AFRICA

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INTRODUCTION

Grain legumes can contribute a huge amount of symbiotic nitrogen to traditional cropping systems in Africa. Bambara groundnut (*Vigna subterranea* L.Verdc) is an important food legume crop with the ability to form symbiosis with specific root-nodule bacteria and to contribute significant amount of N to soil N fertility (Nyemba & Dakora, 2010). At farm level, yield of Bambara groundnut is often low partly due to little understanding of its symbiotic N nutrition. Similarly, there is little information on the diverse microsymbionts nodulating this legume species. This study assessed symbiotic N_2 fixation in Bambara groundnut sampled from farmers' fields, and characterized bacterial symbionts nodulating Bambara groundnut.

MATERIALS AND METHODS

Bambara groundnut plants were collected from 26 farmers' fields from Mpumalanga Province, South Africa, in 2009. Shoots and pods were oven-dried (60 °C), weighed, and milled for ^{15}N isotope analysis using mass spectrometry. Isolations and characterization of root-nodule bacteria were done as described by Vincent (1970).

RESULTS AND DISCUSSION

Isotopic analysis showed that the symbiotic dependency of Bambara groundnut ranged from 55 to 97%. Actual amounts of N-fixed for different farms ranged from 3.7 kg $N.ha^{-1}$ to 212.7 kg $N.ha^{-1}$. Bacterial isolates exhibited phenotypic differences in their growth rate, colony appearance, shape, and texture. The strains (i.e. both slow and fast-growers) markedly differed in their symbiotic efficacy on Bambara groundnut. The 16S rDNA sequencing data revealed a diverse microsymbionts (i.e. *Bradyrhizobium, Burkholderia*, *Mesorhizobium* and *Rhizobium* species) nodulating Bambara groundnut.

CONCLUSIONS

The data revealed that Bambara groundnut highly depends on N_2 fixation for its N nutrition, and is nodulated by diverse of microsymbionts that differed in their symbiotic efficacy.

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Keywords: Bambara groundnut, bacterial isolates, nitrogen fixation, symbiotic efficacy

SELECTING FOR DROUGHT TOLERANCE AND N_2 FIXATION IN 25 GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES USING ^{13}C AND ^{15}N NATURAL ABUNDANCE TECHNIQUES

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INTRODUCTION

Groundnut is a major grain legume in Africa, often cultivated for its oil and dietary protein. It has great potential for improving soil fertility via symbiotic N_2 fixation. Earlier studies evaluated symbiotic N contribution by groundnuts in traditional cropping systems in Africa (Nyemba & Dakora 2010). Although variable amounts have been reported, they nonetheless contribute to ecosystem functioning. Elsewhere in the world, groundnut genotypes have been selected for increased grain yield and disease tolerance. However, in Africa, few studies have evaluated symbiotic N contribution and drought tolerance by this species. The objective of this study was to select groundnut genotypes grown in the field for enhanced plant growth and high symbiotic performance and drought tolerance.

MATERIALS AND METHODS

Field trials were conducted with 25 groundnut genotypes at (Nelspruit, Mzinti and Kliplaatdrift) in Mpumalanga, South Africa. A randomized complete block design with three replications was used and each plot measured 2 m × 5 m (i.e. 10 m^2). The soil was classified as sandy loam, plants were rainfed, not inoculated and received 250 $kg.ha^{-1}$ NPK application at land preparation. Five whole plants were sampled at close to physiological maturity per plot, oven-dried at 60 °C for 72 h. The samples were ground to fine powder for isotopic (^{15}N and ^{13}C) analysis using mass spectrometry and data was further analyzed using Statistica program.

RESULTS AND DISCUSSION

Data revealed significant ($p \leq 0.05$) differences in biomass yield, N concentration and N content, $\delta^{15}N$ values, %Ndfa and amount of N-fixed at all sites. The $\delta^{15}N$ values of groundnut genotypes ranged from -0.08‰ to +1.06‰ at Nelspruit, +0.41‰ to +0.95‰ at Mzinti and +0.73‰ to +1.96‰ at Kliplaatdrift. The amount of N-fixed at Nelspruit was as low as 76 $kg.ha^{-1}$ for ICGV99033 and PC327K31 and as much as 188 $kg.ha^{-1}$ for ICGV00362. At Mzinti, 10 genotypes contributed over 100 kg $N.ha^{-1}$, while at Kliplaatdrift, only 5 genotypes fixed more than 100 kg $N.ha^{-1}$. Data on $\delta^{13}C$ values also revealed marked difference in drought tolerance. Genotypes ICGV03157 and ICGV00369, showed much lower ^{13}C discrimination at all sites, indicating greater water-use efficiency compared to the remaining genotypes.

CONCLUSION

Groundnut genotypes have great potential for high symbiotic N_2 fixation, enhanced growth and increased grain yield. Across the three locations, ICGV03157 and ICGV00369 showed lower $\delta^{13}C$ discrimination and can indicate their tolerance to drought. Taken together, the data suggest that the $\delta^{15}N$ and $\delta^{13}C$ can be used as tools to identify genotypes for N_2 fixation and drought tolerance in crop species.

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ACKNOWLEDGEMENT

This study was funded by National Research Foundation, South African Research Chair in Agrochemurgy and Plant Symbioses and Tshwane University of Technology.

Keywords: Plant growth, grain yield, traditional cropping system, water use-efficiency

CALIBRATING THE MIR FOR USE IN SOUTH AFRICA

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INTRODUCTION

The understanding of the soil and assessment of its quality and function has been gained through routine soil chemical and physical laboratory analysis. There is a global thrust towards the development of more time and cost efficient methodologies for soil analysis as there is a great demand for larger amounts of accurate, inexpensive soil data to be used in environmental monitoring, modeling and precision agriculture. Diffuse reflectance spectroscopy with a wavelength in the mid infrared (MIR) provides a good alternative that may be used to enhance or replace conventional methods of soil analysis, as it overcomes some of their limitations

MATERIALS AND METHODS

A spectral library was developed by scanning the legacy data of # samples from 28 profiles soil of the Weatherly catchment with the MIR. Calibration curves for various chemical soil properties were created using the spectral library. The calibration curves were validated using # samples from new profiles from the Weatherly catchment. The location of these profiles was on a 100 m grid and selected transects.

RESULTS AND DISCUSSION

For the ions S, Na, K, and Mg 70% of the samples fitted onto the calibration curve. The calibration curve only accounted for 40% of the samples for CEC, pH, Ca, Fe, N, C:N and base saturation. This means that for the first group of ions only 30% of the samples have to be analysed using wet chem, and even for the second group laboratory costs will be cut by 60%. The reason for the inability of the calibration curve to account for all the samples lies in an incomplete spectral library. However when wet chem values are available for the outliers, they can be included in the spectral library and the calibration curve can be updated. Thus with time, all samples should be able to be included in the calibration curves.

CONCLUSIONS

The MIR has proven to be rapid, timely, less expensive, non destructive and more straightforward than conventional analysis. It shows great potential for large scale application in South Africa. However to be able to use it effectively, we need to expand the spectral library to accommodate all possible soil property values.

ACKNOWLEDGEMENTS

Bruker Optics for the loan of the MIR machine.

Keywords: calibration, diffuse reflectance spectroscopy, MIR, soil properties, spectral library

INTERACTIVE EFFECT OF N, P AND INOCULATION ON GROWTH, NODULATION, N_2 FIXATION AND YIELD COMPONENTS OF PROMISCUOUS AND NON-PROMISCUOUS SOYBEAN (*Glycine max* (L.) MERR.) GENOTYPES

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INTRODUCTION

Soybean (*Glycine max* (L) Merrill) is extensively cultivated in Mozambique due to its marketability. However, yields in Mozambique are low compared to other areas in the world. Lack of improved varieties, poor cultural practices, and low use of inoculants and fertilizers limit production. Applying inoculants improves soil fertility via N_2 fixation, and enhances crop yield. In tropical soils, P and N deficiencies constrain crop yields. Combining P with inoculants increase protein and oil content in soybean (Islam *et al.,* 2004). Enhancing soybean yield in Mozambique will therefore require seed inoculation, P and N application. This study evaluated plant growth, nodulation and grain yield of two soybean genotypes in response to N and P application and rhizobial inoculation (RI).

MATERIALS AND METHODS

A field experiment was conducted at Ruace, Mozambique in 2010 using Storm and TGx-1904-6F varieties, a granular inoculant containing bradyrhizobial strain USDA 61A101, N and P. Fertilizers (40kg.ha^{-1}) were applied at planting. The inoculant was drilled into opened furrows in each plot. A split-plot design was used with 4 replications. P was assigned as the main plot whilst genotypes, N and inoculation were sub-plots. Nodules were sampled at 50% flowering, and whole plots harvested at physiological maturity to determine grain yield.

RESULTS AND DISCUSSION

Significant ($p<0.05$) interactions were shown for all parameters. Nodulation and grain yield was high in Storm whilst TGx-1904-6F produced greater shoot biomass. Whereas P application increased nodule number, shoot biomass and grain yield.ha^{-1}, N, I and N+I treatments significantly improve nodule numbers, plant growth and grain yield. Independent of N and I, P application increased grain yield.

CONCLUSIONS

The application of P, I and starter N increased nodulation, biomass and grain yield in both genotypes. Genotype TGx-10904-6F increased grain yield with P application compared to the other genotype, Storm. The results suggest that the application of N, I and P can increase grain yield of soybean genotypes in Mozambique.

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ACKNOWLEDGEMENTS

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Keywords: Inoculation, rhizobial species, genotypes, P-response

EFFECTS OF WINTER ROTATIONAL COVER CROPS ON SOIL PHYSICAL PROPERTIES OF A HARDSETTING SOIL IN EASTERN CAPE PROVINCE, SOUTH AFRICA

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INTRODUCTION

Winter rotational cover crops (WRCC) are often used to boost soil fertility. However, selection and use of WRCC for soil physical improvement is usually overlooked even on structurally degraded soils with hardsetting properties. Hitherto, information regarding the effects of WRCC under conservation agriculture (CA) on soil physical properties is scarce. The objective of this study was to determine the effects of WRCC on selected soil physical properties of a hardsetting soil.

MATERIALS AND METHODS

Bulk density, penetration resistance (PR), aggregate stability, soil polysaccharides, infiltration and water retention characteristics were determined at depths 0 to 15 cm and 15 to 30 cm after four rotations of growing vetch (*Vicia dasycarpa* cv. Max), lupin (*Lupinus angustifolius* cv. Tanjil) and oats (*Avena sativa* cv. Sederberg) and a winter fallow control.

RESULTS AND DISCUSSION

No significant bulk density differences were observed between the cover crops and the control. However, oats significantly ($P \leq 0.05$) reduced penetration resistance (PR) whilst vetch resulted in significantly higher PR values within the two soil depths compared to the weedy fallow control. Aggregate stability was significantly improved under WRCC compared to the control in both soil depths. This was coupled with a significant increase in macro-aggregate fractions under WRCC. Both hot water extractable and dilute acid extractable polysaccharides showed no significant correlation with aggregate stability. Water infiltration was significantly improved by oats but not vetch and lupin. Cover crops significantly ($P \leq 0.05$) increased plant available water capacity (PAWC) compared to the control. Legume cover crops may have increased wetting and drying cycles within the profile, thereby increasing PR. Additional biomass from WRCC may have increased organic matter improving aggregate stability consequently improving water retention.

CONCLUSION

The WRCC improved most of the soil physical properties studied. Under CA, selection of WRCC should also consider their effects on soil physical properties and not biomass and soil fertility alone.

ACKNOWLEDGEMENT

This study was funded by Govan Mbeki Research and Development Center at the University of Fort Hare.

Keywords: Conservation agriculture, infiltration rate, penetration resistance, mean weight diameter, plant available water

SCREENING OF WHEAT BREEDING LINES FOR THE DEVELOPMENT OF RUST RESISTANT GERMPLASM

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INTRODUCTION

Stripe, leaf and stem rusts are major diseases of bread wheat in South Africa and can result in considerable yield and quality losses. The use of resistant cultivars is the most sustainable and environmentally safe method of controlling rust diseases. However, the main problem with this strategy is that resistance conferred by a single gene is often short-lived due to the continuous development of new rust pathotypes. Therefore, there is a continuous need to identify rust resistant germplasm and to incorporate combinations of different genes into wheat lines with good agronomic characteristics for the ultimate release of a well-adapted rust resistant cultivar.

MATERIALS AND METHODS

Wheat breeding lines (638) from 19 breeding populations were screened for seedling resistance against leaf, stem and stripe rust pathotypes during 2010/11 cropping season at ARC-Small Grain Institute, Bethlehem. Three prevalent pathotypes, 3SA133, 3SA140 and 3SA145 were used for leaf rust evaluations. Stem rust evaluations were carried out using three pathotypes, 2SA88, 2SA106 and 2SA107, while a single pathotype, 6E22A^{+} was used to screen for stripe rust resistance. Plants were evaluated at the peak of disease infection and rated using a scale of 0 – 4. Resistant lines were expressed as a percentage for stripe, leaf and stem rust and will advance in the breeding programmes.

RESULTS AND DISCUSSION

Results indicated significant variation in the reactions of the breeding populations of wheat to the various rust pathotypes. The overall levels of rust resistance in the breeding lines were low. Percentage of resistance varied for the different rusts with levels between 3 and 10 % for leaf rust, 3 and 56% for stem rust and 11 and 60% for stripe rust. Selected lines will be subjected to vigorous screening in conjunction with molecular marker application.

CONCLUSIONS

The identification of rust resistant breeding lines is essential for the breeding programs for the ultimate release of well adapted rust resistant cultivars. New genes and gene combinations are being investigated to improve the current levels of rust resistance in the breeding programs.

*Keywords***:** rust resistance, stem rust, stripe rust, *Triticum aestivum*, yellow rust

BIOTIC AND ABIOTIC DAMAGE TO MAIZE EARS AND ITS EFFECT ON FUSARIUM EAR ROT AND THE PRODUCTION OF FUMONISINS

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INTRODUCTION

Fusarium verticillioides Sacc. Nirenberg (syn = *F. moniliforme* Sheldon) and the African stem borer, *Busseola fusca* (Lepidoptera: Noctuidae), are among the most significant crop production constraints to maize production in South Africa. In this study the interaction between *F. verticillioides* and *B. fusca* and mechanical damage were investigated to elucidate the effects they may have on Fusarium ear rot (FER) and fumonisin production in both Bt and non-Bt maize cultivars.

MATERIALS AND METHODS

Field trials were conducted at Potchefstroom during the 2008/09, 2009/10 and 2010/11 seasons. To study the *B. fusca* x *F. verticillioides* interaction, maize ears were inoculated with *F. verticillioides* MRC 826 only, with both *F. verticillioides* and *B. fusca*, and with *B. fusca* only. To study the *F verticillioides* x mechanical damage, maize ears were physically damaged with a cork borer (different sizes and number of wounds) prior to inoculation with *F. verticillioides* MRC 826. Control treatments were included in all trials. All ears per treatment were hand harvested at physiological maturity. FER was visually rated by expressing visible FER as a percentage of the total ear surface. *Busseola fusca* damage was quantified by measuring feeding tunnel length on each ear. Fumonisins were quantified using HPLC. A multifactor ANOVA was performed on all data using StatGraphics5^{+}.

RESULTS AND DISCUSSION

Results from the 2008/09 season indicated that the *B. fusca*x *F. verticillioides* interaction significantly increased FER severity and ear damage compared to other treatments, but it did not significantly increase fumonisin production by *F. verticillioides*. No significant *B*. *fusca* x *F. verticillioides* interaction was recorded in a similar trial planted in 2010/11, possibly due to high rainfall that may have affected the survival of *B. fusca*. Results from the 2009/10 and 2010/11 seasons indicated that the severity of both FER and fumonisin contamination increases with the level of mechanical damage in both naturally and artificially *F. verticillioides*-inoculated maize plants. Results from Bt vs non-Bt trials planted in 2009/10 and 2010/11 indicated a lower incidence of FER in Bt maize than in non-Bt maize. There was no significant difference in *B. fusca* damage per ear in all treatments, suggesting that the increase in FER in the non-Bt maize is probably due to *B. fusca* acting as a vector for *F. verticillioides*. However, there was no significant difference in fumonisin contamination between the Bt and non-Bt maize. This could be attributed to widespread bird damage at the tip of the ears that was observed in this trial. Bird feeding and damage may have resulted in the inoculation of all treatments with the fumonisin producing *F. verticillioides* MRC 826.

CONCLUSIONS

This study showed that biotic and abiotic damage to maize ears remains a problem to maize production despite the adoption of Bt technologies. A better understanding of these interactions is required before specific control strategies can be identified. It appears that integrated disease and pest management practices need to be used in tandem to manage maize ear rots and mycotoxin contamination.

ACKOWLEDGEMENTS

We thank the Maize Trust and the ARC for funding.

Keywords: *B. fusca*, *F. verticillioides*, fumonisins, Fusarium ear rot

SELECTION FOR HERBICIDE RESISTANCE IN WHEAT AFTER ETHYL METHANESULPHONATE MUTAGENESIS

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INTRODUCTION

The use of novel crop cultivars with herbicide resistance is relatively simple yet effective crop production technology. Use of herbicide resistance in crop production is the cheapest and most effective form of weed control both for small scale and commercial farmers. Wheat mutants that are resistant to herbicide would be of great value, since weed control using post-emergence herbicides would make it possible to achieve high yield and quality grain. The objective of this study was to select herbicide resistant wheat germplasm after inducing genetic change using chemical mutagenic agent, ethyl methanesulphonate (EMS). Selected lines will be used as breeding stock to introgress herbicide resistance genes.

MATERIALS AND METHODS

Seeds of the two selected wheat varieties (SST-056 and SST8-75) were treated with EMS at 0.5% concentrations for 2 h at 35 ºC. Treated wheat seeds with comparative controls (55 g per treatment) were planted at the experimental farm of the University of KwaZulu-Natal. Seeds were planted in a completely randomized design in seedbeds at Ukulinga farm. Four weeks after planting both mutagenised and untreated standard checks M1 plants were sprayed with two types of herbicides (metsulfuron-methyl and bromoxynil) at three different doses. Metsulfuron-methyl was applied at the recommended rate of 4 g ha^{-1} and bromoxynil at 2 L ha^{-1}. The three doses of herbicides were twice, four and eight times the recommended dose. Two weeks after treatment, herbicide resistance was assessed on a scale of 0 to 10. Data were subjected to the Krusakal-Wallis non-parametric test procedure to compare the herbicide resistance among varieties.

RESULTS AND DISCUSSION

The analysis showed significant differences among varieties, tested herbicides and doses applied. The EMS treated wheat lines showed greater degree of herbicide resistance compared to untreated controls. There was significant positive correlation between herbicide doses and the death weeds. Significant differences ($p<0.01$) among varieties in response to the various doses of herbicide were observed for weed killing. These differences were more pronounced at the highest herbicide doses.

CONCLUSIONS

Based on the present findings, it is concluded that EMS treatment generated herbicide-resistant individual plants per variety which will be selected for next mutation generation using the respective herbicide and doses.

ACKNOWLEDGEMENT

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Keywords: Bromoxynil, EMS, herbicide resistance, metsulfuron-methyl, *Triticum aestivum* L.

EVALUATING RAINWATER HARVESTING AND CONSERVATION TECHNIQUES ON THE TOWOOMBA ARCADIA ECOTOPE FOR DRYLAND MAIZE PRODUCTION

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INTRODUCTION

Water scarcity affects dryland crop production and threatens the livelihood of millions of people in developing countries most particularly in Africa. In the semi-arid areas of southern Africa, water and soil fertility are the main factors limiting food production (Botha, 2006). According to Oweis *et al.,* (1999) water harvesting is a term that describes a number of different practices that have been used for centuries in dry areas to collect and utilize rainfall more efficiently. These practices are designed to ensure water availability to the plants during the growing season by reducing excessive run-off and encouraging water infiltration. The objective of this study is to increase maize production under dryland conditions and improve the livelihood of small-scale farmers in Limpopo Province, through integrated crop production, water and soil fertility enhancement.

MATERIALS AND METHODS

The trial was conducted on the Arcadian ecotope at the Towoomba research station in Limpopo Province. The test crop was the maize hybrid, PAN 6P-563R, established at a plant population of 20 000 plants ha^{-1}. Five treatments were applied (Conventional tillage, No-till, Daling-plough, Infield rainwater harvesting and mechanized-basins) which were replicated four times in a RCBD. The trial was planted in 2008/2009 and 2009/2010. Each treatment had two access tubes to measure soil water content (SWC).

RESULTS AND DISCUSSION

There was no clear trend for SWC of the treatments. However, results indicated that the SWC decreased at 57 DAP though there was frequent rainfall, this is attributed to water demand by maize at tasseling stage. Daling-plough had higher SWC than all treatments followed by MB > CON > NT > IRWH. Poor rainfall distribution in 2008/2009 resulted in lower grain and biomass production, but improved in the 2009/2010. The IRWH technique produced 500 kg ha^{-1} more grain that the rest of techniques except conventional tillage which only differed with 144 kg ha^{-1} from the IRWH yield.

CONCLUSIONS

The preliminary results indicate that IRWH has the potential of improving maize production under dryland condition. Hence, the project is still running for more conclusive results.

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Keywords: Conservation techniques, ecotope, rainwater harvesting, yield

VALIDATION OF THE SURFACE RENEWAL METHOD FOR ESTIMATING SUGARCANE EVAPOTRANSPIRATION

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INTRODUCTION

Due to ever increasing pressure on water resources for irrigated agriculture, accurate estimation of evapotranspiration (ET) is vital. Within the past decade, accuracy of ET estimates has improved mainly due to new and increasingly sophisticated methods such as those based on micrometeorology. These methods include eddy covariance, Bowen ratio, surface renewal and scintillometry. Surface renewal (SR) is a relatively new, inexpensive and simple method based on high frequency air temperature (T_a) measurements (Mengistu & Savage, 2010). The SR method has been evaluated for a wide range of crop canopies in South Africa, but not for green cane harvested sugarcane. The objective of this research was to validate the accuracy of the SR method for sugarcane under such conditions by comparing ET estimates with that of weighing lysimeters.

MATERIALS AND METHODS

A field trial was conducted at the South African Sugarcane Research Institute (SASRI) research station at Pongola using two weighing lysimeters (2.44 m by 1.52 m and 1.22 m deep). Soil surfaces were covered by a residue layer 0.14 m thick (8.3 t/ha). ET was calculated as daily change in lysimeter mass (converted to mm water), plus irrigation, minus deep drainage. A SR system was set up above the four-month old N14 crop canopy of each lysimeter. Sensible heat flux (H) was determined from high-frequency T_a measurements. A SR weighting factor of 0.5 was used. Soil heat flux plates and net radiometers were used to measure soil heat (G) and net irradiance (R_n) respectively. Latent energy (λE) was calculated as the residual of the shortened energy balance equation ($\lambda E = R_n - H - G$) and converted to daily ET (mm).

RESULTS AND DISCUSSION

Good agreement (R^2 = 0.87, slope = 0.63) was obtained between lysimeter and SR determined ET values although evaluation conditions were not ideal due to rainfall. During the 20-day evaluation period (day of year 126 to 146, 2010) lysimeter ET values varied between 2.6 mm on a sunny day and 0.4 mm on a cloudy day. SR-determined ET values for the same two days were 2.9 and 1.1 mm respectively. Reasons for discrepancies will be investigated further and discussed in the paper.

CONCLUSIONS

The SR method is a relatively simple, inexpensive and accurate method for sugarcane ET estimation. As a result, this method will be used to quantify ET of various sugarcane production systems in an attempt to increase efficiency of water use.

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Keywords: sugarcane, evapotranspiration, surface renewal, weighing lysimeters, crop residue blanket

EFFECT OF SOIL PARENT MATERIAL AND ROOTSTOCK ON MERLOT VINE PERFORMANCE AND WINE QUALITY

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INTRODUCTION

Most vineyard soils around Stellenbosch developed from parent materials derived, in part, from granite or shale. These parent materials may confer rootstock-dependent differences in vine performance and wine style, possibly by affecting potassium (K) availability. To investigate, Merlot vines on 101-14 Mgt and Richter 110 rootstocks were grown on mainly granite-, and shale-derived soils, under semi-controlled conditions.

MATERIALS AND METHODS

Merlot vines on Richter 110 (R110) and 101-14 Mgt rootstocks were planted during 2005 in soils derived from decomposed granite (g), and from weathered Namibian greywacke/shale (s) in a drainage lysimeter at Stellenbosch. The soil treatments were irrigated separately, using micro sprinklers, at a tension of -0.07 MPa. Lime, nitrogen and phosphorus (but not K), were applied, and standard management practices were followed. Predawn and midday leaf water potentials, stem circumferences, cane masses and yields were determined. Wines were prepared and evaluated after 6 months storage by an experienced panel of tasters.

RESULTS AND DISCUSSION

Averaged over the seasons 2007/08 to 2010/11, stem circumferences were similar in the treatments g101-14 Mgt, gR110 and s101-14 Mgt but significantly ($p = 0.05$) smaller (>) in sR110. Cane masses declined in the sequence: g101-14 Mgt, s101-14 Mgt > gR110 > sR110. Yields were greater from granite than from shale soils, and from R110 than from 101-14 Mgt. Yields peaked in gR110, and were lowest in sR110. Bunch masses were greater from vines on granite than shale soil, and from R110 than from 101-14 Mgt. Fullness was more prominent in wines from g101-14 Mgt than from other treatments. Overall wine quality was highest from vines in g101-14 Mgt, but significantly lower from sR110. Since the soil matric, and midday leaf water potentials did not differ, water availability probably did not contribute to the observed differences. Leaf blade and petiole K concentrations were similar, even though Bray II K was higher in the granite (62 mg kg^{-1}) than the shale soil, which, at 39 mg kg^{-1} (1.7% of S-value) may have been deficient.

CONCLUSIONS

Under irrigation, soils derived mainly from granite promote greater vegetative growth by Merlot vines than shale soils. On granite and shale soils, Merlot vines on 101-14 Mgt are more vigorous than on R110. Yield and overall wine quality reflect an interaction between soil parent material and rootstock. The relatively poor growth of the Merlot/R110 vines, and the poor quality of wine from these vines when grown on shale as compared with granite, could have been due K deficiency. Further investigation into the role of K is required.

ACKNOWLEDGEMENTS

The authors wish to thank Winetech and the ARC for their financial support.

Keywords: granite, Merlot, potassium, rootstock, shale, Stellenbosch

A REVIEW OF WEATHER-BASED IRRIGATION SCHEDULING DECISION SUPPORT SYSTEMS

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Irrigation scheduling is a complex, but very important operation to ensure efficient use of scarce water for crop production. Weather-based tools are available to support scheduling decisions (irrigation scheduling decision support systems – ISDSS) but the extent of uptake by growers has been varied. A review of existing ISDSS was conducted with the aim of identifying key features that could enhance the development and implementation of weather-based irrigation scheduling tools.

ISDSS that do not rely on crop model simulations, provide estimates of reference evapotranspiration from daily weather data with tabulated values for crop evaporation coefficients for different crops, growth stages and planting dates. Information is supplied through various media. The information is not field-specific and provides indirect support for scheduling decisions by enabling users to estimate crop evapotranspiration, the soil water balance and irrigation requirements themselves.

Model-based ISDSS simulate crop canopy development, crop evapotranspiration (ET_C), the soil water balance and crop yield using daily weather data and field specific input data. System outputs include ET_C, soil water content (or deficit) and, in some cases, recommended irrigation actions. Information is field-specific and reported through graphs and tables. Systems are either operated locally on desktops (e.g. SWB by Annandale *et al*., 1999) or on central web servers (e.g. PlanteInfo by Thysen & Detlefsen, 2006).

The strengths and weaknesses of the various systems will be highlighted and issues promoting the adoption of ISDSS such as advice content and presentation, ease of use, user support and marketing will be elaborated upon. The findings will assist the refinement and further implementation of the MyCanesim ISDSS (Singels & Smith, 2008) for sugarcane irrigation scheduling.

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Keywords: Irrigation scheduling, decision support, weather, model

STABLE ISOTOPES ($\delta^{15}N$ and $\delta^{13}C$) AS A PREDICTOR OF NITROGEN NUTRITION AND WATER-USE EFFICIENCY (WUE) IN ROOIBOS (*Aspalathus linearis*)

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INTRODUCTION

Rooibos *(Aspalathus linearis)* is a tea legume endemic to the Cape Floristic Region (CFR) where soils are sandy, acidic and low in nutrients. In addition to production of Rooibos tea, *A. linearis* is a raw material in the cosmetic and pharmaceutical industries (Joubert *et al.,* 2008). As a legume *A. linearis* can make a significant contribution to the N economy of soils, thus increase crop yields without the negative effect of chemical fertilisers (Muofhe & Dakora, 1999). Although reports exist on the N nutrition of *A. linearis* there is little information on N fixation and WUE of *A. linearis* cultivated in different locations. The stable $\delta^{15}N$ and $\delta^{13}C$ isotopic signatures of plant samples reveal information about abiotic and biotic controls on the cycling of C and N. In this study therefore, the $\delta^{15}N$ and $\delta^{13}C$ was used to evaluate N nutrition and WUE of *A. linearis*.

MATERIALS AND METHODS

Five shoots of one-, two- and three-year old cultivated *A. linearis* plants were sampled per farm from 20 sites in the Western Cape Province of South Africa. Sub-samples were oven-dried at 60 $^{\circ}$C for 72 h and ground to fine powder (< 0.85 mm particle size) for $\delta^{15}N$ and $\delta^{13}C$ isotope analysis.

RESULTS AND DISCUSSION

Stable $\delta^{15}N$ and $\delta^{13}C$ isotopic signature of plant samples varied among locations, indicating different N-fixed and WUE respectively. Among the one-year old plantations the N-fixed values were significantly higher at Driehoek. Langerberpunt and Heaveld (farm 1) had the highest N-fixed value among two-year old and three-year old plants respectively. Among the one-year old plants the $\delta^{13}C$ values were significantly greater (i.e. less negative) at Heaveld (farm 1). Langerberpunt and Heaveld (farm 2) had the highest (or less negative) $\delta^{13}C$ value among two-year old and three-year old respectively, indicating higher WUE.

CONCLUSION

The differences in N-fixed (predicted by $\delta^{15}N$) and WUE (predicted by $\delta^{13}C$) of plant samples among locations could possibly be due to water availability, soil mineral nutrition and/or ineffective microsymbiont.

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Keywords: Water-use efficiency, $\delta^{13}C$, Isotopic analysis

AN ANALYSIS OF RATOON YIELD DECLINE IN IRRIGATED SUGARCANE: EFFECTS OF CULTIVAR AND ENVIRONMENT

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INTRODUCTION

Sugarcane yields generally decline with successive ratoons, necessitating costly re-planting. Recent grower reports of cultivar differences in ratoon yield decline (RYD) prompted an investigation into such claims. The objectives of this study were to (i) explore trends in RYD under different production conditions over longratoon cycles, (ii) investigate cultivar differences in RYD, and (iii) evaluate a statistical method to detect RYD differences.

MATERIALS AND METHODS

Four cultivar trials were established in South Africa and two in Swaziland in 2003 under different environmental conditions. Trials consisted of six to eight cultivars established in RCBDs with four to ten replicates. Each trial was harvested annually for seven consecutive crops (plant crop plus six ratoons). The tons estimated recoverable crystal yields (TERC) of the five most common cultivars were analysed using an unbalanced analysis of variance (ANOVA) and variance components analysis. Quadratic curves were fitted to capture the RYD trends of cultivars within trials. The differences between the three derived quadratic coefficients for cultivars (averaged over trials) and trials (averaged over cultivars) were analyzed using ANOVA.

RESULTS AND DISCUSSION

The effects of cultivar, site, ratoon, cultivar x site, and site x ratoon were highly significant ($P<0.001$), while the cultivar x ratoon and cultivar x site x ratoon interactions were significant ($P<0.05$). The largest percentage of variation was accounted for by the site x ratoon interaction (34.4%), followed by the site (21.02%), and ratoon (17.41%) main effects, respectively. The cultivar x ratoon interaction only accounted for 0.19% of the variation, showing that RYD was more dependent on site differences than cultivar differences. The fitted curves (r^2= 0.52 to 0.99) captured the RYD trends for the different cultivars. One site showed an improvement in TERC at later ratoons, which was associated with improved management practices. On average, cultivar N25 showed the slowest RYD, while N32 showed the fastest decline. There were no significant differences between cultivars for any of the quadratic coefficients when averaged across sites. When coefficients were averaged across cultivars (i.e. cultivars treated as replicates) there were highly significant differences ($P<0.001$) between sites for all three quadratic coefficients.

CONCLUSIONS

The RYD trends shown in this study have not been reported elsewhere and are more commercially relevant than observations of ratooning in conventional plant breeding trials. The study has shown that RYD varies more between sites than between cultivars. Growers can therefore improve ratooning ability more by optimizing the environment (management), rather than focusing on perceived cultivar differences.

Keywords: Ratoon yield decline, sugarcane, irrigation

WATER STRESS EFFECTS ON GROWTH AND DEVELOPMENT OF SUGARCANE. A REVIEW

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Irrigation water in the Lowveld area of Mpumalanga is often insufficient to meet the demands of crop production. When this occurs, it is important for sugarcane farmers to optimally allocate the limited water to the various fields. This requires knowledge about the response of the sugarcane crop to water stress during different development phases. This paper reviews existing knowledge pertaining to how water stress effects the development and growth processes of sugarcane with a view to identify knowledge gaps.

Water stress reduces tiller population and the number of green leaves per stalk due to decreased rates of tiller and leaf appearance and an increased rate of tiller and leaf senescence (Smit & Singels, 2006). Stalk and leaf expansive growth rates are reduced by mild water stress (leaf water potential (Ψ_L) below – 700 kPa) (Koonjah *et al*., 2006). Water stress decreases photosynthesis (PS) rates when Ψ_L drops below -800 kPa through decreased stomatal conductance (Inman-Bamber & De Jager, 1986). Sucrose accumulation in the stalk is enhanced during mild water stress as PS is not affected as severely as expansive growth, causing photo-assimilates to be stored as sugar rather than being consumed for structural tissue production.

The Canegro model simulates a reduction in tiller population and accelerated leaf senescence during water stress. The model uses process-specific soil water deficit factors to regulate rates of PS and expansive growth, and is thus able to mimic enhanced sucrose accumulation during mild stress (Singels *et al*., 2010). The model also simulates a delay in photosynthetic recovery after a severe stress event.

The review suggests that sugarcane yields are less sensitive to water stress during the tillering phase than during the stalk growth phase because the plant can compensate for reduced tiller and leaf numbers after stress is relieved, but cannot compensate for the loss in stalk mass. An experiment will be conducted to test this hypothesis and to obtain quantitative information for predicting yield response to water stress events of different severity and timing, with the aim of optimizing limited water for irrigated sugarcane production.

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Keywords: expansive growth, irrigation, photosynthesis, plant water stress, sucrose accumulation

AEROBIC DEGRADATION OF BIOCHAR *IN VITRO*

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INTRODUCTION

The inherent stability of biochar against oxidation led to the assumption that biochar is chemically and biologically inert to such an extent, that its mineralization rate was thought to be negligible (Goldberg, 1985). The majority of carbon in biochar is in a highly stable state and has a mean residence time of a 1000 years at a mean annual temperature of 10ºC (Roberts et al. 2010). However, many studies have since then reported on the ability of basidiomycetes to colonize and degrade coal.

MATERIALS AND METHODS

The incubation study was conducted in closed columns installed in a laboratory at room temperature and filled with silica sand amended by addition of 10 wt% biochar. The biochar used was produced from pine wood pyrolized at 450ºC. Microbial inoculation was done with a filtered suspension produced from rotting pine wood. The trial consisted of six treatments, where inoculant, fertilizer and bernessite were added in different combinations. Gas extractions were made from the soil-airspace and the headspace of the column with 5 ml syringes. Gas composition was determined using gas chromatography. Columns were leached once a month for collection of solubilized organics. Total organic carbon (TOC) < 8 µm was determined colorimetrically by the rapid oxidation with spectrophotometric finish.

RESULTS AND DISCUSSION

The abiotic oxidation of biochar by atmospheric oxygen showed no CO_2 production and the only losses of carbon came from the leaching of the water-soluble organics from the biochar. However, the addition of the highly oxidative soil mineral, birnessite led to increases in the amount of leached solubilised organics from the columns and clearly showed that it can facilitate oxidative degradation of biochar. The addition of biochar alone did not stimulate microbial activity, whilst the addition to biochar-amended sand of fertilizer and glucose, to provide the microbial population with the essential elements and a labile C source, significantly stimulated the microbial population and enhanced biochar degradation.

CONCLUSIONS

This study has clearly shown that biodegradation of biochar in aerobic conditions produces not only gaseous, but also liquid products, which were previously disregarded in biochar degradation studies. The rate and volumes of biodegradation are largely controlled by nutrient availability, particularly N and P. The addition of glucose facilitates colonization of biochar, but has no effect at advanced stages of biodegradation. Presence of highly-oxidative soil mineral birnessite has contributed abiotic biochar degradation, but had little effect on biodegradation. The rates of biodegradation observed in columns were comparable to previous short-term observations. Biochar degradation resulted in significant changes in microbial community structure and substantial acidification of the sand/biochar mixture over time. Acidification of the sand/biochar mixture was strongly correlated with amounts of gas and liquid products produced.

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Keywords: biochar, biodegradation

IN VITRO ANAEROBIC DIGESTION OF BIOCHAR BY A METHANOGENIC CONSORTIUM

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INTRODUCTION

The ability of some microorganisms to metabolize coal is a well known since the studies conducted by Potter (1908). The inoculation of coalbeds with methanogens to enhance methane production is a commonly used process referred to as Microbially Enhanced Coalbed Methane production (Scott, 1999). The proposed use of biochar as a soil amendment in agricultural practices and subsequent possible erosion of charcoal into surface water systems and possibly even ground water aquifers, calls for an assessment of biochar degradation in anaerobic conditions and associated gas emissions.

MATERIALS AND METHODS

The trial had a factorial experimental design with all treatments done in triplicate. The trial was conducted at room temperature. The biochar used was produced from pine wood slow-pyrolized at 450ºC. The trial was conducted in 500 ml Erlenmeyer flasks containing 50 grams of granulated methanogenic consortium to investigate the effect of pH and increasing biochar loads (expressed as chemical oxygen demand -COD), on the biodegradation of biochar. The trial consisted of three main treatments assessed over three periods each with increasing biochar loads. The trials were conducted at pH 5.5, 7 and 8. The COD input were increased every 28 days from ±900 to ±1850 to ±2250 $mg \cdot L^{-1}$. N and P were added to all treatments based on carbon loads at the rate of 1000:10:1 (C:N:P). Sampling was done four times within each incubation period. The substrate feed and the effluent parameters monitored with every feed included the following: COD reduction (APHA, 1998), pH, alkalinity (as $CaCO_3$), total biogas produced and its composition.

RESULTS AND DISCUSSION

The greatest COD removal efficiencies were attained from digesters with starting pHs of 7 and 8, whilst the least effective COD removal efficiency occurred at starting pHs of 5.5. The increase in COD input had no significant effect on COD removal efficiencies in any treatment. The methanogenic consortium produced CO_2 throughout the trial, whilst methane production was inhibited for the most part at pHs of 5.5 and 8. Methane production was very erratic at starting pH=7, but occurred more often compared to the other treatments. When methane production did occur the gas composition consisted of 70% CH_4 and 26% CO_2.

CONCLUSIONS

The COD removal efficiency of the digesters was low compared to anaerobic digestion of organic waste, due to the recalcitrant nature of biochar against hydrolytic depolymerisation. We proposed that better control over pH, alkalinity as well as an increase in hydraulic retention time would improve both the COD removal efficiency and methane production. The effects of such parameters temperature, light and pressure should still be investigated.

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Keywords: biochar, chemical oxygen demand

A REVIEW ON THE YIELD AND QUALITY OF THE SPANISH-TYPE GROUNDNUT (*Arachis hypogaea* L.) CULTIVAR TUFA AS DETERMINED DURING 2008-2011

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INTRODUCTION

The Groundnut industry of South Africa relies on a constant supply of high quality Spanish-type groundnuts to provide prospective buyers with the required product. To the producer the most important considerations in cultivar choice are the expected yield and the monetary value of the crop. The value of the crop is largely influenced by the grading quality obtained. Tufa has been released in 2009 into the market and an evaluation of its performance is required. A review on the National Groundnut cultivar evaluation trials was compiled focusing on the yield and grading quality of Tufa.

MATERIALS AND METHODS

Data from the National groundnut cultivar trails for the cultivar Tufa and the control Kwarts were evaluated in terms of yield and grading quality. Standard cultivation practices were used under irrigation and dryland conditions. Information for the localities Burhmansdrif, Douglas, Vaalharts, Hoopstad and Lichtenburg were used for data analysis. Grading procedures according to PPECB standards were used to obtain yield and grading data

RESULTS AND DISCUSSION

It was found that from 2008 till 2011 the average yield for the dryland trials was 3014.09 kg ha^{-1} and for the irrigation trials was 4597.92 kg ha^{-1}.The control cultivar, Kwarts yielded 2440.03 kg ha^{-1} in the dryland trials and 3856.59 kg ha^{-1} in the irrigation trials The average choice grade obtained by Tufa on the dryland trials was 79.37 % while on the irrigation trials an average of 74,82 % was obtained. The control cultivar Kwarts obtained an average choice grade of 78.14 % in the dryland trials and 77.45 % in the irrigation trials.

CONCLUSION

Stability is key for any groundnut cultivar to make a contribution towards a stable groundnut industry. Tufa is a groundnut cultivar that is able to produce a high yield under irrigation as well as dryland conditions with a good percentage choice grade making it a cultivar that will contribute to the stability of the groundnut industry of South Africa.

Keywords: Arachis, grading, quality, Tufa, yield

FUMONISIN PRODUCTION, PATHOGENICITY AND MATING TYPE IN A SOUTH AFRICAN POPULATION OF *Fusarium verticillioides*

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INTRODUCTION

Fusarium ear rot of maize is caused by *Fusarium verticillioides, F. subglutinans* and *F. proliferatum*. Of these, *F. verticillioides* and *F.proliferatum* produce toxic secondary metabolites called fumonisins that are categorized as class 2B carcinogens. *Fusarium verticillioides*is considered the predominant *Fusarium* species isolated from maize in South Africa. The aims of this study, therefore, were to 1) isolate *F. verticillioides* from maize kernels, stems and roots, 2) characterise these isolates by their ability to produce fumonisins, 3) determine their mating type and 4) determine their pathogenicity.

MATERIALS AND METHODS

Maize ears, stems and roots were collected from subsistence and commercial farmers' fields in South Africa. Isolations were made from the kernels, stems and roots, and *Fusarium* species identified using morphological characteristics, species-specific PCR primers and sequencing of the translocation elongation 1-α factor gene. The presence or absence of the *MAT*1, *MAT*2, *FUM*1 and *FUM*19 genes were determined using specific primer sets. Fumonisin production was determined by HPLC. Ten *F. verticillioides* isolates that produced different fumonisin levels *in vitro* were selected for pathogenicity testing and fumonisin production in a field trial.

RESULTS AND DISCUSSION

Fusarium verticillioides was the primary *Fusarium* species isolated from kernels (58%), roots and stems (64%). *Fusarium verticillioides* isolates were divided into five groups, with fumonisin levels ranging between 0 and 2 ppm (65%), 2 and 5 ppm (14%), 5 and 10 ppm (10%), 10 to 20 ppm (8%) and above 20 ppm (3%). All *F. verticillioides* isolates contained the *FUM*1 and *FUM*19 genes. The *MAT*1 gene was present in 56% of the *F. verticillioides* isolates and 44% contained the *MAT*2 gene. The ten isolates used in the field trial were all able to produce ear rot symptoms. The disease severity of GCI51, GCI309, GCI340, MRC826 and GCI1608 and the resultant fumonisin levels of these isolates measured in maize ears had correlation coefficients of above 0.7.

CONCLUSIONS

The majority of Fusarium ear rot fungi collected in South Africa was identified as *F. verticillioides*. The ratio of the mating type genes in the *F. verticillioides* population was almost 1:1. The *F. verticillioides* isolates can produce a wide range of fumonisins (0-35.843ppm) *in vitro* as well as *in planta* (0.59-15.512ppm). In this study, isolates were identified as either low (trace amount of fumonisins) or high fumonisin (>10ppm) producers, which may be used in future trials for selection of resistant maize cultivars.

ACKNOWLEDGEMENTS

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Keywords: Fumonisin, *Fusarium verticillioides*, mating type genes, pathogenicity

EFFECT OF BIOCHAR ON SOIL CHEMISTRY, WHEAT GROWTH AND N FERTILIZER LEACHING OF SANDY SOIL (W. CAPE, RSA)

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INTRODUCTION

Soil degradation in intensive agriculture and associated N pollution of surface and ground waters are particularly acute on sandy soils, which are common in the Western Cape, RSA. The current growing global interest in biochar (BC), pyrolyzed biomass, as a soil amendment is attributed to its potential to permanently sequester C in soils, improve the fertility of degraded soils, and reduce the nutrient leaching (Laird 2008). There have also been some reports on the negative interactions of biochar with certain soil nutrients and toxicity effects. Thus, the objectives of our study were to investigate the effect of applying locally-produced biochar on the fertility of low potential sandy soil from the Western Cape, and to determine the optimum biochar application level. Furthermore, we investigated the effect of biochar on the leaching of inorganic N fertilizer from the sandy soil.

MATERIALS AND METHODS

The biochar (BC) was produced from pine sawmill waste using slow pyrolysis (450 °C). The acidic (pH_{H2O} 5.1), sandy soil (Kroonstad) was taken from Brackenfell, Western Cape, RSA. A wheat pot trial was carried out for 12 weeks using the sandy soil with five BC application levels (0, 0.05, 0.5, 2.5, and 10% w/w) with or without the addition of a broad-spectrum fertilizer. Total above and below ground biomass, leaf and soil nutrients, soil C and N and soil pH were determined. Leaching columns filled with sandy soil and biochar (0, 0.5, 2.5, and 10% w/w) were set-up to determine the effect of BC on N fertilizer (ammonium nitrate) leaching over a period of 6 weeks.

RESULTS AND DISCUSSION

Seedling germination and emergence was not affected by the BC. The addition of BC led to a significant increase in soil pH, water holding capacity, exchangeable basic cations, and P. However, it suppressed N and micronutrient uptake at an application level above 0.05 %, most likely due to the high C:N ratio of BC and over-liming of soil, respectively. The optimum BC application level in the wheat pot trial was 0.5% (app. 10 tha^{-1} to a depth of 15 cm) for the fertilized treatments (21 % biomass increase), and 2.5 % (app. 50 t $ha^{-1}$to a depth of 15 cm) for unfertilized treatments (29 % biomass increase). Biochar (0.5, 2.5, and 10.0 % w/w) also significantly decreased the leaching of nitrate (26, 42 and 95 %, respectively) and ammonium (12, 50, and 86 %, respectively) fertilizer from the sandy soil.

CONCLUSIONS

Biochar has the potential to enhance C sequestration, nutrient and water retention in low potential sandy soils, as shown from the results obtained in the study. However, the majority of biochars are alkaline and have a high C:N ratio, and thus care should be taken when applying it on poorly-buffered sandy soil or without the addition of N. Our findings suggest that an application rate of 10 t ha^{-1} should not be exceeded when applying biochar on acidic, sandy soil.

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Keywords: biochar, carbon sequestration, leaching, soil chemistry, soil fertility, wheat

RESOURCE USE EFFICIENCY OF SUGARCANE COMPARED WITH OTHER CANDIDATE CROPS FOR BIOMASS PRODUCTION: PRELIMINARY RESULTS

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INTRODUCTION

Sugarcane with high dry biomass yields is considered as a possible source of energy in sub-optimal environments and is expected to have better resource use efficiency than 'sucrose-type' sugarcane. In order to test this hypothesis, a set of biomass- and sucrose-type sugarcanes and other candidate crops were screened for their biomass water-productivity (WP_b: total aboveground dry biomass per unit of evapotranspiration) and radiation use efficiency (RUE: total aboveground dry biomass per unit of intercepted solar radiation).

MATERIALS AND METHODS

Dry biomass yield, water use and radiation interception of 14 genotypes (sucrose-and biomass-type sugarcanes, napier grass, sorghum, kenaf and tropical sugar beets) were measured in irrigated bin (at Mount Edgecombe, 16/09/2010–14/12/2010, 5 reps) and field (at Komatipoort, 01/09/2010–04/10/2011, 3 reps) completely randomized trials. Crops were harvested 3 months after planting (bin trial) or at physiological maturity (5–13 months, field trial).

RESULTS AND DISCUSSION

In the bin trial, the sorghums and napier grass achieved significantly higher WP_b than the other crops (5.87–8.67 $kg \cdot m^{-3}$ compared with a range of 1.72–3.57 $kg \cdot m^{-3}$).The ranking of crops for WP_b was similar in the field trial, although differences were smaller (3.53–5.23 $kg \cdot m^{-3}$ compared with 2.17–4.88 $kg \cdot m^{-3}$). In terms of RUE, the sorghums were again the best performers (2.60–3.67 $g \cdot MJ^{-1}$), followed by kenaf (2.92 $g \cdot MJ^{-1}$), the sugarcanes (2.05–3.19 $g \cdot MJ^{-1}$) and sugar beets (1.83–1.94 $g \cdot MJ^{-1}$).Field-determined values for WP_b and RUE for the sorghums and the sugarcanes were comparable with values from the literature (Sinclair & Muchow, 1999). Differences between biomass yields of different sugarcane types confirmed expectations (Alexander, 1985), and the differences in WP_b and RUE between sugarcane types were also significant.

CONCLUSIONS

The preliminary results demonstrate that Big Kahuna sorghum and N31 sugarcane achieve higher resource use efficiencies and seem as promising candidates for biomass production in high potential environments. Future research will explore the performance of selected crops in water stressed environments, as well as the agronomic feasibility of production systems.

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Keywords: biomass water-productivity, radiation use efficiency, sorghum, sugar beet, sugarcane, water use efficiency.

PREFERENTIAL FLOW ASSESSMENT IN SOIL ON FRACTURED BEDROCK AND COVER SAND AQUIFERS

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INTRODUCTION

This study investigates the different flow patterns in the soils found in two contrasting aquifer systems: A fractured bedrock system at the Kogelberg Nature Reserve, Kleinmond, and a cover sand system in Riverlands Nature Reserve, Malmesbury. The results from this research will ultimately contribute to improving the accuracy of ground water recharge estimation and catchment model upscaling.

MATERIALS AND METHODS

Soil surveys were conducted in both reserves during which soils were classified according to South African Soil Classification system. Samples were collected at representative observation points which provided textural data for use in pedotransfer functions (PTFs). These PTFs were used to estimate plant available water (PAW) and hydraulic conductivity (K) for the observed profiles. Infiltration experiments were subsequently done to investigate the infiltration patterns of distinctly different soil forms at two sites from each reserve. The experiments included double ring and mini disc infiltration, volumetric water content determination and flow path visualisation using a staining dye.

RESULTS AND DISCUSSION

The infiltration study showed that shallow, rocky soils that grade into bedrock would have infiltration rates far greater than those estimated using PTFs. This is due to the prevalence of continuous preferential flow (PF) of water in these profiles. Recharge estimates would thus be inaccurate in such soils and calibration using locally derived data is recommended. On the contrary, PTFs produced accurate infiltration estimates relative to measured infiltration rates in deep sandy soils in Kogelberg and Riverlands. It should however be noted that an increase in PF in these soils had subsequently higher K values than estimated, thus illustrating the link between PF and accelerated infiltration rates.

CONCLUSION

These results confirm that using soil survey information, in the form of a soil map illustrating the soil distribution pattern, and calibrated hydrological properties; one can calibrate recharge models by incorporating the large degree of heterogeneity in a given catchment.

Keywords: Preferential flow, fractured bedrock aquifer, cover sand aquifer, infiltration pattern, soil pattern, ground water recharge

GROUNDWATER RECHARGE ESTIMATION USING SOIL PATTERN ANALYSIS

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INTRODUCTION

This research aims to improve the catchment scale hydrological models of two aquifer systems: A fractured bedrock system at the Kogelberg Nature Reserve, Kleinmond, and a cover sand system in Riverlands Nature Reserve, Malmesbury, South Africa. This study focussed on strengthening the link between what is known about a given soil form and the hydrological assumptions that can be drawn from that classification.

MATERIALS AND METHODS

Soil surveys were conducted in both reserves during which soils were classified according to the South African Soil Classification system. Samples were collected at representative observation points which provided textural data for use in pedotransfer functions (PTFs). These PTFs were used to estimate plant available water (PAW) and hydraulic conductivity (K) for the observed profiles. A statistical analysis was performed in order to investigate whether there is a difference between the hydrological properties of the different soil classification units.

RESULTS AND DISCUSSION

A statistical comparison between the hydrological properties (K and PAW) of the different soil forms suggest that hydraulic properties differed between the deep sandy soil forms (Fernwood, Pinegrove and Witfontein in Kogelberg and Witfontein, Concordia and Lamotte in Riverlands) and the shallow rocky soil forms (Cartref and Glenrosa in Kogelberg). Thus, grouping of hydrologically similar units (HSUs) could be done on the basis of the soil forms present within the given catchments. These findings were then implemented by compiling a binary decision tree that serves to interpolate hydrological data based on the soil forms present in a given HSU.

CONCLUSION

These results confirm that soil survey information, in the form of a soil map and calibrated hydrological properties, can be used for delineation of hydrological units that encompass a large degree of heterogeneity in a given catchment. These findings can assist in the upscaling of groundwater recharge models in the respective catchments by allowing accurate interpolation and so improve groundwater management.

Keywords: Preferential flow, fractured bedrock aquifer, cover sand aquifer, soil pattern, soil classification, ground water recharge.

RESISTANCE TO *Ditylenchus africanus* IN GROUNDNUT IN SOUTH AFRICA

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INTRODUCTION

Groundnut is an important cash crop both for commercial and small-scale farmers. The effect of the plant-parasitic nematode *Ditylenchus africanus* on this crop is mainly qualitative, leading to downgrading of groundnut consignments. This nematode is difficult to control due to its high reproduction and damage potential. Growing resistant crops or cultivars is one of the easiest ways to reduce initial nematode population densities and provides an effective alternative for the management of plant-parasitic nematodes in several crops. Currently there are no cultivars available with resistance to *D. africanus*. The objective of a comprehensive study was to investigate the potential of introducing host-plant resistance as an effective and economically-feasible, alternative management tool for *D. africanus* on groundnut.

MATERIAL AND METHODS

Twelve groundnut genotypes selected on the basis of specific breeding traits were evaluated during two seasons against *D. africanus* in micro-plot trials located in Potchefstroom and field trials located in Jan Kempdorp and in Hartswater. The micro-plot trials were artificially inoculated and the field trials had high infestations of the nematode due to regular groundnut cultivation. Nematode and yield assessments were made after harvesting. Nematode data were ln(x+1) transformed before being subjected to an analysis of variance (ANOVA). Means were separated by an LSD test ($P \leq 0.05$). The yield quality of each groundnut genotype was determined according to standard grading procedures for all trials.

RESULTS AND DISCUSSION

Local breeding line PC254K1 and cultivar GC7 were found resistant to *D. africanus*. Both consistently maintained significantly lower nematode numbers compared to the rest of the genotypes tested in this study. Reduced nematode numbers also consistently corresponded with better quality yields from the genotypes. A genotype with probable levels of tolerance to the nematode was also identified and another was confirmed.

CONCLUSION

PC254K1 and CG7 could be used as major sources of resistance to *D. africanus* in the development of new commercial cultivars. Tolerance to the nematode could also be useful in areas of lesser infestation or where crop rotation is practiced more extensively. The groundnut industry and local economies could significantly benefit from this information.

Keywords: breeding, *Ditylenchus africanus*, groundnut, management, resistance

ASSESSING CANOLA SEED LOSS

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INTRODUCTION

Canola growers have raised questions about the difference between the potential yield of canola (as indicated by several seasons of canola cultivar trials) and the actual (or realized) yields achieved. Avoidable seed losses currently exacerbate the perception that canola production is less profitable than wheat production. Harvesting is a critical step in the production of canola (*Brassica napus*) (Thomas *et al*., 1991). Significant seed losses can occur due to natural shedding and due to pod-shatter during the harvesting process. The objective of this trial was to determine the effect of harvesting process and pod treatment at ripening on seed loss in canola.

MATERIALS AND METHODS

The trial was conducted from 2008 to 2010 and consisted of a randomized split plot design with two main treatments (plots harvested straight or following swathing) and four sub-plot treatments that included an anti-shatter agent at three different stages of crop maturity and desiccation of the crop by a herbicide. Potential yield per sub-plot was estimated from 15 randomly selected 1m row lengths harvested from each sub-plot at the optimum swathing time. Actual yield was determined by harvesting each sub-plot with a combine harvester. Calculations of the seed losses pre-harvest and during the harvesting process were done by applying formulas suggested by Riethmuller (2006). ANOVA was used to determine the effects of treatment and their interactions on harvested actual yield, losses before and during the harvesting process and total losses. The Student's t-test (P=0.05) was used to compare treatment means.

RESULTS AND DISCUSSION

Although no significant differences in potential yield were recorded between harvesting methods, swathed canola resulted in higher ($P<0.05$) actual yield (1872 kg ha^{-1}) than the canola harvested without swathing (1716 kg ha^{-1}). Total seed loss differed significantly between the harvesting methods, with swathed canola resulting in lower total seed loss than directly harvested canola. A major factor contributing to these differences was the stormy conditions experienced in the 2009 season which caused severe pre-harvest losses (due to pod shatter) in the plots that were not swathed before harvesting. Analysis of the data on pre-harvest losses and losses during the harvesting process showed no significant difference between the harvesting treatments over the trial period. There were no differences ($P>0.05$) in seed yield among the "anti-shattering agent" and control treatments. The desiccation of the crop showed lower yields than the control treatments.

CONCLUSIONS

Although swathed canola showed higher yield over the trial period than harvesting without swathing, the differences on a year to year basis may vary between the two methods, depending on climatic conditions and management of the crop. The use of anti-shatter agents needs to be investigated further.

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Keywords: canola, harvest, losses, straight, swathed

AN ECONOMIC EVALUATION OF CONTINUOUS CROPPING- AND CROP/PASTURE ROTATIONS IN THE CENTRAL CROPPING REGION OF THE SWARTLAND, WESTERN CAPE

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INTRODUCTION

Winter cereal production has been the basis of rain-fed agriculture in the Western Cape since the 1700s. In the Swartland wheat has been the main crop for the past century and was produced in monoculture with an occasional break of bare fallow or oats pasture, although (bitter) narrow-leaf lupins were widely used in rotation with wheat from the 1950s to the 1970s. The establishment of annual legume pastures (*Medicago* and clover) was encouraged during the land improvement scheme of the 1970s & 1980s with limited success despite extensive research showing the benefits of including such pastures in rotation with wheat. Canola has been promoted as a cash crop in its own right and as a suitable rotation crop since the early 1990s, also with limited success. In this paper we undertook an economic analysis that compares several crop and crop/annual legume pasture rotation systems. This was done in an attempt to determine the potential economic implications of including canola, lupins and sheep production from annual legume pastures into the rain-fed grain production systems of the Swartland.

MATERIALS AND METHODS

No-till production practices are used for all crops in the experiment. The economic analysis compared gross margin levels (considering gross income, and direct- and indirect allocatable variable input costs) of a large-scale, long-term crop rotation experiment. Data from the 2002 to 2010 seasons were included in the analysis. Eight rotation systems were compared, each with a 4-year cycle, viz. 1-wheat monoculture (WWWW), 2-WWWC, 3-WCWL, 4-WWLC, 5-WMWM, 6-WMCM, 7-WMcWMc-1 and 8-WMcWMc-2 (where W = wheat, C = canola, L = lupin, M = medic & Mc = medic /clover mixed pasture).

RESULTS

Canola had similar input costs to wheat, while lupin and sheep production from annual legume pastures had the lowest input costs. Continuous cropping (systems 1 to 4) consistently had the highest input costs except in 2004 and 2006 when there were no differences ($P<0.05$) among systems. In four of the nine years, systems 1 and 2 had higher ($P<0.05$) input costs than all systems that included pastures (systems 5 to 8). System 6 tended to have the lowest input cost over all years. The high cost of fertilizer was a main contributor to input costs for the continuous cropping systems. The highest gross margins were obtained from the crop/pasture systems (systems 5 to 8) in most years although high input costs due to lime and phosphorous applications as well as certain herbicide applications reduced the margins in some pasture systems, in some years. System 1, the monoculture, tended to have the lowest gross margin, and system 8 tended to have the highest gross margin over all years. The continuous cropping system 3 (WCWL) was similar in gross margin to the crop/pasture systems in most years. Four-year "rolling" mean gross margins for the period 2004 to 2007 and 2007 to 2010 confirmed these trends with system 8 (WMcWMc-2) having higher ($P<0.05$) gross margins than system 1 (WWWW) in both periods.

CONCLUSIONS

These results illustrate the benefits of including crops such as canola and lupins, and sheep production from annual legume pasture in the rainfed farming systems practised in the Swartland, Western Cape.

Keywords: crop sequence, *Triticum aestivum, Brassica napus*, annual *Medicago* & *Trifolium* spp*, Lupinus angustifolius*

PREDICTING SOIL ORGANIC CARBON CONTENT FROM LOSS-ON-IGNITION

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INTRODUCTION

Carbon is the backbone of all organic substrates, such as soil organic matter, and is therefore regarded as one of the most important indicators of soil quality (Bone *et al.*, 2010). Current interest in soil quality and carbon sequestration requires standard techniques, with sufficient precision, to measure soil organic carbon (SOC) levels and allow for the evaluation of trends over time (Conyers *et al.*, 2011). The aim of this study was to develop regression equations for predicting SOC content from weight loss-on-ignition (LOI).

MATERIAL AND METHODS

Representative soil samples were taken on the Outeniqua Research Farm near George from Katspruit, Westleigh, Witfontein and Pinegrove soil forms. Sampling depth ranged from 0 to 800 mm in 100 mm increments. The land-use on the Katspruit, Westleigh and Witfontein were 18 year no-till kikuyu-ryegrass pastures. The Pinegrove was a virgin soil associated with indigenous Renosterveld. Soil organic carbon was determined by the Walkley-Black method and LOI was determined by destruction of organic matter in a furnace at 550°C for three hours.

RESULTS AND DISCUSSION

Soil organic carbon contents ranged from 0.09% to 7.22% and LOI values ranged from 0.43% to 12.08%. Significant ($P<0.0001$) linear relationships between SOC and LOI were observed for all soil forms with coefficients of determination (R^2) between 0.750 and 0.976. The slopes of the regressions differed ($P<0.05$) which implies that the relative proportions of SOC differed between soil forms. Intercepts did not differ ($P>0.05$) from zero, suggesting that weight losses due to non-organic substances, such as carbonates, salts and structural water, were negligible. Both analytical methods were highly reproducible with low coefficients of variation.

CONCLUSIONS

The LOI method proved to be a useful indexing method to predict SOC, since it was reproducible and precise. Unique relationships between SOC and LOI were found to exist within different soil forms, illustrated by differences between coefficients between soil forms. As a result, the use of one universal equation for predicting SOC from LOI is not recommended.

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Keywords: No-till pastures, Soil organic matter, Walkley-Black

SELECTION OF COMBINED RUST AND RUSSIAN WHEAT APHID RESISTANT WHEAT LINES USING BOTH MARKER ASSISTED SELECTION AND PHENOTYPIC SCREENING

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INTRODUCTION

Wheat production in the Free State Province of South Africa is hampered by both Russian wheat aphid (RWA) and cereal rusts (Stripe, Leaf and Stem rust). Yield losses as a result of these pests can be significant and should they occur in combination or succession the impact is devastating. Host plant resistance as a single trait for either aphid or rusts has proven effective; however combining multiple resistant genes against different biotic stresses is a primary focus of breeding programmes as this has many advantages for producers. The aim of this study was to select wheat plants containing both resistance to RWA and targeted rust resistance genes within the same generation.

MATERIALS AND METHODS

Complex breeding lines generated from a top-cross between two BC_5 generation lines with RWA resistance (*ex* PI 225227) and rust resistance (Lr34/Yr18, Sr35), respectively were selfed to the F_3 generation. Seeds were planted individually in cones, leaf material from week-old plants were sampled for DNA extraction there after seedlings were screened with RWA biotype RWASA1 in the greenhouse. Concurrently, marker-assisted selection (MAS) with gene specific markers (Lagudah *et al.,* 2009; Zhang *et al.,* 2010) was conducted. Individuals with RWA resistance containing both Lr34/Yr18 and Sr35 genes were identified and grown out for seed increase.

RESULTS AND DISCUSSION

Two hundred and twenty-six lines potentially containing multiple resistance genes for RWA and rusts were genotyped. All plants susceptible to RWASA1 were discarded. Individuals containing both simple sequence repeat (SSR) flanking markers for *Sr35* as well as the gene specific marker for *Lr34*were identified. Plants not containing the required combination were culled. This paper discusses practical use of this methodology by exploring the allelic frequencies of specific gene markers and validates the breeding strategy used in the development of the material.

CONCLUSIONS

Concurrent utilisation of phenotypic screening and MAS can notably speed up the combination of desirable traits by identifying plants with combinations of resistance genes.

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Keywords: Diuraphis noxia, *Puccinia graminis* f. sp. *tritici*, *Triticum aestivum*

TO Bt OR NOT TO Bt, THAT IS THE QUESTION

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INTRODUCTION

One concern about growing GM crops is the potential negative impact that it could have on diversity and abundance of non-target organisms. While most studies assessing impacts of Bt crops have focused on limited numbers of species it is important to also study effects on arthropod communities. This information can be used in risk assessments and to evaluate the possible impact of Bt maize on non-target organisms at different trophic levels. Assessment of the impact of Bt maize on the environment is hampered by the lack of a checklist of species present in maize ecosystems. The aims of the study were to compile a checklist of arthropods that occur on maize and to compare diversity and abundance of arthropods and functional groups on Bt and non-Bt maize.

MATERIAL AND METHODS

Collections of arthropods were done during the 2007/2008 and 2008/2009 growing seasons on Bt and non-Bt maize plants at two localities, *i.e*. Vaalharts in the Northern-Cape and Venda in the Limpopo province of South Africa. The focus was on collecting arthropods that occur on plants during the reproductive stage of plant growth only and therefore only takes into account above-ground on-plant diversity. Three maize fields were sampled per locality during each season. Twenty plants, each of Bt and non-Bt maize, were randomly selected from the fields at each site. Morpho-species were identified and grouped into functional groups: detritivores, herbivores, predators and parasitoids. Priority species for future research was identified following an ecological model approach, using the extensive data base on arthropod species richness and abundance in the receiving environment.

RESULTS AND DISCUSSION

A total of 8771 arthropod individuals, comprising 288 morpho-species and representing 20 orders were collected during this study. Diversity differed between localities, but not between Bt and non-Bt maize. Arthropod biodiversity in maize was high compared to similar studies in other countries. The following non-target functional groups were identified as important for future research: herbivores (Aphididae, Tetranychidae), predators (Anthocoridae, Forficulidae, Coccinellidae, Staphylinidae) and parasitoids (Braconidae and Scelionidae).

CONCLUSIONS

This short-term study indicated that abundance and diversity of arthropods, as well as the different functional groups did not differ between Bt and non-Bt maize.

ACKNOWLEDGEMENT

This work formed part of the Environmental Biosafety Cooperation Project between South Africa and Norway coordinated by the South African National Biodiversity Institute.

Keywords: Arthropods, biodiversity, diversity indices, GM maize, risk assessment, South Africa

A FRAMEWORK FOR DOCUMENTING OF SOIL SERIES

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INTRODUCTION

Objective: The objective of the paper is to present a formal framework to document new and existing soil information and established tacit soil knowledge in an accessible media platform. It will be ideally suitable for regular use by agricultural advisors. The proposed framework will create a platform to accumulate area-based soil technology information for practical soil use applications, while focussing on mean soil property values. The framework will be reliant on existing soil classification classes and standard soil profile description and analysis methods. It will be strongly orientated to using additional location-based information sources including geology, climate, topography and vegetation. It will also be suitable for regular information additions by knowledgeable area-based agricultural advisors. The accumulated information source should be ideally suited to technology transfer applications by agricultural and environmental advisors.

Historical perspective: The earliest definition of soil series in South Africa (pre 1969) recognised Soil Series as a collection of like soil profiles. Soil morphology, analyses and underlying geology were prominent features. They preceded a formal classification system, but were effective as soil technology transfer instruments. Subsequently, the South African Binomial System recognised the series as a class in the classification system. Their main function was to provide a consistent framework for national scale information. The Taxonomic System preferred to define natural soil bodies, effectively limiting the classification to only the soil form with limited soil property class information. Similarly, soil qualifiers also only provide supplementary qualitative information. The proposed framework reinforces soil property values within locally defined soil classes. It departs from the current perception of rigid soil classes within a hierarchal system recognising the importance of additional local natural resource factors in soil formation.

MATERIAL AND METHODS

Materials: The soil information source will be standard internationally recognised profile descriptions and analysis methods. Soil distribution information will be derived soil survey maps and the national land type coverage. Additional geology, climate, topography and vegetation information will be drawn from readily accessible national sources. Standard statistical techniques, GIS and database packages will document the information.

Methods: Within a given geographic area experienced soil scientists should soon be become aware of the dominant soils of the district. Their tacit knowledge will identify the dominant soil form (or forms) and their estimated geographic range. Existing soil and geology maps will indicate the first estimate boundaries, with empirical climate ranges and tacit knowledge providing further refinements.

DISCUSSION AND CONCLUSIONS

The basic framework structure will be illustrated with three soil series tables. Each soil series will document characteristic modal soil property values, generalized soil distribution and a technical assessment in agricultural, urban and environmental land uses.

ACKNOWLEDGEMENTS

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Keywords: Soil series, soil technology transfer, soil property values

BLUE-GREEN COLOURATION IN SOIL: INDICATOR OF MODAL GLEYED/WETLAND CONDITIONS?

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INTRODUCTION

The current definition of the G-horizon in the South African soil classification system refers to the occasional presence of blue-green tints in soil (Soil Classification Working Group, 1991). Their occurrence is linked, in the description, to periods of long saturation with water in the soil profile. In recent literature blue-green tints or mottles in soil are specifically attributed to the formation of Fe(II)-Fe(III) layered double hydroxide (LDH) phases. The generic name Green Rust (GR) has been attributed to this group of Fe(II)-Fe(III) LDH minerals. Developments in the investigation of GR during the past decade yielded that they are stable at Eh conditions of -0.5 to 0.5 V (moderate reduction) and pH conditions of 6 to 11. Two main mechanisms of formation have been proposed in literature (Ruby *et al*., 2010; Antony *et al*., 2008).

OCCURENCE

The presence of GR in G-horizons has been confirmed during numerous soil surveys. A distinct observation regarding their presence is that GR occur in horizons that do not exhibit free flowing water but rather a matrix that is clayey, often structured and in many case not completely saturated with water – even though grey matrix colours dominate. A distinct example was found in soils of a Highveld pan where the soils at the surface were saturated with water (and with a 30 cm of free water on top) while soil material at 40 cm depth exhibited only moist conditions with abundant GR.

DISCUSSION

The current literature on GR as well as the areas where these workers have found it leads to the postulation that there is more variation in saturated soils horizons than currently accommodated in the definition and description of the G-horizon. The potential of using the observed variation in the description of hillslope hydrological processes as well as in expanded modal profile description is elaborated upon and discussed.

CONCLUSIONS AND RECOMMENDATIONS

Blue-green colours in soil only occur under conditions of moderate reduction. The use of GR to expand on modal profile classification and soil hydrology description should be investigated further. An improved understanding of gley morphology of South African soils can improve the assessment of the water regime of wetland soils.

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PROPOSED HYDRIC SOIL INDICATORS FOR THE SOILS OF THE HALFWAY HOUSE GRANITE DOME

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INTRODUCTION

In August 2009 site development and excavation work was stopped on the Pan African Parliament (PAP) site in Midrand, Gauteng. The results of a post impact wetland delineation exercise led to the launching of a criminal investigation by the DEA with the subsequent sentencing of the original environmental assessment practitioner (EAP). During the legal proceedings, the emphasis of the defence team was on the challenging of wetland indicators on the PAP site as identified in the wetland delineation report. Central to the case was the absence of hydric soil indicators for the Halfway House Granite Dome (HHGD) soils not conforming to the thrust of the Wetland Delineation Guidelines (WDG) (DWAF, 2005).

MATERIALS AND METHODS

Soil survey data from approximately 35 free and fixed grid soil surveys conducted on the HHGD were used to generate a conceptual catena for the area. This catena was based on soil sequences along concave and convex slopes as well as combinations of these. Soil samples were collected from 24 selected points on the HHGD and analysed for particle size distribution (7 fractions), organic carbon (Walkley Black) and moist and dry soil colour. The water table was monitored for a year and period and depth of soil saturation calculated.

RESULTS AND DISCUSSION

The soil surveys revealed that the convex slope soils were generally shallow (less than 50 cm to weathered rock, solid rock or ferricrete) and that concave slope soils were generally deeper (more than 50 cm) with a distinct increase in depth towards water courses. Mottling was conspicuously absent (or very feint and diffuse) in most areas but grey colours (although occurring in 80 % of the landscape) increased in intensity towards drainage depressions. The analysis data revealed that the majority of the soils on convex slopes were dominated by coarse sand with less than 8 % clay. Soils on concave slopes exhibited increases in clay content (up to 50 % in some drainage depressions). Organic carbon levels were below 1 % in A-horizons on the convex slopes but increased to more than 1 % (with a distinct reduction in soil colour value) in seepage areas on concave slopes. Borehole data indicated that some upland soils on the PAP site were saturated with water to the surface for 6 months – in line with the definition of a wetland in the National Water Act (NWA).

CONCLUSIONS AND RECOMMENDATIONS

Hydric soil indicators are presented along with topographic indicators for the purpose of elucidating wetland identification, description and functioning on the HHGD. A dedicated publication on the subject will be generated, peer reviewed and published as an aide in the understanding of wetlands in this area to prevent further losses of wetlands to development.

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Keywords: Hydric soil indicators, Halfway House Granite Dome, concave slopes, convex slopes

OCCURRENCE AND IMPLICATIONS OF TOPSOIL/SUBSOIL COLOUR VARIATION ALONG A HILLSLOPE ON THE PLINTHIC CATENA

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INTRODUCTION

The "Catena" (introduced by Milne in 1935) and later incorporated into the description of land types in South Africa (Land Type Survey Staff, 1972 – 2006) is well known in the SA plinthic catena (B land types – Land Type Survey Staff, 1972 – 2006). It is characterised by a grading of soils from red in the highest point in the landscape through yellow soils in midslope positions to bleached (yellow and grey) soils in footslope positions (Fey, 2010). The colour sequence is ascribed to different Fe-minerals stable at increasing degrees of wetness grading down a slope (Cornel and Schwertmann, 2003).

MATERIALS AND METHODS

Soil survey data of 450 observations come from three detailed fixed grid soil surveys in the Mpumalanga Highveld. Soil colour Munsell notation of topsoil and subsoil, master and diagnostic horizons was determined (Soil Classification Working Group, 1991). The colour descriptions were split up in order for the comparison of hue, chroma and value, respectively, for all similar diagnostic horizons as well as for comparison between topsoil and subsoil horizons.

RESULTS AND DISCUSSION

A distinct trend was observed in that Orthic A-horizons overlying Yellow-brown Apedal B-horizons exhibited a marked lighter colour compared to the underlying B-horizon as well as Orthic A-horizons overlying Red Apedal B-horizons. The lighter colour often approached those of Orthic A-horizons overlying E-horizons. This implies that topsoil colour is not indicative of subsoil horizon colour – especially in soils of the Avalon, Clovelly, Glencoe and Pinedene forms. The lighter coloured A-horizons also exhibited a marked lower clay content compared to the underlying B-horizon.

CONCLUSIONS AND RECOMMENDATIONS

The lighter coloured A-horizons on high chroma B-horizons has major implications for the conceptual classification of the soils as well as description of hillslope hydrology and mapping of soils from aerial photographs and satellite images.

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Keywords: Soil colour, soil horizons, hillslope, plinthic catena, bleached colours

OXIDATION AND OTHER PEDOGENIC PROCESSES OF GOLD TAILINGS DAMS

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INTRODUCTION

Although acid mine drainage (AMD) from pyrite bearing tailings dams are known for almost two centuries, only limited success has been achieved in the final and sustainable rehabilitation of these anthropogenic structures. One of the main challenges is to understand and recognise alternative acidification processes and realise that normal soil acidification and pedogenic processes are not dominant or significant.

MATERIAL AND METHODS

Analysis of samples from and modelling of the processes were done on several mine dumps.

RESULTS AND DISCUSSION

Field studies reveal that real AMD from tailings dams is restricted to the outer superficial rind of the tailings dams. Modelling shows that the oxidation rate in the core will take thousands of years to reach the bottom of the tailings dam. This phenomenon results into extreme AMD infiltration and seepage around the toe of gold tailings dams with a relatively inactive core.

CONCLUSIONS

Together with the acidification process, additional pedogenic processes e.g. solubility and mobilisation of some heavy metals are present. Transformation and transportation of elements and minerals are common and this presentation is about the misperceptions and also the extraordinary pedogenic processes in pyrite bearing mine tailings.

THE PHILOSOPHY OF (SOIL) CLASSIFICATION

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INTRODUCTION

Humans classify the objects in their environment. Soils are similarly classified, but unlike other disciplines, with only one system, a myriad of soil classification systems developed internationally. This was probably due to the relatively young nature of Soil Science and to accommodate for the local variations in soil. The soil classification system of South Africa (Soil Classification Working Group, 1991) is in dire need of rejuvenation. The purpose of this paper was to investigate classification systems to guide this rejuvenation process.

DISCUSSION

Categorization takes place by breaking natural continuums into discrete taxa and therefore necessarily involves uncertainty (Roth, 2005). Humans, however, prefer to classify in levels. According to Miller (1956) humans favour 7±2 classes, with a maximum of 15. Classification should also follow the knowledge tree (Drucker, 1990). Soil data should be used to construct information, which can be used to infer knowledge. Knowledge should therefore be the aim, but it should be based on data. Soil classification should also aim to reflect the diversity of soils, their internal and external relations, serve to inventorise the natural resource, thus aiding in its protection and use (Krasilnikov, 2002). Soil properties are continuous and do not form distinct classes. This makes classification difficult, but it can be accommodated by defining a central concept and then classifying the distance from the concept, or through the definition of quantitative borders of an archetype. The first approach leads to fuzzy boundaries, while the second might lead to the artificial separation of natural bodies. Ibanez *et al*. (2008) proposes that intergrades be addressed by the “x” or “notho-“ signs.

CONCLUSIONS

A vast body of knowledge exists on the science of classification and should not be ignored, although this should not be the focus, when the soil classification system is rejuvenated. Based on the literature alluded to here, it is proposed that the rejuvenated soil classification system should: be hierarchical; not have more than seven taxa in each level; be based on data; have knowledge as its aim; and not shy away from intergrades, but address it as such.

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Keywords: classes, hierarchy, taxon, taxonomy

PEDOLOGICAL CRITERIA FOR ESTIMATING SUBSURFACE LATERAL FLOW IN E-HORIZONS IN SOUTH AFRICAN SOILS

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INTRODUCTION

E-horizons formed by reduction and eluviation are generally considered to be an indicator of subsurface lateral flow (SLF) between the A and B-horizons, a hydrological process important in the generating of streamflow in a variety of catchments. There is, however, uncertainty in the interpretation of the hydropedological behaviour of some E-horizons.

METHODOLOGY

This study used a physical index (SLFI) to estimate the importance of SLF in profiles with E-horizons. SLFI was defined as being equal to $\frac{K_{sC}}{K_{sI}} \times (tan\beta \times L)$, where K_{sC} and K_{sI} are the vertical saturated hydraulic conductivity of the conducting and impeding horizons, respectively; and β and L are the slope angle and slope length, respectively. Data was obtained from the Land Type database. The importance of SLF in Podzols was calculated but these profiles were not used in the criteria.

The profiles used for the development of pedological criteria numbered 156 and an additional 80 profiles were used to validate the criteria. SLFI values were determined for the 156 profiles and then divided into three groups, with high medium and low values. Our basic hypothesis was that the individual quantifiable and non-quantifiable soil and landscape properties influencing the pedogenesis of E-horizons, and their integrated pedogenetic expression in soil forms, would be most and least strongly expressed in the profiles of the 'high' and 'low' SLFI groups, respectively. This concept was employed in a unique way to allocate numerical values expressing the estimated importance of the criteria with regard to SLF.

In order to validate the pedological criteria, the 80 test profiles were subjected to a similar procedure to that used to develop the criteria, resulting in an integrated pedological criteria value for each profile which was then correlated against its SLFI value. Selected measured properties, i.e. organic carbon (OC), Fe, Mn and clay content, of the test profiles were also correlated against their SLFI values in the validation process.

RESULTS

Not only did the criteria result in acceptable predictions of estimated interflow importance, but also followed tendencies in some fundamental attributes of E horizons such as the decrease from A to E horizons and an increase from the E to B horizons in organic matter, Fe, Mn and clay contents.

CONCLUSIONS

The criteria develop based on easily observable soil and landscape properties gave a good approximation of the importance of interflow in profiles with E-horizons formed by reduction and eluviation.

Keywords: hydrological behaviour, interflow; Land Type database; PUB; soil properties

RAPID SOIL MAPPING UNDER RESTRICTIVE CONDITIONS IN TETE, MOZAMBIQUE

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INTRODUCTION

The need for large area soil surveys is increasing, especially in areas where no or very little baseline information is available. No longer are soil surveys carried out for agricultural purposes only, but a vast array of disciplines is increasingly using soil maps to support decision making. In some instances land owners are forced to do soil surveys. Soil maps are required by law to be part of environmental impact assessments (EIA's) for various land use changes.

An unrealistic demand for a soil survey, as part of an EIA, to determine the agricultural potential of 370 km^2 possibly land mine infested dense bush created an opportunity to research the potential of digital soil mapping in the Tete Province, Northern Mozambique.

MATERIAL AND METHODS

A free survey was conducted along the available roads of the area. The soil land inference model (SoLIM) was used to derive soil-landscape rules. Based on geology and topography, the area was divided into three prominent areas where different sets of rules applied. A soil map was created using SoLIM. Independant observations were made for validation purposes.

RESULTS AND DISCUSSION

One hundred and fifty square kilometres were mapped with an overall accuracy of 57%. Furthermore, when including borderline observations within one pixel of the correct soil map unit, the accuracy increased to 76%. With a little more time and experience, the accuracy can be greatly improved.

CONCLUSIONS

All soil surveys, irrespective of the scale, extrapolate and interpolate information compiled by data retrieved from soil observations. Digital soil mapping proved to make much more of field observations and tacit knowledge through computer developed soil landscape rules. New methods of soil survey exist whereby large areas can rapidly be mapped to a good standard. Experience will vastly improve the products.

Keywords: Environmental impact assessment, Fuzzy logic, Soil Survey, SoLIM.

NATIONAL-SCALE STRATEGIC APPROACHES FOR MANAGING INTRODUCED PLANTS: INSIGHTS FROM AUSTRALIAN ACACIAS IN SOUTH AFRICA

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INTRODUCTION

A range of approaches and philosophies underpin national-level strategies for managing invasive alien plants. This study presents a strategy for the management of taxa that both have value and do harm.

MATERIALS AND METHODS

Insights were derived from examining Australian Acacia species in South Africa (c. 70 species introduced, mostly > 150 years ago; some have commercial and other values; 14 species are invasive, causing substantial ecological and economic damage). Options for combining available tactics and management practices were considered. The following categories were identified: (1) categories of species based on invaded area (a surrogate for impact) and the value of benefits generated and (2) management regions based on habitat suitability and degree of invasion. For each category and region, strategic goals were identified and combinations of management practices to move the system in the desired direction were proposed.

RESULTS AND DISCUSSION

Six strategic goals were identified that in combination would apply to eight species categories. Furthermore, 14 management practices were identified that could be strategically combined to achieve these goals for each category in five discrete regions. When used in appropriate combinations, the prospect of achieving the strategic goal will be maximized. As the outcomes of management cannot be accurately predicted, management must be adaptive, requiring continuous monitoring and assessment, and realignment of goals if necessary.

CONCLUSIONS

Invasive Australian Acacia species in South Africa continue to spread and cause undesirable impacts, despite a considerable investment into management. This is because the various practices have historically been uncoordinated in what can be best described as a strategy of hope. Our proposed strategy offers the best possible chance of achieving goals, and it is the first to address invasive alien species that have both positive value and negative impacts.

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Keywords: Adaptive management, biological control, biological invasions, ecosystem services, invasive alien species, resource economics.

THE EFFECT OF SOIL TILLAGE AND CROP ROTATION ON THE DEVELOPMENT, YIELD AND QUALITY OF WHEAT IN THE SWARTLAND SUB-REGION OF THE WESTERN CAPE

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INTRODUCTION

Tillage method and crop rotation can be regarded as two important factors that will influence mineralisation of nitrogen in the topsoil. The amount of nitrogen mineralised is influenced by, amongst others, soil aeration and water content of the soil (Garabet *et al*,. 1998) and may therefore differ between systems and tillage methods. As a result of differences in nitrogen mineralisation potential, the productivity of the wheat crop may differ between cropping systems and tillage methods. The aim of this study was to quantify soil nitrogen mine-ralisation potential and wheat productivity as affected by tillage practice and crop rotation.

MATERIALS AND METHODS

This study was conducted during the 2010 and 2011 growing season, as a component study within a long-term tillage/crop rotation trial. In this trial three crop rotations, namely continuous wheat (WWWW), wheat/medic/wheat/medic (WMcWMc) and wheat/canola/ wheat/lupin (WCWL) are allocated to main plots replicated four times. Each main plot is subdivided into four sub-plots allocated to four tillage treatments, namely zero till (soil left undisturbed and then planted with a star-wheel planter for minimal soil disturbance), no-till (soil left undisturbed until planting and then planted with a no-till planter), minimum till (soil scarified March/April and then planted with a no-till planter) and conventional tillage (soil scarified late March/early April, then ploughed and planted with a no-till planter). In the component study wheat after wheat, wheat after medic and wheat after canola were monitored. Soil samples were collected at two weekly intervals, to a depth of 150mm, from just before planting until harvesting. Ammonium-N and nitrate-N content were determined. The samples used to determine nitrogen content, were also used to determine gravimetric soil water content. Leaf area and dry mass production were monitored by sampling 20 plants per treatment combination every four weeks, starting at four weeks after emergence. Total biomass production, grain yield and grain quality were determined after harvesting.

RESULTS AND DISCUSSION

Nitrogen mineralisation shows similar trends between treatment combinations. Except for the conventional till treatment, where nitrogen mineralisation increased towards the end of the growing season, no differences (P=0.05) in nitrogen mineralisation and soil moisture content were recorded between the tillage methods tested. The mineral nitrogen content of the topsoil for all tillage treatment combinations remained within the 20-50 $mgkg^{-1}$ range. The wheat monoculture produced the highest leaf area index for the no-till treatment (1.4), whilst in the rotational systems it was highest in the minimum (1.58) and conventional till (1.55) treatments. The highest biomass was produced under minimum and no-till conditions for the rotational systems, although results were not significant. Grain yields of 2608, 3071, 3154 and 1784 $kgha^{-1}$ (P=0.05) were recorded for the conventional, minimum, no- and zero till treatments respectively. Protein content varied between 10.64 and 11.14% but did not differ significantly (P0.05) as a results of the treatment combinations tested.

CONCLUSIONS

The study showed that conventional till, did not result in higher levels of mineralised nitrogen or moisture content in the topsoil. As a result minimum and no till treatments tend to result in better crop development and higher grain yields.

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Keywords: Biomass, LAI, mineralised nitrogen, soil moisture content.

EFFECT OF ZINC FERTILIZATION ON YIELD AND GRAIN ZINC CONCENTRATION OF MAIZE

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INTRODUCTION

Zinc deficiency is an increasingly important risk factor to agriculture and human health globally. According to a report by the World Health Organization (WHO, 2002) Zn is the most deficient micronutrient in both man and crops and ranks fifth among the most important health risk factors, specifically in developing countries. In general, regions with Zn deficient soils are also the regions where Zn deficiency in humans is widespread (Alloway, 2008). The high and monotonous consumption of cereals with low concentrations and bioavailability of Zn is suggested to be a major reason for Zn deficiency in humans. Cakmak (2008) proposed that grain Zn levels in the range of 40-60 mg Zn kg^{-1} be considered sufficient for human nutrition. Maize is one of the world's most important cereal crops and is highly susceptible to Zn deficiency. Against this background, research was undertaken to study the effect of different Zn application methods on grain yield and Zn concentration of maize grown on Zn-deficient soils in South Africa.

MATERIALS AND METHODS

A trial implemented in 2009/10 to test soil, foliar and combination treatments of $ZnSO_4.7H_2O$ to maize was repeated in 2010/11. In the 2009/10 season, the trials were located on soils with Zn concentrations of 2.6 mg kg^{-1} and 0.7 mg kg^{-1} (DTPA extraction). In the 2010/11 season the trial was repeated at three sites, all with Zn levels that averaged 0.6 mg Zn kg^{-1} in the topsoil. The trial layout was a Randomized Complete Block Design (RCBD) with nine treatments and four replicates. The control which received no Zn was compared to a soil application of 11 kg Zn ha^{-1}, a foliar application of 0.305 kg Zn ha^{-1}, applied at five and again at nine weeks after emergence and a combination treatment of the first two.

RESULTS and discussion

There was no significant effect on the yield of the maize from any of the treatments. The Zn concentration of the grain was significantly increased at two of the trial sites when $ZnSO_4$, was applied as a foliar at five and nine weeks after emergence. At one of the trial sites, grain Zn concentration increased significantly by 26% to 30.0 mg kg^{-1}, compared to the control. Leaf analyses showed that the greatest increase in concentration of Zn was when $ZnSO_4$ was applied as a foliar. Increases in leaf Zn concentrations did not result in a yield increase, which implies that adequate amounts of Zn were available to meet the crop demand, regardless of the method of application. With no yield increase none of the Zn applications were economically justifiable.

CONCLUSIONS

Foliar application of Zn is the most effective way to increase the Zn concentration of the grain. However, the minimum required level of 40 mg Zn kg^{-1} was not achieved and the treatments had no significant effect on the yield of the maize. Before applying Zn to a crop, it is important to measure the Zn status of the soil to increase the likelihood of an economic response.

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EFFECT OF BIOCHAR ON SELECTED SOIL PHYSICAL PROPERTIES OF A LOW POTENTIAL SANDY SOIL

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INTRODUCTION

Globally biochar has been evaluated as a means to improve soil fertility and to mitigate greenhouse gases (GHGs). Little research has been published on the effects of biochar incorporation on soil physical properties. In the Western Cape area (South Africa), low potential, sandy soils are commonly found. The role of biochar in the modification and possible stabilisation of soil structure, especially in sandy soils, is a desirable field of study, especially when events such as root logging, erosion and drought of annual agricultural crop species could be minimised. The objective of this study was to investigate the effect of locally-produced biochar on sandy soil physical properties that contribute to soil quality and sustainability.

MATERIALS AND METHODS

The biochar (BC) was produced from pine sawmill waste using slow pyrolysis (450 °C). The acidic, sandy soil (Kroonstad) was taken from Brackenfell, W. Cape, RSA. A pot trial was carried out using winter wheat for 12 weeks with five different application levels of biochar (0, 0.05, 0.5, 2.5, and 10 % w/w). The water-use was monitored throughout the trial (evapotranspiration and gravimetric water content). The above- and below ground (root structural development) biomass was collected and analysed at harvest. The percentage of water stable aggregates (WSA) and bulk density of the soils was also determined.

RESULTS AND DISCUSSION

Maximum wheat biomass yield was obtained at an application level of 0.5 % BC. The water use efficiency of the wheat plants increased in the 0.05 and 0.5 % BC treatments. There was a highly significant increase in the WSA formation with increasing amount of BC applied. This effect is attributed to the liming effect of the applied BC, along with the increase of exchangeable Ca^{2+} (from the BC) and the fertiliser-derived P that precipitated with Ca due to the increase in pH. There was a significantly higher gravimetric water content in the 2.5 and 10 % BC treatments than the lower BC rates. This can ascribed due to a change in pore structure, namely that more meso- and micro-pores were present as the BC rate increased. The bulk density was only significantly lower for the 10 % treatments. The wheat root systems differed greatly among the fertilised-BC treatments: the 2.5 and 10 % treatments had a more complex fibrous root system (more extensive branching and thinner roots) than 0, 0.05 and 0.5 % application rates. This is attributed to the increased water holding capacity along with a reduction of N and P availability with increasing addition of BC.

CONCLUSIONS

Biochar promoted aggregation in the sand-rhizosphere and increased water holding capacity of the sandy soil. The findings reported here provide new information on the effect of biochar on the structural development of sandy soil, combined with biochar- and root growth effects for winter wheat. The addition of biochar at low application levels (approximately 1-10 t ha^{-1} to 15 cm depth) increased the biomass yield and water use efficiency of winter wheat. Besides long term carbon storage, biochar can have immediate positive effects on the physical properties of sand and plant growth.

Keywords: biochar, soil physics, water-stable aggregates, rhizosphere, wheat