Abstracts:

Poster Presentations

THE INFLUENCE OF SILICON ON *Altenaria alternata* IN CITRUS

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INTRODUCTION

The application of silicon (Si) reduces the severity of diseases in several economically important crops. Several studies in both monocotyledonous (rice and wheat) and dicotyledonous plants (cucumber) have shown that plants supplied with Si can produce phenolics and phytoalexins in response to fungal infection. This suggests that Si could be a possible avenue to mitigate *Alternaria alternata* in the South African citrus industry. Therefore, an experiment to determine the effect of different concentrations of Si, applied to young citrus trees, on *Alternaria alternata* infection was conducted.

MATERIALS AND METHODS

Pathogenicity was tested by inoculating citrus leaves with *Alternaria alternata* according to the method described by Dhingra and Sinclair (1995). Spores of *Alternaria alternata* were cultured on agar in a Petri dish. After seven days of incubation the fungi were carefully removed from the agar surface and filtered through cheesecloth to separate the mycelium and spores. The concentration of the spores was determined using the hemocytometer method to ensure a minimum initial concentration of $5x10^5$ spores mL^{-1}. Citrus leaves were surface sterilized by dipping them in 70% ethanol for 5 seconds. After drying and wounding the leaves by making small incisions to the leaf surface, uniform quantities of the fungi (pure culture) were placed on the adaxial leaf surface using a Pasteur pipette. The experiment was conducted at room temperature and treatments consisted of two citrus varieties ('Fairchild' and a 'Nova' mutant), three Si concentrations (0, 500 and 1000 mg L^{-1}) and five replicates. Fungal growth was measured at 3, 5 and 7 days after inoculation.

RESULTS AND DISCUSSION

Alternaria alternata symptoms were observed on the leaves after three days and the highest disease incidence was observed five days after inoculation. The symptoms observed under controlled conditions were similar to those found under field conditions. Disease severity in both varieties was significantly reduced when the Si was applied at 1000 mg L^{-1}.

CONCLUSIONS

The *Alternaria alternata* isolates used are pathogenic to 'Fairchild' and the 'Nova' mutant and will be used for disease trials under field conditions. Si applied at a concentration of 1000 mg L^{-1} significantly reduces the disease incidence.

REFERENCES

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Keywords: Citrus, *Alternaria alternata*, silicon, pathogenicity

RESPONSES OF LOW NITROGEN TOLERANT AND INTOLERANT MAIZE HYBRIDS TO NITROGEN FERTILISER APPLICATION

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INTRODUCTION

Soils in the maize triangle of South Africa are sandy, thus highly subjected to occasional nutrient leaching that renders them deficient in major plant nutrients. Nitrogen (N) is considered the most limiting nutrient for profitable maize production in most African soils (Irshad et al. 2002). High N application rates are required for optimal crop yields, but this is often impractical for smallholder farmers due to high fertiliser prices This study was carried out to determine the response of low nitrogen tolerant and intolerant maize hybrids to nitrogen application.

MATERIALS AND METHODS

A rainfed field trial was conducted in clay loam soil during the 2012/13 summer season with three low nitrogen tolerant (LNT) maize hybrids (JH1102, JH1104 and CZH0835) and three intolerant (LNI) hybrids (SC403, SCI513 and PAN413) evaluated at four fertiliser levels (0, 40, 80 and 120 kg N ha^{-1}) at ARC-Grain Crops Institute (Potchefstroom). Phosphorus and potassium were applied at optimal rates based on soil test results. Treatments were fitted in a randomised complete block design and arranged in a split-split plot with four replications. Nitrogen fertiliser rates were assigned to the main plots, N tolerance to the sub-plots and maize hybrids to the sub-sub plots. Maize grain yield was determined at physiological maturity with protein content of physiological mature maize kernels determined using a near-infrared reflectance (NIR) grain analyser.

RESULTS AND DISCUSSION

The interaction effect of fertiliser, N tolerance and hybrids was not significant for maize grain yield and protein content. Nitrogen tolerance had a significant ($P<0.01$) effect on grain yield, while N fertiliser and N tolerance had significant ($P<0.001$) effects on protein content. Plots fertilised with 40 and 80 kg N ha^{-1} showed a 7% grain yield advantage over plots receiving 120 kg N ha^{-1}. Grain yield from the LNT hybrid plots was consistently higher than that of the LNI hybrids regardless of the N fertiliser application rate. The response of grain protein percentage to N fertiliser application rates followed a similar pattern. The LNT hybrids showed the highest grain yield of 4.39 t ha^{-1} with 80 kg N ha^{-1}, while the highest grain yield of 3.93 t ha^{-1} with 40 kg N ha^{-1} was obtained for the LNI hybrids. The LNT hybrids showed marginal grain yield increases with no N fertiliser application and at the lowest application rate (40 kg N ha^{-1}), but increased by 27% and 15% when fertilised at 80 and 120 kg N ha^{-1}, respectively. Generally, the LNT hybrids planted with no N fertiliser application gave marginal grain yield advantage over the LNI fertilised at 80 and 120 kg N ha^{-1}. Average grain yield ranged from 3.45 to 3.93 t ha^{-1} for the LNI hybrids, while it varied between 3.52 t ha^{-1} to 4.39 t ha^{-1} for the LNT hybrids. Mean protein percentage ranged from 9.4 to 11% and 9.8 to 11.5% for the LNI and LNT hybrids, respectively.

CONCLUSIONS

Low soil N tolerance of a maize hybrid has a profound influence on its final grain yield and protein content. Using clay loam soil, the LNT hybrids could be planted with no N fertiliser application and still give comparable grain yields to that of the LNI hybrids fertilised at 80 and 120 kg N ha^{-1}.

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Keywords: Fertiliser rates, maize grain yield, maize hybrids, low N tolerance, grain protein content

EVALUATION OF MAIZE PRODUCTION UNDER LARGE-SCALE RAINWATER HARVESTING AND CONSERVATION TECHNIQUES

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INTRODUCTION

Less than 15% of South Africa's land area is arable. This implies very limited scope for conventional food production. In addition, South Africa is a semi-arid, water-scarce country with an average rainfall of less than 500 mm per annum (Schulze *et al.*, 1997). Rainwater harvesting and conservation (RWH&C) practices have not only been demonstrated to increase agricultural production but also to be environmentally sustainable. This study seeks to assess RWH&C techniques for improved cropland productivity.

MATERIALS AND METHODS

Cropland field experiments were carried out over four seasons (2008/09 - 2011/12) in three provinces on the Glen/Swartland, Glen/Oakleaf, Fort Cox/Oakleaf, Towoomba/Hutton and Towoomba/Arcadia ecotopes to compare RWH&C techniques. Five treatments, *viz.* conventional tillage (*CON* – control), in-field rainwater harvesting (*IRWH*), Daling plough (*DAL*), mechanized basins (*MB*) and minimum/no-till (*MIN/NT*), replicated four times, were laid out in randomized block designs. Maize was used as the test crop and the indicators used were grain yield and rainwater productivity (RWP).

RESULTS AND DISCUSSION

Field preparation, implementation, planting, maintenance and harvesting went well with the implements only posing minor practical problems. Variations in yields and RWP were recorded between seasons, as well as between localities. The general trend clearly demonstrated that RWH&C techniques produced higher grain and RWP values, compared to *CON*. *IRWH* performed the best followed by *DAL*, *MB* and *MIN*/*NT*. *IRWH* performed better on the loam to clay soils while *DAL* permed better on the sandy soils.

CONCLUSIONS

Results indicate that RWH&C techniques induced higher yields and RWP values than *CON* with *IRWH* and *DAL* being the most effective.

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ACKNOWLEDGEMENTS

Water Research Commission; Department of Agriculture, Forestry and Fisheries; Provincial Departments of Agriculture of Free State, Eastern Cape and Limpopo for funding and collaboration.

Keywords: Conservation tillage, maize, rainwater harvesting

SEED QUALITY OF A BAMBARA GROUNDNUT LANDRACE DIFFERING IN SEED COAT COLOUR

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INTRODUCTION

Bambara groundnut (*Vigna subterranea* L.) is an underutilised African legume that fits the same ecological niche as the exotic *Arachis hypogea*. It is drought tolerant and has been suggested as an exemplar underutilised crop for promotion in marginal areas of agricultural production. In South Africa, it is still cultivated using landraces, and little is known about their seed quality characteristics. The aim of this study was to evaluate seed quality characteristics (viability and vigour) of a local bambara groundnut landrace on the basis of seed coat and speckling colour

MATERIALS AND METHODS

A bambara groundnut landrace was purchased from Capstone Seeds (Mooi River) and separated into four selections (plain red, plain cream, black speckled and brown speckled) based on seed coat and speckling colour. The standard germination test was performed using 25 seeds (x4 replicates) of each selection in a germination chamber set at 25°C over a period of 10 days. Electrolyte conductivity (EC) was measured hourly using 20 seeds of each landrace selection over a 24 hour period. Seed imbibition was evaluated using two imbibition methods (seed testing water bath and seed soaking) using 10 (x3 reps) seeds per landrace selection. Seeds were imbibed for 0 (control), 30, 60, 120, 240, 480, 960, 1 920, 3 840, 7 680 minutes on a seed testing water bath and 0 (control), 60, 120, 180, 240, 300, 360, 420, 480, 540, 600, 660, 720 minutes using the seed soaking method. Seeds were weighed at each interval and their water activity (a_w) determined. Electron microscopy was used to determine seed coat thickness.

RESULTS AND DISCUSSION

There were highly significant differences ($P<0.001$) among landrace selections with respect to germination, EC as well as imbibition and water activity. Black speckled seeds and the plain cream landrace selection had the highest and lowest final germination (87% and 67%), respectively. The brown speckled landrace selection had the highest EC (1 400 μs/g) while the plain cream landrace selection had the lowest EC (36 μs/g).. The imbibition rate and water activity showed much fluctuation. Electron microscopy showed that the brown speckled and plain cream landrace selections had the thickest (116 μm) and thinnest (107.9 μm) seed coats, respectively.

CONCLUSIONS

Seed quality in bambara groundnut is associated with seed coat colour. Darker coloured seeds showed better viability while the plain cream selection was more vigorous. The variations in seed quality observed in this bambara groundnut landrace justify the need to develop a framework for seed quality selecting in bambara groundnut. . Results of this study are useful for immediate seed selection by farmers and long term crop improvement for the seed industry. Future research will focus on field trials to confirm results of this preliminary study under field conditions.

Keywords: Bambara groundnut, colour, speckling, seed quality

CREATING NEW NAVEL ORANGE VARIETIES VIA SOMACLONAL VARIATION

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INTRODUCTION

The South African citrus industry produces a wide range of citrus products. However, there is still a constant search for new and improved varieties. Therefore the Agricultural Research Council (ARC) - Institute for Tropical and Subtropical crops (ITSC) Citrus Scion Breeding program aims at breeding and selecting new superior quality citrus varieties.

Navel oranges are exceptional fresh fruit. Their deep orange flesh, easy peeling rind and sweet pleasant flavour make them popular among consumers. However, due to the complex biology of this group of oranges, breeding new varieties using conventional breeding is virtually impossible. Navel oranges are mostly pollen sterile and set parthenocarpic fruit. While chance seeds obtained in navels are generally polyembryonic and the resulting seedlings are of nucellar origin, the resulting plants are essentially clones of the seed parent. Therefore alternative methods need to be sought to develop improved navel varieties.

MATERIALS AND METHODS

Plantlets can be produced by isolating undeveloped ovules from sectoral chimeras and culturing them *in vitro*. Somaclonal variation through selecting ovules from sectoral chimeras can been used to obtain genetic variability in these navel varieties. At the ARC-ITSC in Nelspruit, immature ovules were extracted from seedless Cara-cara navels and cultured on a suitable medium. The young seedlings were later transferred to the ARC-ITSC Addo Research Station at Addo and micro-grafted onto rootstocks in the glasshouse. Once the trees were strong enough they were planted in the Forcing House at Addo for evaluation.

RESULTS AND DISCUSSION

To date four new navel selections, containing a fine textured, soft and juicy flesh, have been made from these seedlings. Two of these selections are promising and are being evaluated further.

CONCLUSION

The harnessing of somaclonal variation, via the culture of immature ovules as obtained from chimeric sectors is a viable method for developing improved citrus varieties, especially for varieties such as navels that are difficult to improve through conventional breeding.

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Keywords: Breeding, citrus, culture, ovule, polyembryonic

EFFECT OF ETHEPHON APPLICATIONS ON LEAFY LITCHI FLOWER PANICLES AIMING TO REMOVE LEAVES AND INCREASE FLOWERING AND FRUIT SET – PRELIMINARY RESULTS

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INTRODUCTION

Leafy flower panicles occur in litchi when temperatures during flower initiation are not low enough. Leaves on flower panicles are a stronger sink than fruit and can reduce fruit set. Leafy flower panicles are easily induced in the cultivar Mauritius by early flower emergence during autumn when temperatures are not consistently low enough. Such panicles do not only grow long, but also use starch reserves and as a results have low fruit set. In order to avoid poor flowering and fruit set due to leafy panicles, leaves can be removed either mechanically by hand or chemically by plant growth regulators. Chemical removal of leaves has been successfully done in China. The aim of this study therefore was to determine the effect of Ethephon on leafy flower panicles to remove leaves and increase flowering and fruit set.

MATERIALS AND METHODS

The trial was conducted in the Malalane area on various growth stages and lengths of flower panicles during the 2009 litchi season. The growth stages were: small buds < 0.5 cm, small leafy panicles < 10 cm, big leafy panicles > 10 cm, pure flower panicles any size (without leaves), small leafy panicles with leaves removed by hand, big leafy panicles with leaves removed by hand. Ethephon was applied at concentrations of 125, 250, 500, 750 and 1250 ppm to 20 panicles of all stages.

RESULTS AND DISCUSSION

With increasing Ethepon concentrations, the percentage flowering was reduced in all panicle stages. The highest concentration caused a high mortality of panicles, especially on pure flower panicles. Hand removal of leaves did the least damage and caused high numbers of flowering and fruiting panicles. Ethephon application to small buds reduced flowering. Among the leafy flower panicles, which are the main target for Ethephon sprays, concentrations between 125 and 500 ppm caused the highest percentage of flower panicles, leafless flower panicles of the total amount of flower panicles and fruit panicles. Number of fruit per panicles was highest in treated leafy flower panicles.

CONCLUSIONS

The preliminary results show that there is merit in removing leaves on leafy flower panicles as flowering and number of fruit per panicle can be increased. Ethephon was shown to be effective in removing leaves from leafy flower panicles, thereby improving flowering and fruit set. In order to verify these results, the trial should be repeated including more concentrations and untreated panicles for each growth stage.

Keywords: Ethephon, flowering, leafy flower panicle, *Litchi chinensis* Sonn., temperature

THE EFFECT OF FOLIAR SPRAYS ON VASE LIFE AND THE OCCURENCE OF STEM TOPPLE IN CUT TULIPS

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INTRODUCTION

Stem topple, in which the flower stem lacks rigidity, is a serious physiological disorder in cut tulips which reduces the already short vase life (Iwaya-Inoue and Takata, 2001). This disorder has been found to be especially prevalent in tulips grown hydroponically in South Africa (Van Wyk 2012, personal communication). The collapse of the flower stalk is described as a symptom of calcium deficiency, and is characterized by the curvature of peduncles during flowering (Gomez-Merino et al., 2009). The aim of this study was to determine the efficacy of foliar fertilizer sprays to mitigate stem topple and thus extend vase life.

MATERIALS AND METHODS

Various foliar sprays, including calcium nitrate ($CaNO_3$), CalTrain and NonTox Silica® were evaluated for their effect on the occurrence of postharvest stem topple and their efficacy in extending the vase life of two Triumph tulip cultivars, 'Jumbo Pink' and 'Strong Gold'. These plants were grown in a standard Steiner nutrient solution. The trial was conducted in a split-plot design.

RESULTS AND DISCUSSION

Cut tulips treated with foliar fertilizer sprays which contained calcium, such as $CaNO_3$ and CalTrain, had a significantly longer vase life (2 days), and reduced postharvest stem topple by as much as 22% compared to the control. In addition, the mean day of first flower removal from the vase was significantly longer for $CaNO_3$-treated stems (day 6.44) compared to control stems (day 4.31). This value has important implications for the vase life guarantee offered by retailers. Cultivars differed significantly in terms of vase life. With cultivars 'Strong Gold' and 'Jumbo Pink' having mean vase lives of 11.2 and 7.15 days respectively.

CONCLUSIONS

Calcium containing foliar sprays proved effective in extending the vase life and reducing the incidence of post-harvest stem topple of cut tulips that were grown hydroponically under South African conditions. Future research should be focused on evaluating the use of higher concentrations of boron, in combination with calcium-containing foliar sprays for increased efficacy in reducing stem topple and increasing vase life.

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Keywords: Stem, quality, vase life, calcium, CalTrain, CaNO3, NonTox Silica®

EVALUATION OF HERBICIDES AND HERBICIDE APPLICATION TECHNIQUES FOR CONTROL OF LEAFROLL INFECTED GRAPEVINES

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INTRODUCTION

Grapevines infected with leafroll virus are on the increase. This virus has a pronounced negative effect on grape quality and the productive lifespan of grapevines (Over de Linden and Chamberlain 1970). The danger of the virus being spread from infected grapevines to adjacent healthy ones necessitates fast and effective removal of these grapevines. Mealy bug carrying the virus may survive on live root remnants remaining after infected grapevines were removed mechanically. At present no herbicide is registered for the control of grapevines in existing vineyards or on soils to be re-planted with grapevines. The aim of the study is to identify herbicides that can kill both the above-ground growth and the root system of infected grapevines, without affecting the young grapevines replacing them, negatively.

MATERIALS AND METHODS

Based on the results of phase one of the trial, nine treatments, consisting of different herbicide/application technique/time of application combinations, were applied to six year old recently infected (two seasons or less) Chardonnay/ Ramsey vines established on a medium textured soil.

RESULTS AND DISCUSSION

The post-harvest (end of March) basal stem application of the 2% solution of triclopyr (480g/L) in diesel took a year to kill all roots to a depth of 200 mm (2010) and 300 mm (2011). During the 2010/11 season, most roots were controlled in the 300-900 mm soil layer as well. A post-harvest foliar application of the 80 g/L picloram and 80 g/L fluroxypyr mixture controlled the grapevine roots to a depth of 200 mm and depending on the season, some of the roots were killed to a depth of 500 mm. The Cabernet/Richter 99 vines which replaced the treated grapevines showed no phytotoxic or leaf-roll symptoms. This was attributed to the fact that no live roots were presentin the 0-200 mm soil layer on which the mealy bug could survive on.

CONCLUSIONS

There are indications that climatic variation between seasons could affect herbicide efficacy. The post-harvest basal stem treatments with triclopyr as a 2% solution in diesel and the mixture of 80 g/L picloram and 80 g/L fluroxypyr should be registered for the control of leafroll infected grapevines.

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ACKNOWLEDGEMENTS

Thanks to Winetech and ARC for funding the research and Me. R. Carsten for visual identification of the leaf-roll infected grapevines.

Keywords: Grapevines, herbicides, leaf-roll virus, phytotoxicity

EFFECT OF MANAGEMENT PRACTICES APPLIED TO COVER CROPS SELECTED FOR BIO-FUMIGATION ON WINTER GROWING WEEDS

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INTRODUCTION

Bio-fumigation with cover crops is an alternative for the chemical control of nematodes (Lazzeri et al. 2004). Cover crops is also an alternative for chemical weed control (Fourie 2010), which may help control herbicide resistant weeds. The aim of the study is to determine the weed control efficacy of cover crops selected for their ability to bio-fumigate the soil and the resultant species composition of the weed community.

MATERIALS AND METHODS

The trial was executed on a sandy soil near Stellenbosch. Two management practices, namely full surface chemical control from grapevine bud break (CC) and slashing followed by two way mechanical cultivation with a disc harrow during grapevine bud break, as well as full surface chemical control from November (MC), were applied to each of five cover crops. Two treatments, namely no cover crop (MC) and no cover crop (CC) were also applied.

RESULTS AND DISCUSSION

The *Lolium* species (ryegrass) were totally suppressed by *Avena sativa* L. cv. Pallinup (Pallinup oats) (CC) and *Eruca sativa* cv. Nemat (CC). *Euphorbia peplus* tended to be suppressed in the CC treatments compared to that of the MC treatments. Pallinup oats and *Brassica napus* cv. AVJade allowed *Raphanus raphanistrum* to become dominant, whereas *Sinapis alba* cv. Braco (mustard) and *Brassica juncea* cv. Caliente199 allowed the ryegrass to become either dominant or one of the most dominant species. With the exception of the mustard cover crop treatments, the ryegrass in the MC treatment of a cover crop tended to be higher than that of the CC treatment.

CONCLUSIONS

When selecting a cover crop for bio-fumigation, the ability to compete with herbicide resistant ryegrass should be taken into account. The effect of different soil management practices on the weed population over the long term needs clarification.

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ACKNOWLEDGEMENTS

Thanks to Winetech and ARC for funding the research.

Keywords: Cover crops, grapevines, soil management, weed control

EFFECT OF IRRIGATION ON THE PERFORMANCE OF SELECTED COVER CROPS IN THE BREEDE RIVER VALLEY

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INTRODUCTION

Irrigation frequency during winter and the water distribution pattern of the system affect cover crop performance in the semi-arid grapevine regions (Fourie 2005). Approximately 25% of the vineyards in South Africa are drip irrigated. Cover crop management in the drip irrigated vineyards of the Breede River Valley is a challenge. The aim of the study was to determine whether cover crop management can be applied in a sustainable manner in the drip irrigated vineyards of the Breede River Valley.

MATERIALS AND METHODS

The trial was carried out in a 14 year old Chardonnay/99 Richter vineyard established on a sandy clay loam soil near Robertson (33°50'S, 19°54'E). Twelve treatments consisting of four cover crop species irrigated by means of three irrigation systems were applied.

RESULTS AND DISCUSSION

Triticale v. Usgen 18 produced acceptable amounts of dry matter with 157 mm of rain during winter. Fifty percent of the rain occured during the first eight weeks with intervals not exceeding a fortnight, whereafter the dry intervals did not exceed three weeks. Relatively high rainfall from October to December enabled *Chrysopogon zizanioides* to establish successfully where no irrigation was applied to the vine row (DV). Irrigation in the work row improved dry matter production by 257%. *Phalaris aquatica* produced between 57% and 93% more fibre when irrigated with micro-sprinklers (MV), compared to where sub-surface drip irrigation was applied in the work (DW) and DV, respectively. *Atriplex semibaccata* established successfully within one summer with monthly precipitation varying between 0.8 mm and 23.9 mm. High summer rainfall or DW, enabled the species to produced sufficient amounts of fibre. The grass cover crops controlled the weeds effectively, irrespective of the irrigation method applied. However, *Atriplex semibaccata* was suppressed by weeds with an upright and dense growth habit.

CONCLUSIONS

Triticale v. Usgen 18 and *Phalaris aquatica* should be considered for cover crop management in vineyards where drip irrigation is applied in the vine row. Sub-surface drip irrigation in the work row may also be considered to improve cover crop performance.

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ACKNOWLEDGEMENTS

Thanks to Winetech and ARC for funding the research.

Keywords: Cover crops, grapevines, irrigation method, weed control

INFLUENCE OF BAMBARA GROUNDNUT (*Vigna subterranea* (L) Verdc.) SEED COLOR ON GERMINATION

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INTRODUCTION

Bambara groundnut is an indigenous African legume with a wide adaptation to different environments. It is popular among subsistence farmers in sub-Saharan Africa but little research is done on this crop. The crop is still cultivated from landraces, with no improved cultivars available. The objective of this study was to compare seed performance of three different seed colors of Bambara groundnut.

MATERIALS AND METHODS

Seeds of Bambara were divided into three distinct color groups namely cream, brown speckled and black speckled seed. For the standard germination test 25 seed of each color were selected and replicated four times. Seed was germinated between germination papers at 25°C for 8 days where after germination percentage were calculated. The electrolyte conductivity (EC) of 50 seeds from each colour was measured over a period of 24 hours to determine electrolyte leakage of the seed. Germination speed, as defined by the germination velocity index (GVI) was calculated according to the formula by Maguire (1962).

RESULTS AND DISCUSSION

Germination percentage and the germination velocity index (GVI) significantly differed between the different colored seed. The values determined for germination in black speckled (86.67%) and brown speckled (77.33%) seeds were significantly different ($P<0.001$) from the cream (66.67%) seeds. These results showed that the darker coloured seeds had a faster germination rate. Electrolyte leakage differed significantly ($P<0.001$) amongst the bambara groundnut seed colour selections. Brown speckle seeds had the highest EC value (616.2 μSg^{-1}) and cream had the lowest EC value (27.5 $\mu S\ g^{-1}$). This implies that, based on results of electrolyte leakage, brown speckled seeds had lesser vigour than black speckled and cream seeds, respectively.

CONCLUSION

Bambara seed germination is associated with seed colour. Seed colour can be used for germplasm selection to grow the crop under various conditions. Darker coloured seed were more vigorous than light coloured seed, therefore farmers may use darker coloured seeds for fast emergence which is directly proportional to higher yields.

Keywords: germination percentage, germination velocity index, electrical conductivity, seed vigour, electrolyte conductivity

MAIZE SEED GERMINATION AS AFFECTED BY AGE, CULTIVAR AND SEED DRESSING WITH CHLOTHIANIDIN

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INTRODUCTION

Clothianidin is an insecticide registered as a seed dressing on maize and sorghum giving a broad-spectrum of insect control to pests such as wireworm and cutworm. Most seed companies in South Africa use either an insecticide or fungicide, or both as seed dressings and deliver the seed already treated to producers. Seed dressings such as clothianidin can assist seed vigour, ensuring uniform germination and seedling establishment (density) that will in turn lead to higher yields. The aim of this study was to compare and evaluate maize seed germination treated with a new product from Villa Crop Protection containing clothianidin and the registered product of Bayer, (Poncho® 600 FS).

MATERIALS AND METHODS

Untreated seed of three Pioneer Hi-Bred cultivars was treated with Villa Clothianidin 600 FS and Poncho® 600 FS, according to label instructions. Seed dressings of each cultivar (2400 per cultivar) were done to accommodate 400 seeds per seed treatment, including a label rate, double the label rate of each product, as well as a control treatment (untreated seed). After drying, samples of each product treatment were divided again (1200 seed per cultivar) and stored at 15 °C for one year. Germination tests were done on the remaining seeds (fresh) according to the International Seed Testing Association's Rules (2011). Shoot and root lengths were measured and expressed as a percentage of the untreated control treatments. After one year, germination tests were done on the stored samples (stored) to evaluate the effect of storage on maize seed with seed dressing. Data were subjected to an ANOVA to determine significant differences between the means at P=0.05.

RESULTS AND DISCUSSION

Fresh seed: Cultivar had the greatest effect on germination parameters. Germination percentages ranged between 91 and 99% and did not differ significantly between seed dressing treatments for both products and dosage rates. A significant interaction was recorded between seed dressing treatments and cultivars with regard to root length.

Stored seed: Cultivar still had the greatest effect on germination parameters, except for shoot length. Germination percentage only differed significantly between seed dressing products and dosage rates at four days after seeding, but not at seven days. Mean germination percentages between cultivars and seed dressing treatments and dosage rates varied between 92 and 94%.

CONCLUSIONS

Treated maize seed stored for one year had slightly lower germination percentages than treated fresh seed, but was still commercially acceptable (greater than 80%). Seed germination percentages were similar between clothianidin products and dosage rates, and only varied among cultivars.

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Keywords: cultivars, germination, clothianidin, seed age

EVALUATION OF AGRONOMIC PERFORMANCE OF NEWLY DEVELOPED SOUTH AFRICAN POPCORN HYBRIDS

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INTRODUCTION

Economic production of popcorn in developing countries is hampered by lack of adapted local varieties. Planting of varieties that are not adapted to stress-prone environments in sub-Saharan Africa, leads to major crop failures in the predominantly tropical region. Agronomic traits such as grain yield and secondary traits need to be evaluated before popcorn varieties can be recommended for production. The objectives of the study were to determine variability and evaluate agronomic performance of newly developed popcorn hybrids.

MATERIALS AND METHODS

The 119 F_1 hybrids were planted at Cedara Research Station and Ukulinga Research Farm during 2011/2012 summer season. The hybrids had been developed from eighty-seven inbred lines. A widely grown commercial hybrid (P618) from the USA was included as the control. Experiments were laid in 10x12 alpha lattice design with two replications at each site. Each experimental plot was 15 m long. Plants were spaced 30 cm apart within the rows and 90 cm between the rows. Standard cultural practices recommended for dent maize were applied. The following traits were recorded: grain yield, ear length, plant height, days to mid-pollination, ear position, number of ears per plant, stem lodging, shelling percentage and northern corn leaf blight (NCLB). Data was analyzed using Proc GLM procedure in the SAS statistical package. Analysis of variance (ANOVA) was done to determine differences among hybrids considering all agronomic traits.

RESULTS AND DISCUSSION

The hybrids differed significantly (P = 0.01) for most agronomic traits. Means for grain yield ranged from 1.0 to 5.2 t ha^{-1}. The hybrid 11POPH20 had the highest yield of 5.2 t ha^{-1} which was 80% more than the control hybrid (P618) with a mean yield of 2.9 t ha^{-1}. The mean yield for the trial was 2.7 t ha^{-1}. Significant variability is important since it provides an opportunity to improve popcorn hybrids through selection.

CONCLUSIONS

The study indicated significant differences between popcorn hybrids for all agronomic traits, which increase chances to improve popcorn hybrids through selection. Hybrids with better resistance to NCLB disease and yield compared to the control were identified for advancement in the breeding programme.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation and the KwaZulu-Natal Department of Agriculture and Environmental Affairs.

Keywords: Maize hybrids, popcorn agronomy

DEVELOPING MOLECULAR MARKERS FOR THE IDENTIFICATION OF *Digitaria sanguinalis* AND *D. nuda*

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INTRODUCTION

Large crabgrass (*Digitaria sanguinalis* (L.) Scop.) and naked crab grass (*Digitaria nuda* Schumach.), are both important grass weeds in maize production. While large crabgrass can effectively be controlled chemically, naked crabgrass is often poorly controlled. Morphological similarities between the two grasses, especially during the early seedling stages, often result in incorrect identification and subsequently poor weed control. This can lead to significant yield losses, especially in maize crops where these grasses have an overlapping distribution. The use of RAPD (Random Amplified Polymorphic DNA) markers as a tool for fast and correct identification of these grasses at an early stage is investigated in this study.

MATERIALS AND METHODS

Young leaves (seven to eight weeks old) from *D. sanguinalis* and *D. nuda* were harvested and genomic DNA extractions were performed using the CTAB method. Sixteen primer sets were evaluated and PCR products were initially viewed on agarose and polyacrylamide gels. Polymorphisms was then measured based on the banding patterns observed.

RESULTS AND DISCUSSION

The RAPD markers were able to amplify regions of the genomic DNA. From these amplification products, differences and similarities which exist between the two species could be characterised. The differences in the bands were not as clearly visible when agarose gels were used during electrophoresis and were replaced with polyacrylamide gels.

CONCLUSION

RAPD markers can be used for species differentiation between *D. sanguinalis* and *D. nuda*. Correct identification of grass species can assist producers in the decision making process of weed control and timely application of herbicides to minimize the risks of crop yield losses.

Keywords: Digitaria nuda, Digitaria sanguinalis, RAPD markers

SOIL AND MINE WATER ASSESSMENT FOR PROPOSED COMMUNITY AGRICULTURAL PROJECTS

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INTRODUCTION

GCS Water and Environmental Consultants (GCS) was appointed by a South African coal mine in KwaZulu-Natal to assess the feasibility of irrigating community agricultural projects with excess water emanating from two mine shafts. The agricultural projects support existing subsistence and small-scale commercial agriculture in the surrounding communities, for which further, arable land is being sought. Regulatory requirements have necessitated a strategy at the mine for water conservation and re-use. The region receives summer rainfall of approximately 700mm per annum, is hot and dry, and dominated by bushveld, grassland and deep, well-drained soils.

MATERIALS AND METHODS

Three underground water samples were taken at one mine shaft only, since water quality data were already available for the others. The samples were analysed for pH, alkalinity, acidity, bicarbonate, calcium, magnesium, potassium, sulphate, manganese, iron, Total Dissolved Solids (TDS), Electrical Conductivity (EC), sodium, chloride, fluoride, aluminium, nitrates, nitrites and silica. The water quality of the main storage dam was also assessed for these parameters. Soil was surveyed and sampled on a proposed agricultural site of 18.4ha; while existing data were available for alternate sites. No irrigation occurs currently at these grassland sites. The soil was sampled to a depth of 30cm, and sampled for pH (KCl), calcium, magnesium, potassium, sodium and phosphorus, and particle size distribution was calculated. Water volumes from each source were made available.

RESULTS AND DISCUSSION

The soils analysed at the potential, new agriculture sites were classified as predominantly well-drained Oakleaf soil forms, with Katspruit soil forms also present. The water quality indicated elevated EC, TDS, sodium, chloride, fluoride and aluminium. When compared against Department of Water Affairs water quality guidelines, the quality indicated saline conditions (>540mS/m or TDS of 3000mg/l), but suitability for irrigation with limitations. When implementing management measures, planting more tolerant crops (tomato and spinach), using drip irrigation and monitoring EC and soil conditions could result in crop yields of up to 90%, compared to ideal growing conditions. Based on climate and crop requirements, it was calculated that available volumes are adequate to irrigate the 14.5 ha suitable for cultivation. The main storage dam indicated compliance with DWA irrigation standards. The option of blending water from the shafts with water from the main storage dam to improve the reliability and quality of the water was investigated. As water volumes from each source are unpredictable, a 'Water Blending Spreadsheet with Fitness-for-Use Criteria' was created. This can be used to blend volumes of water from the abovementioned sources in order to meet water quality standards for agricultural use.

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CONCLUSIONS

It is possible to re-use excess shaft water for the purpose of vegetable irrigation. Saline water conditions, however, require specific management for agriculture. Water blending according to the 'Fitness-for-Use Criteria' would provide a solution for ameliorating saline conditions, when required, to ensure optimal re-use of water. Implementing the proposed strategy would provide local communities with a food source for the life of the mine, while ensuring regulatory and mine processing requirements are met.

Keywords: Mine, reuse, soil, water

TRENDS IN TOTAL SOIL CARBON ACCUMULATION IN DIFFERENT SHORT ROTATION CROP AND CROP/PASTURE SYSTEMS AT LANGGEWENS IN THE SWARTLAND

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INTRODUCTION

Wheat monoculture, with an occasional break of bare fallow or oats pasture, under conventional tillage management has resulted in total soil carbon levels dropping to below 0.5% in the Swartland during the middle 1990's. The introduction of crop rotation with alternative crops such as canola, annual legume pastures (annual Medicago and annual clover species) and lupin under minimum till and no-till management practices has the ability to improve the soil carbon content. It was thus the aim of this study if the soil carbon content could be improved using these production systems.

MATERIALS AND METHODS

In this poster we compare changes in % soil carbon content over time as recoded in the long-term crop rotation trial on the Langgewens research farm. This was done in an attempt to determine the potential implications of including alternative crops and conservation agriculture tillage methods on soil carbon content in the rain-fed production systems of the Swartland. Data from the 2000 to 2010 seasons were included in the analysis. Soil organic carbon content in top 150mm of the soil profile was determined using the Walkley Black method. Eight rotation systems with 4-year cycles were compared, 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 AND DISCUSSION

All systems tested showed increases in total soil carbon content over time. The monoculture wheat system, with no crop rotation, showed the lowest % soil carbon accumulation when compared to the other systems that included alternative crops in rotation. Systems that included pastures tended to be more proficient in the accumulation of soil carbon. Cash crop systems tended to accumulate carbon slower which might be attributed to disturbance of the soil by a planter in two of the four years, added to the lower total plant residues from lupin and canola left on the soil surface.

CONCLUSIONS

The inclusion of alternative crops in rotation with wheat improves the % soil carbon over time. The general trend in all the systems tested above is that it will take longer than 30 years for the soil carbon content to improve by 1 percentage point.

Keywords: % soil carbon, crop rotation, conservation agriculture

THE EFFECT OF SOIL COVER ON MEDICAGO PASTURE RE-ESTABLISHMENT UNDER CA PRACTISES IN RAIN FED CONDITIONS

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INTRODUCTION

Medics are used as a rotational crop in pasture rotations with wheat, oats and barley under rainfed conditions of the Western Cape. At present conservation agriculture (CA) become a very popular production system in the Western Cape. Conservation agriculture consists of three principles: Continuous minimum soil disturbance with tillage implements; growing different crops in rotation and create a permanent soil cover by using the residue from previous crops. To qualify as a CA system a soil cover of at least 30% in required, but to achieve all benefits higher soil cover is recommended. The benefit of medics in rotations is that it will re-establish after a year or two of alternative crops without any re-planting. But, by leaving the residues from the previous year's crop on the soil surface, the re-establishment and ultimately production of the medics may be affected. For this reason an experiment was conducted to determine the effect of different sources and levels of residue cover on the re-establishment of medics in a CA production system.

MATERIAL AND METHODS

The research was done at the Tygerhoek Experimental farm (Riviersonderend, Southern Cape). As main plots, the re-establishment of medics was determined after wheat (WM), barley (BM) or oat (OM) crops in two-year rotation systems as well as after two years of medics (MM) which was preceded by a grain crop in a three-year rotation system. Sub-plots (1x1m) with different residue levels (0%, 25%, 50%, 75% and 100% residue cover) were created. Re-establishment (%) was determined by calculated the counted number of medic seedlings per plot as a percentage of the number medic seedlings established in seedling trays without any residue cover under optimum conditions for germination.

RESULTS AND DISCUSSIONS

The results show a reduction in medic re-establishment with 100% residue cover. While re-establishment with residue cover levels of 0%, 25%, 50% and 75% did not differ significantly. Possible causes for the reduction may be physical obstruction due to the residue cover; lower light intensities; allelopathy or higher incidence of insect pests and diseases. Re-establishment of medics was also affected by residue source with the highest re-establishment after a wheat crop (WM) followed by barley (BM) and oats (OM). The poorest re-establishment was in medic residue (MM). Barley is known for its allelopathic ability which may cause the lower re-establishment. The poor re-establishment in medic residue (MM) may be because of more pests or pathogens.

CONCLUSIONS

The source and level of residue cover had an effect on the medic re-establishment. Because a minimum soil cover of 30% is required in CA systems, a 75% cover with wheat residue will be best suited for medic re-establishment in CA systems.

Keywords: Conservation agriculture, residue cover, medic re-establishment

PROPAGATION POTENTIAL OF SWEET POTATO (*Ipomoea batatas* [L] Lam) CULTIVARS IN LIMPOPO

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INTRODUCTION

Deficiency of vitamin A in humans is widespread in South Africa, leading to impaired immune response. Orange fleshed sweet potato (OFSP) cultivars that are rich in ß-carotene, a major precursor of vitamin A (Low *et al*., 2001), can be incorporated into diets amongst the rural poor. However, production of OFSP in Limpopo province is currently insignificant probably due to unavailability of planting material of high yielding improved cultivars. The study aimed to evaluating vine multiplication potential of improved OFSP cultivars.

MATERIALS AND METHODS

The experiment was conducted during the 2010/2011 cropping season at the University of Venda's experimental farm, Thohoyandou (22° 58.081'S, 30° 26,411'E and 595 m asl), Limpopo Province, South Africa. Three improved OFSP cultivars (Impilo, Bophelo, Dagga) and one cream cultivar (Mvuvhelo) were established in nursery blocks (2.5 plants m^{-2}) and followed by continuous propagation, first to the base blocks and then to the nursery blocks. The experimental plots had 20 plant rows, each 6m long and 1m apart. The following parameters were measured on three demarcated rows on each replicated block at monthly intervals: stem thickness, number of marketable cuttings and marketable weight of the cuttings. The four cultivars were considered as four populations and the data was analysed as a randomized split-plot with sampling dates as the sub-plot factor using Genstat Release 11.1.

RESULTS AND DISCUSSION

There were no significant differences in stem thickness, number of stem cuttings and marketable weight of stem cuttings amongst the four cultivars at all sampling dates. However, sampling dates affected ($P<0.05$) stem thickness, number of stem cuttings and marketable weight of stem cuttings. Thicker stems were obtained at 8 months after planting, MAP (5.6 mm) compared to 7 (5.1 mm) and 6 MAP (5.0 mm) as expected. Unexpectedly, more cuttings were collected at 6 (60) than at 8 (20) and 7 (15) MAP. Similarly, marketable weight of stem cuttings was greater at 6 MAP (800g) compared to 8 (320g) and 7 MAP (200g). The lower number of stem cuttings and marketable weight of stem cuttings at 7 MAP could probably be due to drought that was experienced during this period (Amante, 1994).

CONCLUSIONS

The four cultivars showed good vine multiplication potential through production of high number of cuttings with good marketable weight. In addition, the study showed that harvesting time is important in determining vine yield in this environment.

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ACKNOWLEDGEMENTS

The authors would like to thank the Dept of Science and Technology for funding this study.

Keywords: ß-carotene, marketable weight of stem cuttings, number of stem cuttings, stem thickness

A SURVEY TO DETERMINE UTILIZATION AND MANAGEMENT OF INDIGENOUS LEAFY VEGETABLES IN LIMPOPO

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INTRODUCTION

Indigenous leafy vegetables play an important role in ensuring intake of various essential vitamins and mineral elements. However, there are some species that are consumed by the communities but not scientifically identified. Therefore, the objectives of this study were to identify indigenous leafy vegetables utilized by rural communities in Limpopo Province and to determine plant species collected from the wild or cultivated for use as leafy vegetables, medicine, cultural role, their management practices and marketing.

MATERIALS AND METHODS

The study was conducted in three districts namely Capricorn, Sekhukhune and Vhembe, during May – July 2013. Three villages were identified from each district to conduct the survey, 45 households, utilizing these vegetables were interviewed from each village, making a total of 135 households per district. The following information was gathered during the survey; identification of indigenous leafy vegetables, their medicinal uses, cultural purposes, cultivation practices and their marketing. SPSS was used to analyze the data using descriptive statistics.

RESULTS AND DISCUSSION

Forty-five indigenous leafy vegetables utilized as relish were identified in the three districts. Twenty one are cultivated while the other 32 are collected from the wild. Some of the collected species from the wild are being considered for domestication as they are highly preferred but supply is limited. In Capricorn 83% and in Sekhukhune 92% prefers spider plant and in Vhembe, Capricorn and Sekhukhune 54.7%, 50% and 62% prefer amaranth respectively. Cowpea, amaranth, black jack and pumpkin are the 4 commonly utilized as relish. Some ILVs are utilized only in certain districts such as nightshade in Vhembe district while spider plant is utilized in Capricorn and Sekhukhune districts. Some of these ILVs can be used for medicinal purposes such as treating, high blood pressure, ear infection, tooth ache, etc. Furthermore, ILVs can also be used for cultural purposes across tribal groups e.g. searching for ancestors and smoothening baby delivery. Most of the respondents (76.3%) from Vhembe indicated that tractors are used to prepare the land before and during planting and 84% and 50% from Sekhukhune and Capricorn use hand hoes, respectively. Few apply irrigation while most stated that they depend on rain-fed cropping, but in Vhembe 78.9% use furrow irrigation while 51% and 73.4% use relay on rain-fed in Sekhukhune and Capricorn. The fresh or dried ILVs are sold locally by villagers.

CONCLUSION

There are many indigenous leafy vegetables found in Limpopo of which people utilize them as their source of food, use as medicine, cultural roles and as their family income.

Keywords: Utilization, indigenous leafy vegetables, medicinal roles, cultural role, management practices, marketing

PLOIDY OF PRUNUS ROOTSTOCKS

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INTRODUCTION

"Marianna" and "Maridon" plum rootstocks are two of the most common rootstocks used in the South African stone fruit industry. "Maridon" was developed from the “Marianna" rootstock in the 1960s (Hurter, 1969) using pollination experiments which led to "Maridon” having a different number of chromosomes (triploid), and different DNA content, in its nucleus. This led to the new variety having different characteristics to "Marianna". Recently, "FeherBesztercei", a semi-dwarfing rootstock for apricot and plum, was introduced to South Africa. Since the ploidy of this rootstock is unknown, the aim of the investigation was to determine its ploidy by comparing it with plum rootstocks with known ploidy levels.

MATERIALS AND METHODS

To determine the ploidy level, "FeherBesztercei", nuclei suspensions were prepared from leaf samples of the three rootstocks. Protocols for ploidy determination by flow cytometry were derived from recommended methods from the manufacturer (Partec). DAPI (4',6-diamidino-2-phenylindole) was the fluorescent stain used for staining nuclei. Young leaves of "Marianna" and "Maridon" were used as controls.

RESULTS AND DISCUSSION

The control samples clearly demonstrated that flow cytometry could be used to distinguish the two closely-related diploid ("Marianna") and triploid ("Maridon") rootstocks using histograms. From these results it could be established that "FeherBesztercei" is a hexaploid**.**

According to our knowledge this method has not been used before to distinguish between "Marianna" and "Maridon".

CONCLUSIONS

The results show that flow cytometry is a suitable method to distinguish between closely-related varieties which differ on chromosome ploidy level.

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ACKNOWLEDGEMENTS

We wish to thank THRIP and NRF for funding of this project

Keywords: Chromosome; Flow-cytometry; Rootstocks

INFLUENCE OF PLANT DENSITY AND HARVESTING METHOD ON YIELD OF BASIL (*Ocimum basilicum*) GROWN IN A CLOSED HYDROPONIC SYSTEM

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INTRODUCTION

Soilless cultivation of leafy vegetables in a closed hydroponic system has gained interest and popularity with farmers due to improved yield and quality (Maboko & Du Plooy 2013), as well as efficient use of water and nutrients. An understanding of plant response to plant density and harvesting method is important in developing cultural practices for improved yield of hydroponically grown basil. A study was thus conducted in a shade-net structure in order to evaluate the effect of plant densities and harvesting methods on basil when grown in a closed hydroponic system (gravel-film technique).

MATERIALS AND METHODS

This study was conducted during September to December 2012 (spring/summer season) and repeated January to April 2013 (summer/fall season) in a 40% black and white shade net structure. Seedlings were transplanted 30 days after sowing into a gravel-film technique hydroponic system, as described by Maboko and Du Plooy (2013). Ten treatment combinations were used, including two leaf harvesting methods (tipping and cutting) and five plant densities (10, 16, 20, 25 and 40 plants.m^{-2} at plant spacings of 40 x 25 cm, 25 x 25 cm, 20 x 25 cm, 20 x 20 cm and 10 x 25 cm, respectively). A randomised complete block design with four replicates was used. Tipping is a standard method of harvesting basil and it is done by plucking off the growing points of the shoots or harvesting the terminal leaves with little stem tissue (Davis 1991), while cutting was done by first cutting the plants at a height of 15 cm, with sequential cutting at 5 cm above the previous cutting.

RESULTS AND DISCUSSION

During the spring/summer season, the results showed no significant differences in plant growth and total yield per unit area at plant densities of 20, 25 or 40 plants.m^{-2}. Results during the summer/fall season showed the highest leaf fresh mass, leaf area and total plant fresh mass at the highest plant density of 40 plants.m^{-2}. Harvesting method did not have a significant effect on yield, or on the total fresh and dry mass of basil. Results demonstrate that a plant density of 40 plants.m^{-2} improved growth and yield of basil significantly during the summer/fall season. However, during the spring/summer season, a plant density of 20 and 25 plants.m^{-2} will be more cost effective, with no significant effect on yield.

CONCLUSIONS

Plant density recommendations are therefore 40 plants.m^{-2} during the summer/fall season, and 20 or 25 plants.m^{-2} during the spring/summer season.

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Keywords: Gravel-film technique, leaf area, leaf fresh mass, plant spacing, yield

VARIATION IN SOIL PHOSPHATASE ACTIVITY OF *Wiborgia leptoptera, W. mucronata* AND *W. sericea* SPECIES OF THE CAPE FYNBOS

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INTRODUCTION

The genus *Wiborgia* has about 26 shrub legume species that are indigenous to the Fynbos biome of the Western Cape Province of South Africa. Of the 26 species, only ten are accepted, including *Wiborgia leptoptera*, *W*. *mucronata*, and *W*. *sericea* that are found mostly in the mountain fynbos of the Cape fynbos biome. The genus belongs to the family Fabaceae and as a legume, *Wiborgia* has a potential to contribute N to the fynbos ecosystem through the biological nitrogen fixation process, a process which demands high P levels. The Cape fynbos biome however, has reportedly low plant-available P levels of 0.00004 to 0.00037% (Cramer, 2010). Using natural stands of legumes endemic to the Cape fynbos biome, Maseko and Dakora (2013) reported *Cyclopia* and *Aspalathus* species to produce and increase phosphatase activity for enhanced rhizosphere and shoot P levels. This study evaluated soil acid and alkaline phosphatase activity of *Wiborgia leptoptera*, *W*. *mucronata*, and *W*. *sericea* species of comparable age in the mountain fynbos of South Africa.

MATERIALS AND METHODS

Rhizosphere and non-rhizosphere bulk soil was collected from different locations with natural stands of *Wiborgia leptoptera*, *W*. *mucronata*, and *W*. *sericea* species. Acid and alkaline phosphatase activity was measured in fresh soils using a method by Tabatabai (1994).

RESULTS AND DISCUSION

The data (p=0.05) revealed significantly marked variation in phosphatase activity between rhizosphere and bulk soil as well as between rhizosphere of the three test *Wiborgia* species. For all three species, rhizosphere phosphatase activity was markedly greater than the bulk soil. Acid phosphatase activity was statistically higher in rhizosphere of *Wiborgia sericea*, followed by *W*. *leptoptera* and least in *W*. *mucronata*. Both the *Wiborgia leptoptera* and *W*. *sericea* species showed similar alkaline phosphatase activity in their respective rhizosphere soils whilst *W*. *mucronata* exhibited the least alkaline phosphatase activity compared to its counterparts in the Cape fynbos.

CONCLUSION

The three test *Wiborgia* species varied in their exudation of extracellular phosphatase activity and all exhibited greater phosphatase activity in their respective rhizosphere soil than bulk soil.

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Keywords: Wiborgia, Cape fynbos, phosphatases, phosphorus

GENOTYPIC VARIATION IN RHIZOSPHERE PHOSPHATASE ACTIVITY OF SELECTED GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES GROWN IN MPUMALANGA AND GAUTENG PROVINCES

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INTRODUCTION

Many soils of the Mpumalanga and Gauteng Provinces are acidic, with high Al and Fe concentrations and high P absorptive capacity, which results in low plant-available P in the soil solution (McGee, 1972). However, P is the second most important nutrient element after N, and is important for groundnut growth, as well as for symbiotic establishment and nodule functioning (Weisany *et al*., 2013). Among other P-solubilizing strategies, symbiotic legumes secrete phosphatase enzymes under low-P conditions in order to release soil-bound P for uptake by roots (Maseko and Dakora 2013). This study assessed the ability of selected groundnut genotypes to produce acid phosphatases for improved P nutrition, and evaluated genotypic variation in acid phosphatase activity at kwa-Mhlanga and Bronkhorstspruit in Mpumalanga and Gauteng Provinces, respectively.

MATERIALS AND METHODS

Bulk and rhizosphere soils of groundnut varieties ICGV 07390, ICGV 07395, ICGV 07296, ICGV 07406, ICGV 07396, ICGV 07404 and Kwarts were sampled from kwa-Mhlanga and Bronkhorstspruit in April 2013. The rhizosphere soils were collected from five plants per plot for enzyme assay. Acid and alkaline phosphatase activity were determined for rhizosphere and bulk soils using the method of Tabatabai (1994).

RESULTS AND DISCUSSION

Acid and alkaline phosphatase activities were significantly greater in the rhizosphere soils of varieties ICGV 296 and ICGV 395 than the others at Bronkhorstspruit. At kwa-Mhlanga, however, it was genotypes ICGV 395, ICGV 406 and ICGV 390 that exhibited higher acid and alkaline phosphatase activity, especially when compared to variety ICGV 296. Furthermore, the rhizosphere acid phosphatase activity of groundnut varieties ICGV 07296, ICGV 07390, ICGV 07395, ICGV 07396, ICGV 07404 and ICGV 07406 were markedly greater at Bronkhorstspruit than kwa-Mhlanga. Similarly, the alkaline phosphatase activity in the rhizosphere of genotypes ICGV 07296, ICGV 07395, ICGV 07396 and ICGV 0740 was significantly higher at Bronkhorstspruit than kwa-Mhlanga. However, the activity of this enzyme was similar for genotypes ICGV 07390 and ICGV 07406 at both study sites. We also found that all the test ICGV-genotypes showed significantly higher rhizosphere acid and alkaline phosphatase activity than their Kwarts counterparts at the kwa-Mhlanga experimental site. As to be expected, the acid and alkaline phosphatase activities of groundnut rhizosphere soils were significantly greater than non-rhizosphere bulk soil at both experimental sites.

CONCLUSION

These results indicate that one there was a higher phosphatase activity in the rhizosphere soils of the test groundnuts than in the bulk soil. One mechanism used by groundnut to enhance P nutrition in low-P soils is the secretion of acid phosphatases into the rhizosphere for cleaving and solubilizing particle-bound P. This trait was found to vary between genotypes and study sites.

ACKNOWLEDGEMENT

The South African Research Chair in Agrochemurgy and Plant Symbioses, the National Research Foundation and Tshwane University of Technology are duly acknowledged for their financial support.

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Keywords: Groundnuts, phosphorus, acid and alkaline phosphatases

SCREENING CHICKPEA (*Cicer arientinum* L.) GENOTYPES FOR ENHANCED SYMBIOTIC PERFORMANCE USING 15N NATURAL ABUNDANCE

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a food grain legume that is cultivated for human consumption. Its yields are however generally poor due to low soil nutrient status, especially in N and P. Although the application of chemical fertilizers could overcome nutrient limitation in soils, their high cost combined with unavailability has reduced their use by resource-poor farmers in Africa (Nyemba et al., 2010). Chickpea has the ability to fix atmospheric N_2 when in symbiosis with compatible rhizobium species, particularly strains of *Mesorhizobium ciceri*. However, N_2 fixation in chickpea can be limited by low rhizobial populations and high soil nitrateThe aim of this study was to screen chickpea genotypes for N_2 fixation under field conditions in Mpumalamga Province.

MATERIALS AND METHODS

Field experiments were conducted in the low and highveld regions of Mpumalanga. A randomized complete block design was used with four replicate plots per genotype. The rows were spaced at 50 cm apart and seeds planted at 10 cm apart. At 50% flowering, five plants were excavated, and separated into roots and shoots. The shoots were oven-dried at 60 °C, weighed and finely ground (0.45 mm sieve) for $^{15}N/^{14}N$ isotopic analysis using mass spectrometer. Non-legume plant species were sampled and used as reference plants for determining soil N uptake by the legume.

RESULTS AND DISCUSSION

The $d^{15}N$ values of shoots were significantly low and negative in lowveld area for both 2011 and 2012, indicating the reliance of chickpea on N_2 fixation for its N nutrition. Chickpea dependency on N_2 fixation improved across all locations in 2012, with much higher amount of N derived from fixation (%Ndfa). The amounts of N-fixed varied considerably between and among genotypes, as well as across the three sites, an indication that there was also a location effect. The amounts of N-fixed were influenced by soil N content and plant population, and were lower than those reported for *kabuli* genotypes in other studies.

CONCLUSION

Although a few genotypes did not fix atmospheric N_2, over 50% of the test chickpea cultivars depended more on symbiotic N than soil N for their N nutrition.

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The South African Research Chair in Agrochemurgy and Plant Symbioses, National Research Foundation, and Tshwane University of Technology are acknowledged for their financial support.

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Keywords: kabuli genotypes, N-fixed, N2 fixation, 15N natural abundance

INTERACTION EFFECT OF SEAWEED EXTRACT AND BRADYRHIZOBIA INOCULATION ON GROWTH AND NODULATION OF COWPEA UNDER FIELD AND TUNNEL-HOUSE CONDITIONS

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INTRODUCTION

Cowpea has the ability to improve soil nitrogen economy through biological nitrogen fixation by forming a symbiotic relationship with beneficial soil micro-organisms, such as the *Rhizobia* species. Seaweed extracts are cheap, easy to apply and have been found to improve plant growth and soil microbial activity (Alam *et al*., 2010). The aim of this study was to investigate the interactive effect of seaweed extract and rhizobia inoculation on growth and nodulation of cowpea.

METERIALS AND METHODS

Two experiments (field and pot experiments) were carried out during the 2012/13 planting season with three treatment factors namely; i) Cowpea varieties (Brown landrace, Bechuana-white), ii) Inoculation and iii) Seaweed extract concentrations (0:0 v/v, 1:500 v/v, 1:100 v/v) were combined (2X2X3 factorial) and arranged in a randomized complete block design, with four replicates. The seaweed extract was applied as root drench at planting, 14 and 28 days after planting. Data were subjected to analysis of variance to determine treatment effect using STATISTIX program V10.

RESULTS AND DISCUSSION

Independent applications of seaweed extract and rhizobia inoculation had a significant effect on the number of active nodules, CCI as well as root and shoot biomass accumulation. Application of 1:100 v/v seaweed extract concentration in the presence of Bradyrhizobia inoculation under tunnel-house conditions resulted in a 56.67% increase in the number of active nodules/plant and 27.12 % increase in CCI/plant. Similar trends were observed under field conditions with a 64.43% increase in the number of active nodules/plant and 25.18% increase in CCI/plant. These effects are due to components such as plant hormones and amino acids which play a role in modulating specific metabolic pathways in both the legume and the bacterium, resulting in enhanced growth and *rhizobium*-legume symbiosis.

CONCLUSIONS

The application of seaweed extract in the presents of Bradyrhizobia inoculation could result in improved growth and nodulation of cowpea.

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Keywords: Cowpea, inoculation, seaweed extract, nodulation, Technikelp

THE NITROGEN FERTILIZER VALUE OF MUNICIPAL SEWAGE SLUDGE AS INFLUENCED BY POST TREATMENT DRYING TECHNIQUES

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INTRODUCTION

The use of sewage sludge in agricultural lands is widely practiced around the world. The benefits of its use include acting as a source of micro and macro nutrients, as well as a source of organic matter which can improve the chemical, physical and biological properties of the soil and minimize soil erosion. The sludge biochemical composition is influenced by different sludge treatments and the origin of the water treated. The aim of the study was to evaluate the effect of different treatments and drying techniques on the biochemical composition of sewage sludge organic matter.

MATERIAL AND METHODS

Four sludge materials were used. These included: one activated sludge (Unstable sludge with odour) and three anaerobically digested sludges (ADS). Activated sludge, ADS1 and ADS3 were dried on concrete drying beds while ADS2 was dried in paddies. Activated sludge and ADS3 were both dried in thin layers while ADS1 and ADS2 were dried in thicker layers. ADS1 was also treated with ferric chloride. After drying, different organic compounds were determined using the Van Soest fractionation method. Inorganic N (NO_3-N and NH_4-N) was determined by the steam distillation method. Total N and total organic C were determined using the Carlo Erba method.

RESULTS AND DISCUSSION

The ADS3 sludge was found to have the highest total N and total organic C, followed by activated sludge. Both also had low lignified content. This suggests that ADS3 had high N mineralization potential, due to the high total N content. ADS1 (N = 2.81%) and ADS2 (N = 2.8%) had similar N content and exhibited a higher lignin content than ADS3 and the activated sludge. These show that the drying beds and paddies do not influence the composition of sludge biochemical. The biochemical difference between ADS1& 2 to that of ADS3 show that the thickness of the sludge layers during drying not only influenced the partitioning of N between organic and inorganic forms, but also the lignin content.

CONCLUSION

The method of sewage sludge drying (slower drying in thicker layers versus fast drying in thin layers) influence the lignified content of sewage sludge. This in turn will influence its decomposition in the soil and rate of N release. Drying sludge in thin layers improve the N fertilizer value of sludge.

ACKNOWLEDGEMENTS

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Keywords: Sludge, biochemical, lignified fraction, N and C

ACID PHOSPHATASE ACTIVITY OF INTRA-HOLE AND SOLE PLANTED COWPEA AND MAIZE VARIETIES IN NELSPRUIT, SOUTH AFRICA

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INTRODUCTION

Most soils contain large amount of P that is organically bound and not readily available to plant. P deficiency can affect growth, N_2 fixation, and grain yield in legumes such a cowpea. As a strategy for overcoming low-P stress, nodulated legumes produce acid phosphatises from their roots for solubilising P in the rhizhosphere. In so doing, these legumes may improve the P nutrition of associated cereal crops, especially when intercropped in the field (Makoi *et al*., 2010). Additionally, acid phosphatases in plant organs function by mobilizing P from storage pools and translocating it to sinks, where there is greater demand. The aim of this study was to assess the effect of intra-hole planting of cowpea and maize on P nutrition of the crop species versus their sole counterparts.

MATERIALS AND METHODS

One cowpea cultivar PAN 311 and three maize varieties ZM 523, ZM 521 and ZM 423 were planted in intra-hole planting and sole-cropping. The experiment was laid out in randomized complete block design with the treatments replicated three times. Plots measured 3.7 m × 3.6 m with 90 cm between rows and 30 cm between plants. The plots were not fertilized. The experiment was conducted at Nelspruit in Mpumalanga province. Cowpea and maize plants were sampled at flowering stage, separated into leaves, stems and roots for assay of APase activity using the *p*-nitrophenol method (Lui *et al*., 2004).

RESULTS AND DISCUSSION

The activity of APase in leaves of cowpea variety PAN 311 increased when intra-hole planted with maize variety 523 relative to sole cowpea PAN 311. While with sole cropping, there was greater APase activity in stems of cowpea PAN 311 and maize variety 521. Root APase activity was highest in sole cowpea PAN 311, followed by cowpea intra-hole planted with maize varieties 523 and 521.

CONCLUSION

Intra-hole planting of cowpea PAN 311 with three maize varieties resulted in the highest APase activity in leaves, while sole planted cowpea and maize recorded greater levels of APase activity in stems. These findings have implications for P nutrition in different cropping systems.

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Keywords: P nutrition, P mobilization and translocation, shoot and root APase activity

EVALUATION OF INTRODUCED COWPEA BREEDING LINES IN SOUTH AFRICA

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INTRODUCTION

Production of cowpea in South Africa is limited by lack of improved varieties and good quality seeds for planting (Asiwe, 2009). This is the result of a small market and the fact that variety development take too long to meet immediate farmer needs. Introduction of developed elite breeding lines and their subsequent evaluation and selection for adaptability can fast track the availability of varieties to farmers for immediate cultivation. This study is aimed at evaluating recently introduced cowpea breeding lines from Texas, USA and IITA, Nigeria, to determine their suitability and adaptability in South Africa.

MATERIALS AND METHODS

Forty elite cowpea breeding lines with Glenda as a control were evaluated during the 2012/13 growing season at Ukulima farm, Modimolle, Limpopo using a randomized incomplete block design with three replicates. Supplementary irrigation was provided when necessary. Weeds and insect pests were controlled mechanically and by applying-lambda-cyhalothrin *(*Karate®), respectively. *Cyhalothrin* was applied at recommended rate of 1litre per hectare. Agronomic parameters measured were plant height, number of branches, flower colour and number of pods per plant, pod colour and length, total pod mass as well as number of seeds per pod. Data were analysed using Statistix 9.0 software and treatment means were separated using Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Preliminary results indicate that all the agronomic parameters measured were highly significantly affected by the treatments (P=0.01). The mean plant height (77.09 cm), number of branches (10) and pods per plant (18) of test lines were respectively greater than those obtained from the control check, Glenda (49.37 cm, 9 and 16). Similarly, the mean pod length (18.37cm), pod mass (32.59g) and number of seeds per pod (13) of the breeding lines were higher than those obtained from Glenda (13.95cm, 23.25g and 12, respectively). The above results indicate the diversity and superiority of the introduced breeding lines over the local check as well as the potential of using these breeding lines for the development of better adapted germplasm in South Africa.

CONCLUSIONS

The results showed that cowpea breeding lines performed better than the local control, Glenda and that the varieties are recommended for seed production to meet the immediate needs of farmers.

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Keywords: Adaptability, cowpea, germplasm evaluation

EVALUATING FRUIT COLOUR OF POMEGRANATE (*Punica granatum* L.) CV. 'WONDERFUL' IN THE WESTERN CAPE PROVINCE

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INTRODUCTION

Food appearance is determined mostly by surface colour and is the first sensation that the consumer perceives and uses as a tool to either accept or reject food. Although knowledge about the importance of pomegranate in human nutrition has increased in recent years, the importance of external colour of the fruit has not been studied in detail. Pomegranate maturity status is commonly assessed based on rind and juice colour as well as acidity.

MATERIALS AND METHODS

This study was conducted during the harvest season of 2011/2012 and 2012/2013 with fruits of pomegranate cultivar 'Wonderful', randomly selected from trees on farms located in Bonnievalle, Ladismith and Calitzdorp, in the Western Cape, South Africa. A hundred fruit samples were harvested from each growing location. Fruit peel colour along the equatorial axis of each fruit at two opposite spots were recorded in CIE (L*, a*, b*) using a Minolta Chroma Meter CR-400 after calibration with a white tile background.

RESULTS AND DISCUSSION

Peel colour

During the 2012/2013 season, the fruit peel L* values were significantly higher (49.86) compared to the 2011/2012 (47.67) season. In terms of location, Ladismith had significantly the highest L* fruit value of 50.23 compared to both Bonnievalle (48.31) and Calitzdorp (47.77). Significant differences in the intensity of fruit colour (chroma) per season were recorded, with 2011/2012 showing a high intensity of 45.74 and 2012/2013 showing the lowest colour intensity of 43.69. However results varied significantly across the three localities from 45.73 in Bonnievalle to 44.76 in Calitzdorp and 43.99 in Ladismith.

Aril colour

The 2012/2013 season had significantly higher aril L* value (10.48) compared to the 2011/2012 (8.87) season. The highest L* for the aril was found in Ladismith, with a significant value of 12.67. However, there was no significant difference between Calitzdorp (8.73) and Bonnievalle (7.73).

CONCLUSION

Changes in colour dynamics of peel and arils of pomegranate (cv. 'Wonderful') were mostly as a result of seasonal variation as well as growing conditions. 2012/2013 had better aril colour than 2011/2012 while Ladismith had a better aril colour than both Bonnievalle and Calitzdorp. These results showed that when assessing colour quality of pomegranate 'Wonderful' cultivar, it is important to consider both growing season and locations.

ACKNOWLEDGEMENTS

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Keywords: Aril, chroma, hue angle, peel

ASSESSMENT OF BAMABARA AND GROUNDNUT YIELDS UNDER THREE LEVELS OF NITROGEN FERTILIZATION

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INTRODUCTION

Bambara groundnut (*Vigna subterranean* L.) is an indigenous African leguminous crop known for its high nutrient value and drought tolerance. Groundnut (*Arachis hypogaea* L.) is an important leguminous crop. During innovation platforms with farmers in Diphagane, they identified low crop yield and soil fertility as a problem limiting crop production. Nitrogen (N) is required by crops in comparatively larger amounts than other elements. The study was designed to evaluate bambara and groundnut grain yield under three levels of N fertilization.

MATERIALS AND METHODS

The study is part of a broader spectrum on defining the interplay between market access, crop and livestock technologies and investment risks in water-and market–scarce environments that leads to technology adoption by farm families, enabling then to enhance food security and income through efficient nutrient and water use. A field experiment was conducted at Diphagane of the Limpopo province. Three levels of N were assessed that is, 0, 54 and 107 kg N ha^{-1} on bambara and groundnut landraces. The experiment was laid in a randomized complete block design replicated three times during the 2012 cropping season.

RESULTS AND DISCUSSION

Bambara nut grain yield was 156, 446 and 181 kg/ha for 0, 54 and 107 kg N/ha, respectively. Although the bambara nut grain yields were not significantly different among the three levels of N, application of 54 kg N/ha showed potential to improve bambara nut grain yield. Groundnut grain yield was 208, 390 and 518 kg ha^{-1} for 0, 54 and 107 kg N ha^{-1}, respectively. Groundnut yield was shown to be directly proportionality to the level on N fertilization, however, N levels need to be increase in order to determine the optimum N fertilization and grain yield.

CONCLUSION

Bambara nut grain yield showed potential for yield improvement when 54 kg N ha^{-1} was applied. Further research may focus on increasing the N levels to achieve optimum N fertilization on groundnut.

Keywords: Fertilization, grain yield, nitrogen

EVALUATING SYMBIOTIC N_2 FIXATION OF FIELD-GROWN PIGEONPEA (*Cajanus cajan* L.) CULTIVARS IN THE MPUMALANGA PROVINCE, SOUTH AFRICA

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INTRODUCTION

Pigeonpea is a legume originating from India forming a symbiotic bond with *Rhizobium* cowpea type. It is reported to fix between 38 and 164 kg N ha^{-1} when intercropped with sorghum in Nigeria (Egbe 2007). In South Africa, a ratoon pigeonpea crop can fix between 46 and 144 kg N ha^{-1} (Murwa, unpublished data). This study evaluated the symbiotic performance of twelve pigeonpea varieties grown under field conditions at Mzinti, Nelspruit and Kliplaartdrift in Mpumalanga Province.

MATERIALS AND METHODS

The field experiments were conducted in three locations of Mpumalanga. A Randomized Complete Block Design was used with 12 treatments per plot replicated four times. These genotypes were developed by the ICRISAT. Test Pigeonpea genotypes were planted in a 5 m x 70 cm plot. During planting, plants were neither fertilized nor inoculated while rainfed. Five plants were harvested at physiological maturity, separated into shoots and pods, oven-dried (60^{o}C), weighed, and finely ground (0.45 mm) for ^{15}N analysis.

RESULTS AND DISCUSSION

Whether established at Mzinti, Nelspruit or Kliplaatdrift, pigeonpea genotypes ICEAP1480-32, ICEAP1170-13 and ICEAP1167-11 exhibited markedly greater plant growth and N content, whilst ICEAP87051, ICEAP1170-30 and ICEAP1460-32 recorded the least biomass with significantly lower mean $d^{15}N$ values. As to be expected, the same three varieties derived the highest proportion of N from atmospheric fixation (%Ndfa) at all three experimental sites, By contrast, varieties ICEAP1167-11 and ICEAP1480-32 obtained the least N from the atmosphere. The amount of N contributed by pigeonpea to soils of the experimental sites ranged from a low 85 kg N ha^{-1} in ICEAP1480-32 to 242 kg N ha^{-1} in ICEAP1514-15. Soil N uptake by pigeonpea ranged from 22 kg N ha^{-1} in ICEAP87051 to 131 kg N ha^{-1} in ICEAP1480-32.

CONCLUSION

Varieties ICEAP1170-13 and ICEAP1167-11 recorded the highest %Ndfa and contributed the most N at all three sites when compared to varieties ICEAP1480-32 and ICEAP973-2.

ACKNOWLEDGMENTS

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Keywords: Percent N derived from fixation, N contribution, Nelspruit, Mzinti and Kliplaatdrift

PRODUCTIVITY OF THREE JUTE ACCESSIONS GROWN UNDER GREENHOUSE CONDITIONS AS AFFECTED BY DIFFERENT FERTILIZER APPLICATION RATES

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INTRODUCTION

Jute (*Chorcorus olitorius*) is an indigenous wild leafy vegetable that belongs to the family Tiliaceae. The leaves and capsules are harvested and consumed as a relish. Maintaining availability of this important crop is a major challenge due to limited domestication, declining soil fertility that results in low productivity and the threat of global warming due to climate change. This study aimed at developing an appropriate fertilization strategy that will promote increased availability of Jute as a nutrient-rich leafy vegetable in the South African vegetable market.

METHODOLOGY

A 3 x 6 factorial experiment was conducted under greenhouse conditions during the 2010/11 and 2011/12 summer planting seasons using 10 kg soil-filled pots. Treatments consisted of five different combinations of N-P-K fertilizer rates (0-80-60, 100-0-60, 100-80-0, 100-80-60 and 50-40-30 kg/ha) and three Jute accessions (Tanzania, Kenya and Uganda). Unfertilized control was included as a check; and treatments were arranged as a completely randomized design with four replications. Data collected include growth, biomass and capsule yields, nutrient and nutritional content. Harvested leaves and capsules were oven dried at 65 ºC and ground for nutrient and nutritional analyses using standard laboratory procedures.

RESULTS AND DISCUSSION

Results showed that the performance of the three Jute accessions differed significantly ($P<0.05$) following NPK application. The highest mean fresh and dried leaf weights of 12.3 and 1.85 g/plant, respectively were obtained across the various fertilizer application rates for Uganda. The Kenya accession produced the highest mean number of capsules (11.3), with fresh and dried capsules weights of 18.7 and 1.95 g/plant, respectively. Application of NPK fertilizer resulted in increased crude protein content, recording 24.2, 26.2 and 27.5 percent; but decreased the fat content, recording 3.04, 2.52 and 2.50 percent, respectively for Kenya, Uganda and Tanzania accessions. The three jute accessions also contain variable levels of essential major and micronutrients. Of the two commonly consumed plant parts, the capsules constituted a better source of P, Mg, Ca and Zn than the leaves while the leaves contain a higher source of protein, K, Fe, Cu, and Mn across all three accessions.

CONCLUSION

The differential responses of the three Jute accessions to fertilizer application impose differences in the optimum rate for individual accession due to differences in genetic variability amongst the three accessions. The results also revealed that the plant constitutes an excellent source of proteins, fibre, and minerals which underpins the view that it could serve as a good and cheaper source of balanced nutrition for poverty-ridden households in many resource-poor communities.

Keywords: Balanced nutrition, crop fertilization, crude protein, indigenous wild leafy vegetables

RESPONSE OF DRY BEAN (*Phaseolus vulgaris* L.) VARIETIES TO NITROGEN FERTILIZATION LEVELS

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INTRODUCTION

Dry bean is an important protein seed crop in South Africa grown mostly for human consumption. Beans in both their unprocessed and canned forms, constitute a vital, palatable and nourishing part of the diet of many people, particularly for those in the low income groups. Limpopo is currently producing 8% of the total production of dry beans and Mpumalanga is the biggest producer with 54%. Proper nitrogen fertilization is important for optimizing dry bean yield (Hogg, 2006). The varieties used in the study are poor nitrogen fixers. The objective of the study was to determine the response of dry bean varieties to nitrogen fertilization.

MATERIALS AND METHODS

The field trial was planted on the 8th of January 2013, under irrigation at Towoomba ADC approximately 4km south east of Bela-Bela in Bela-Bela Municipality, Waterberg District, Limpopo Province. The soil analysis were done prior planting and the soils contained low amount nitrogen (0.08 to 1.5%). The trial was 3X3 factorial experiment in a split plot design. Three varieties of dry beans are Jenny, Kranskop, and OPS-RS2 and three levels of nitrogen 0 (N0), 30 (N1) and 65 kg ha^{-1} (N2). The plot consisted of 4 x 5m rows. Within row spacing of 7.5 cm and between row spacing of 90 cm giving a population of 150 000 plants ha^{-1} .Nitrogen levels were the main plot and dry bean varieties were sub-plot. The following data was collected: biomass at 90 DAP, number of seeds per plant, pods per plant, hundred seed weight, moisture content and grain yield. The data was statistically analysed using SAS.

RESULTS AND DISCUSSION

The results revealed that grain yield and hundred seed weight was influenced by nitrogen level. The highest grain yield was produced by (N1) with a mean yield of 2.24 t ha^{-1}. The yield per plant, number of pods per plant and number of seeds per plant were highly influenced by the interaction relationship between nitrogen rates and varieties. The highest yield per plant resulted from Jenny N0 (33.03g) and the lowest for Kranskop N2 (20.76 g). The highest number of seeds per plant was found with OPS-RS2 (N1) (86.80) and the lowest with Kranskop (N2) (40.87).

CONCLUSION

An incease in nitrogen level, can increase performance and yield of varities to a certain extent. The results obtained from this study shows that high nitrogen application reduce yield and performance of the dry bean varties. Therefore, proper nitrogen fertilizer application is important for optimizing dry bean yield.

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Keywords: Grain yield, dry bean

THE EFFECT OF AMMONIUM SULPHATE, SUCKER POSITION AND GROWTH PERIOD ON SUCKER GROWTH IN THE QUEEN PINEAPPLE, *Ananas comosus*

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INTRODUCTION

Queen pineapple plantings are established from suckers taken from plants after their fruit has been harvested. Sucker development must continue on the mother plant until suckers are big enough to be used as planting material, which can take 6 to 8 months after fruit harvest. Research indicates that pineapple sucker formation is influenced by N fertilization. In order to improve the quality of pineapple planting material it is also important to understand sucker growth in relation to position on the stem of the mother plant and the time it required to grow into suitable planting material.

MATERIAL AND METHODS

Based on the results of preliminary trials, three application rates of ammonium sulphate [$(NH_4)_2SO_4$], namely: 1 ton/ha, 0.5 ton/ha and 0 t/ha (control) were applied 1 month after fruit harvest to improve sucker growth. Sucker growth was evaluated by measuring length and fresh weight of the suckers found at each node, starting from the bottom of the stem. Sucker growth evaluation was done at 4, 6 and 8 months after $(NH_4)_2SO_4$ application.

RESULTS AND DISCUSSION

Plants treated with 0.5 and 1 ton $(NH_4)_2SO_4$ after fruit harvest, had significantly longer suckers with higher fresh weight than the plants in the 0 t/ha treatment. Sucker length and fresh weight had a positive correlation with the duration of sucker growth on the mother plant. There was an average of 40 nodes per stem. Suckers with the potential to grow into planting material were found between node 1 and 15. Sucker fresh weight and length decreased significantly on nodes higher up on the stem. The duration of sucker growth on the mother plant and fertilizer application had no significant effect on sucker length and fresh weight when interacting with the node position.

CONCLUSION

$(NH_4)_2SO_4$ application after fruit harvest, the duration of sucker growth on the mother plant after fruit harvest and the node position on the stem influence pineapple sucker length and fresh weight.

Keywords: pineapple, N fertilizer, sucker growth duration, node position

STOMATAL CONDUCTANCE OF *Pelargonium sidoides* DC IN RESPONSE TO SOIL WATER DEPLETION

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INTRODUCTION

Pelargonium sidoides is one of several geophytic species that are important traditional medicines in South Africa (Lewu *et al*., 2006). The tuberous roots of the species are a raw material for a phytomedicine used to treat acute bronchitis and infections of the upper respiratory tract. Over exploitation of the species, for local traditional use and international pharmaceutical companies has led to declines in wild populations. It has been reported that *P. sidoides* which is growing under low rainfall conditions has a higher medicinal value; however the effect of water stress on yield of this plant has not been reported yet. One of the physiological mechanisms which enable plants to adapt to water stress is closing of the stomata. This mechanism is associated with yield reduction due to decrease in photosynthetic rate. The objective was to investigate the stomatal response of *P. sidoides* to soil water depletion level.

MATERIALS AND METHODS

A factorial rainshelter experiment was laid out as randomized complete block design (RCBD) with three replicates, at ARC-Roodeplaat. The irrigation treatments were 30, 50 and 70% allowable depletion levels (ADL) of plant available water. A neutron probe was used to monitor soil water content at 20cm intervals to a soil depth of 100cm and a drip irrigation system was used to irrigate the treatments. Stomatal conductance was monitored with a leaf porometer and leaf samples were observed under an electron microscope for stomatal pore opening.

RESULTS AND DISCUSSION

The results show that water stress had an effect on stomatal conductance throughout the season, as expected. The 30% ADL treatment had a significantly higher stomatal conductance compared to 50% ADL and 70% ADL. An increase in water stress resulted in a decrease in stomatal conductance. When observed under the electron microscope, the stomatal pores of the leaf samples from the 30% ADL were fully open, while those from the 50% ADL were only partially open and those from the 70% ADL were partially to completely closed. However there were differences between the abaxial and adaxial sides of the leaves, with the stomata on the adaxial side not being fully closed for the 70% ADL treatment.

CONCLUSIONS

The results show that *P. sidoides* has a strategy of water stress tolerance through stomatal closure, like most plants. This involves adjustments of the stomatal pore openings on both the abaxial and adaxial sides of the leaf to limit water loss and desiccation.

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Keywords: Pelargonium sidoides, soil water depletion, stomatal conductance

PLANT GROWTH, SYMBIOTIC PERFORMANCE AND WATER-USE EFFICIENCY OF SIX COWPEA (*Vigna unguiculata* L. WALP.) GENOTYPES GROWN IN THE NORTHERN REGION OF GHANA

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INTRODUCTION

Cowpea is an important grain legume in Africa, grown widely across the continent. As member of the Phaseoelae family, cowpea transports fixed-N from nodules to shoots as ureides, a strategy used to conserve water and reduce energy used in transport (Todd *et al*., 2006). Low grain yield of cowpea in the tropics has been attributed to cultivation on marginal soils and erratic rainfall. In a climate change scenario, genotypes with high N_2 fixation and water relations will be ideal in addressing food security. This study evaluated cowpea genotypes for symbiotic performance and water-use efficiency at three sites in the northern region of Ghana.

MATERIALS AND METHODS

Cowpea genotypes (Apagbaala, IT90K-277-2, Omandaw, Padituya, Songotra and Zayura) were planted in a randomized complete block design with four replications at Nyankpala, Savelugu and Karaga in Ghana. At flowering, photosynthetic rate (A) and transpiration (E) of nine young leaves per plot were measured at two sites, and transpiration efficiency (TE) computed as A/E. Five plants were then excavated from soil, separated into shoots, roots and nodules, oven-dried (60^{o}C) and weighed to determine shoot and nodule biomass, respectively. Ground shoot (0.50 mm sieve) were subjected to^{13}C isotopic analysis using mass spectrometry. Xylem sap was pooled from ten plants per plot for ureide assay. Ten plants from two middle rows were sampled for grain yield determination at harvest. Data was analyzed using Statistica. Means were separated using DMRT.

RESULTS AND DISCUSSION

Although nodule number, nodule biomass and xylem ureides levels were higher at Savelugu followed by Nyankpala, grain yield was much greater at Karaga despite lower nodulation and ureides levels, due to better plant growth and higher WUE ($d^{13}C$ = -29.2‰). Genotypes Omandaw, Zayura and Apagbaala elicited higher nodulation and symbiotic N_2 fixation (162.2 µg ml^{-1}, 151.6 µg ml^{-1} and 141.3 µg ml^{-1}, respectively) at Nyankpala while Omandaw maintained higher grain yield across the three sites. Apagbaala produced high yield at Savelugu (1755.0 kg ha^{-1}) and Karaga (2611.3 kg ha^{-1}) while IT90K-277-2 yielded higher at Nyankpala (728.8 kg ha^{-1}) and Savelugu (2002.1 kg ha^{-1}). The genotypes Zayura and Apagbaala with high xylem ureides at Nyankpala also exhibited higher plant growth due to higher photosynthetic rates. At Savelugu, Apagbaala, Songotra and Zayura showed higher photosynthetic rates and transpiration efficiency (TE) which translated into high grain yield for IT90K-277-2 and Apagbaala. Grain yield of Omandaw was high at Savelugu despite low xylem ureides while IT90K-277-2 with low xylem ureides at Nyankpala produced high grain yield. Thus, ureides concentration showed a mismatch between N_2 fixation and grain yield.

CONCLUSION

Although Omandaw was found to produce high grain yield across the three sites, the genotypes Apagbaala, IT90K-277-2 and Zayura were also identified elicit high yields. Xylem ureides concentration showed a mismatch between N_2 fixation and grain yield for some genotypes.

ACKNOWLEDGEMENT

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Keywords: Phaseoleae, xylem sap, ureides, grain yield

PHOSPHORUS NUTRITION OF FIFTEEN MUNGBEAN (*Vigna radiata* L.) VARIETIES AT NELSPRUIT AND KLIPLAATDRIFT IN MPUMALANGA

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INTRODUCTION

Mungbean is a relatively new crop in South Africa with no production statistics at the commercial level. Currently, this grain legume is produced only at subsistence level in the Mpumalanga and Limpopo Provinces of South Africa. The fact that it grows relatively well in the low-P soils of Mpumalanga Province suggests that mungbean has mechanisms such as the exudation of phosphatases for improved soil P supply. Screening for levels of phosphatase secretion in mungbean varieties supplied with and without P under low P conditions is needed to identify low P tolerant genotypes for farmers. The aim of this study was to assess P nutrition in fifteen mungbean genotypes under field conditions in Mpumalanga Province in 2010.

MATERIALS AND METHODS

Field trials were set up in 2010 with the 15 genotypes using a randomized complete block design and four replicates. At both sites, bulk and rhizosphere soils (after planting) were collected from the field, processed, and either assayed for acid and alkaline phosphatase activity, and analyzed for P. Shoots of the fifteen mungbean genotypes were sampled at pod-filling stage, oven-dried (60^{o}C), weighed, finely ground to powder (0.85 mm), and analysed for tissue P.

RESULTS AND DISCUSSION

Acid phosphatase enzyme activity varied significantly between mungbean genotypes at both Nelspruit (zero-P applied) and Kliplaatdrift (20 kg P ha^{-1} applied). The acid phosphatase activity at Nelspruit was almost 2-fold that of Kliplaatdrift. However, rhizosphere P was much greater at Kliplaatdrift due to the application of 20 kg P ha^{-1}. As a result, both shoot P concentration and content were also much higher at Kliplaatdrift. There was a positive correlation between rhizosphere acid phosphatase activity and rhizosphere P concentration, and between rhizosphere P concentration and shoot P level, indicating that the P enzyme activity enhanced P supply in the rhizosphere.

CONCLUSION

The top producing varieties (NM94, VC6486-10-S1 and VC3960-88) show higher phosphatase activity whether under conditions of low P or fertilized P but that suppling exogenous P will suppress phosphatase activity. Supplying exogenous P to mungbean suppressed acid phosphatase activity.

ACKNOWLEDGMENTS

The South African Research Chair in Agrochemurgy and Plant Symbioses, National Research Foundation, and Tshwane University of Technology are acknowledged for their financial support.

Keywords: Acid phosphatase activity, rhizosphere P, shoot P

ATTRIBUTES OF CUT-OFF LOW INDUCED RAINFALL OVER THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

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Cut-off low (COL) weather systems that are associated with rainfall over the Eastern Cape are considered in this study. COLs are objectively identified and tracked over a 31-year period. Daily rainfall data of 22 evenly distributed stations over the Eastern Cape are utilized. Only COLs with a minimum spatial distribution, defined as more than a third of the rainfall stations that need to report rainfall on at least one day of a COL event, are considered for analysis of rainfall attributes. These attributes include the occurrence of COL rain days of different magnitudes, the distribution of the depth and temperature of the COL centres for the rain days of different magnitudes, the associated spatial distribution of rainfall as well as the associated atmospheric circulation. The frequency of COLs over the Eastern Cape has a winter maximum and a summer minimum. COL rain days of small, medium and large magnitudes occur most frequently during the winter, while small and medium magnitude COL rain days experience peaks in autumn and spring respectively. The low-level flow, and in particular the position of the low/trough, seems to be the determinant factor in the occurrence, magnitude and spatial extent of COL induced rainfall.

Keywords: cut-off lows, Eastern Cape, heavy rainfall

THE EFFECT OF NITOGEN LEVEL ON MAIZE GENOTYPE (*Zea mays* L.) EAR ROT INFESTATION

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INTRODUCTION

In South Africa, maize production is limited by both biotic and abiotic stresses. Biotic stresses include insects, diseases and parasitic weeds. Ear rot can reduce grain quality, grain yield and grain feeding value. The most important ear rot fungi are Fusarium (*Fusarium moniliforme*), *Gibberella* (*Fusarium graminearum*), Stenocarpella (*S. maydis*) and Aspergillus (*Aspergillus flavus*). Most farmers, especially small holder farmers, plant their maize under low nitrogen levels due to lack of resources resulting in long term food insecurity. Soil fertility especially low nitrogen affects disease infestation as plant vigour is poor. Severe nitrogen stress delays pollen shed / anthesis and silking. Silking delay is correlated with kernel and ear abortion, whereas stress during grain filling correlates with kernel weight leaving them at a high risk of getting infested by ear rots. The aim of the study was therefore to determine the effect of nitrogen also on ear rot infestation.

MATERIALS AND MATHODS

A study was conducted in 2012/13 at Cedara in Pietermaritzburg on two fertility regimes thus, low Nitrogen whereby nitrogen was depleted from the field for four years and there was no nitrogen applied during the planting season while potassium and phosphorous were applied. The other level was optimum (normal) Nitrogen whereby nitrogen was applied at 75kg N ha^{-1} at planting and 75kg N ha^{-1} top-dressing. The experimental design was a split plot with nitrogen levels set as main plot and genotypes as sub-plots. Forty maize genotypes were compared for agronomic characteristics (flowering, plant height, # cobs per plant, field weight, grain weight and percent moisture). This study was conducted under natural ear rot disease infestation. For ear rot infestation, infected ears were worked out as percentage from total number ears harvested. The plot size was 10 m^2. The trial was replicated two times and analysed with GenStat.

RESULTS AND DISCUSION

The genotypes were significantly different ($P<0.05$) for grain yield. Three major ear rots (Fusarium, *Gibberella*, and Stenocarpella ear rot) were observed, whereas Aspergillus ear rot and stem lodging was not observed. The ear rot infestation results from the low nitrogen regime were higher and significantly different amongst genotypes ($P<0.05$) and also from plants from the optimum nitrogen regime with the most prevailing ear rots being Diplodia and Fusarium ear rot.

CONCLUSION

Ear rot infestation is higher on fields with low nitrogen, therefore nitrogen levels do have an effect to the infestation of ear rot disease.

ACKNOWLEDGEMENTS

Funding from CIMMTY, MELINDA and BILL GATES is gratefully acknowledged.

Keywords: ear rot, nitrogen level, diseases, Diplodia, Fusarium

OPTIMISING ZINC FERTILIZATION RATES FOR COWPEA PRODUCTION UNDER SUPPLEMENTARY IRRIGATION AND RAINFED CONDITIONS

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INTRODUCTION

Zinc (Zn) deficiency has been described as one of the major widespread micronutrient disorders that contribute to public health problems in developing countries. Hotz and Brown (2004) reported that more than 19.7% of South Africa's population is at risk due to inadequate Zn intake. The problem is exacerbated by the high prices of micronutrients-rich foods and exotic leafy vegetables that are locally available. This study determined the optimum zinc rate that would result in high zinc accumulation in cowpea plant tissue under different field conditions for improved human and animal diets.

MATERIALS AND METHODS

Field trials with cowpea variety IT00K-1217 were conducted at Ukulima farm (sandy soil), Modimolle under supplementary irrigation and at the University of Limpopo experimental farm (loamy soil), Syferkuil under rainfed conditions during the 2012/13 season. The average rainfall at Ukulima is higher, but the temperatures lower than at Syferkuil. Pre-planting soil analysis from Syferkuil indicated a much higher (2.76 mg kg^{-1} Zn) content than at Ukulima. Treatments consisted of six blanket zinc rates (0, 5, 10, 15, 20 and 25 kg ha^{-1}) applied to the soil or as foliar application. The experiments were laid out in split plot arrangements fitted into a RCBD with four replicates. Zinc was applied as $ZnSO_4$ (38.5% Zn) while 30 kg P ha^{-1} was applied to eliminate P constraints. Twenty fresh immature cowpea pods were randomly harvested from each plot at twelve weeks after planting and weighed. Grain and fodder yields as well as total biomass were obtained at harvest. Data was subjected to analysis of variance using Statistix 8.1 while treatment means were separated using Tukey's test at 5% probability level. Response variables were modeled using quadratic polynomials to estimate the optimum zinc rate.

RESULTS AND DISCUSSION

Treatments had a highly significant effect on grain yield (P = 0.001) and fresh pod weight (P = 0.002) under supplementary irrigation only. The yield components under supplementary irrigation had a correlation of 0.70 to 0.94 but varied between 0.03 and 0.80 under rainfed condition. Based on the quadratic models, total biomass (4897 kg ha^{-1}) and grain (1602 kg ha^{-1}) yields were optimised at an estimated zinc rate of 54.7 and 33.4 kg ha^{-1}, respectively under supplementary irrigation while the total biomass (5913 kg ha^{-1}) and grain (2696 kg ha^{-1}) yields were obtained at an estimated optimum zinc rates of 20.1 and 26.8 kg ha^{-1}, respectively under rainfed condition. Similarly, fresh pod weight of 155 g and 140 g per twenty pods per plot was optimised at 25.2 kg ha^{-1} and 8.5 kg ha^{-1} zinc application rate under supplementary irrigation and rainfed condition, respectively.

CONCLUSIONS

Quantitative estimates of the optimum zinc rates obtained from the quadratic equations were beyond the levels evaluated; and varied greatly depending on the yield component of interest. Under supplementary irrigation, zinc sulphate application rate of more than 25 kg ha^{-1} might be necessary due to the sandy nature of the soil; thus, further trials with higher rates are needed to validate the data obtained from the model.

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Keywords: Cowpea, improved nutrition, supplementary irrigation condition, zinc deficiency

ECOPHYSIOLOGICAL STUDIES OF *Wiborgiella* SPECIES SUBS. *Wiborgiella sissilifolia* OF THE CAPE FYNBOS

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INTRODUCTION

The genus *Wiborgiella* has recently been discovered in the Fynbos biome of the Western Cape Province of South Africa. Its various species are reported to be endemic to the Fynbos soils which are typically acidic (pH of 3 – 5) and contain very low nutrient levels particularly N and P. Despite the fact that there are a number of studies on the symbiotic performances and phosphorus nutrition of various plant species endemic to the Cape Fynbos, no information exist on P nutrition as well as bacteria nodulating the newly-discovered *Wiborgiella* species. This study is aimed at the characterization and isolation of bacterial species nodulating natural stands of *Wiborgiella* species as well as an assessment of their P nutritional status.

MATERIALS AND METHODS

Fifteen younger (15-20 cm) *Wiborgiella sessilifolia* plants were collected from the Bredasdorp on the 29 August 2013 around 15:30 pm and separated into nodules, roots, stems and leaves. Fifteen plants were sampled and Similarly, rhizosphere and bulk soils were also sampled. Root nodules were kept at 4°C where after it was isolated. Rhizosphere and bulk soils were sub-sampled and used for the determination of acid and alkaline phosphatase activity as well as for nutrient analysis.

RESULTS AND DISCUSSIONS

Of the 80 isolates tested, the bacterial isolates produced 70% colonies which appeared on or before two days of isolation, with a cream-white colour observed in more than 80% of the colonies which were reported to be all non-elastic. Ninety-four % of the colonies showed an ability to produce acid in bromothymol blue (BTB) growth medium. Although isolates are still under authentication the colony characteristics obtained showed that most of the isolates are fast growers and likely to belong to the *Mesorhizobium* genus. Results on the enzyme assay showed that both acid and alkaline phosphatase activity of rhizospheric soils collected around nodulated young *Wiborgiella sessilifolia* species were significantly greater ($p=0.05$) than the adjacent non-rhizosphere bulk soils of the Bredasdorp area, this was supported by the soil analysis results which showed the high levels of P at rhizospheric zone (16.5 mg/kg soil) compared to the low (13.55 mg/kg soil) P levels of the bulk soils.

CONCLUSION

Preliminary data from this study suggests that *Wiborgiella sessilifolia* is nodulated by *Mesorhizobium* or some fast growing bacterium. This species also produce phosphatases. Their increased activity in the rhizosphere is most likely as mechanism to increase P availability for uptake.

ACKNOWLEDGEMENTS

We acknowledge the South African Research Chair in Agrochermurgy and Plant Symbioses, National Research Foundation and Tshwane University of Technology for funding.

Keywords: Mesorhizobium, nodulate, natural stands, acid and alkaline phosphatase activity

MORPHOLOGICAL CHARACTERISATION OF CULTIVATED *Pelargonium sidoides* DC IN THE NORTHERN KWAZULU-NATAL, RSA

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INTRODUCTION

Pelargonium sidoides (Geraniaceae), indigenous to South Africa, is a highly valued medicinal plant used for the treatment of gastrointestinal conditions and respiratory tract infections.

MATERIALS AND METHODS

Quantitative and qualitative morphological characterisation of accessions of *P. sidoides* was conducted using IPGRI/IITA/BAMBNET list for Bambara groundnut. Principal Component Analysis (PCA) and Cluster Analysis (CA) were used to evaluate the morphological variables which highlight the groups of different morphotypes.

RESULTS AND DISCUSSION

The PCA revealed that the first three principal components exhibited Eigenvalues greater than 1 and explained 74.170% of the total variability, contributing all the variables to the morphological diversity among the accessions studied. Cluster analysis grouped the morphotypes into two major groups with each group having two sub-groups. At the qualitative level, two distinguishable flower colours in the field were observed. Many of the accessions had deep purple flowers and a few accessions had pinkish stalks with pink flowers. The occurrence of different flower colours among the studied accessions may be due to association of *P. sidoides* with its close relative *Pelargonium reniforme* (with pink flower colour) found growing in the same habitat.

CONCLUSIONS

The high variation among quantitative characters measured in studied germplasm indicated that, a good possibility exists of finding desirable traits to meet the demands of both researchers and farmers interested in the development of promising cultivars *of P. sidoides*.

Keywords: Pelargonium sidoides, morphological variation, PCA and CA

SOIL AND ORGAN PHOSPHATASE ACTIVITY BY INOCULATED AND UNINOCULATED SOYBEAN VARIETIES AT NELSPRUIT AND BRONKHORSTSPRUIT

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INTRODUCTION

Soybean is a leguminous food legume crop that has shown to contribute symbiotic N to various cropping systems of other countries but hardly South Africa. When grown on low P soils such as those of the Mpumalanga and Gauteng Provinces, soybean and many other plants develop mechanisms such as exudation of phosphatases that cleave soil P from surfaces or cations and thereby increasing its availability for improved uptake and nutrition (Nannipieri 2011; Maseko & Dakora, 2013). This study assessed soil and organ APase (acid phosphatase) and alpase (alkaline phosphatase) activity of various inoculated and uninoculated soybean varieties established at Nelspruit and Bronkhorstpruit.

MATERIALS AND METHODS

Test soybean varieties were sampled at flowering stage and each plant carefully dug out, separated into leaves, stems and roots. Similarly, rhizosphere and bulk soils of the same plants were collected and phosphatase activity in organs as well as in soil was determined using methods by Liu et al (2004) and Tabatabai (1994), respectively.

RESULTS AND DISCUSSIONS

Leaves showed greater APase activity than roots for both inoculated and uninoculated varieties at all test sites. Leaves, stems and roots of uninoculated soybean varieties TGx 1440-1E and TGx 2001-25DM, exhibited higher APase activity at Nelspruit than Bronkhorstspruit. Similarly, uninoculated varieties TGx 1991-18F and TGx 1989-58F showed greater APase activity in leaves, followed by stems, and roots at Nelspruit than at Bronkhorstspruit. For soil phosphatase activity, rhizosphere apase and alpase activity was greater than in bulk soil at both sites. Of the four uninoculated TGx varieties at both sites, variety TGx 1440-1E revealed higher alpase activity at Nelspruit than at Bronkhorstpruit in 2013. Interestingly, there were contrasting results for variety TGx 2001-25DM as it showed greater apase activity at Nelspruit but higher alpase activity at Bronkhorstpruit. TGx 1991-18F exhibited enhanced apase activity at Nelspruit whilst variety TGx 1989-58F showed much higher apase activity at Nelspruit but greater alpase activity at Bronkhorstpruit. Of the inoculated test varieties, rhizosphere apase activity was greater in TGx 1989-58F followed by TGx 1440-1E and least in TGx 2001-19DM. Alpase activity was enhanced in TGX 1989-58F, followed by TGx 1830-20E and least in TGx 2001-19DM. Uninoculated varieties showed higher apase activity in rhizosphere of TGx 2001-25DM and lower in TGx 1989-58F whilst alpase activity was enhanced in TGx 1440-1E and least in TGx 1989-58F.

CONCLUSION

Leaves are the major sink of P and exhibit the highest P-supplying capacity for adaptation of the uninoculated test soybean varieties. Phosphatase activity varied between sites whilst uninoculated varieties showed greater phosphatase activity.

ACKNOWLEDGEMENTS

The South African Research Chair in Agrochemurgy and Plant Symbioses, National Research Foundation and Tshwane University of Technology are acknowledged.

Keywords: Soybean, inoculation, uninoculation, soil phosphatases, organ phosphatases

TEMPORAL FLUCTUATIONS IN EXTRACELLULAR ENZYME ACTIVITIES, MICROBIAL NUMBERS, MOISTURE AND TEMPERATURE, DURING COMPOSTING OF WINERY SOLID WASTE

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INTRODUCTION

Winery and distillery by-products have different management and disposal challenges, especially with regards to solid waste, as no regulations that promote and support the utilization of winery solid waste in a sustainable manner, is currently in place. Composting of solid waste seems to offer a feasible possibility, but compost stages and stability are features not easily ascertained, especially under open field conditions. Enzymatic activity as a marker of different stages of composting has been suggested as a possible option. The objective of the study was to monitor fluctuations in extracellular enzyme activities, microbial numbers, moisture and temperature, during the first phase of an open field composting trial of winery solid waste from late summer to mid-winter.

MATERIALS AND METHODS

The experiment was a randomised open field trial at Nietvoorbij Experiment farm of the Agricultural Research Council near Stellenbosch. Five treatments were applied, and each was repeated five times. Treatments were: T1 (100% spent wine filter material plus standard ingredients, including pruning canes, grape stalks, berry skins and seeds, lined with black plastic underneath each compost heap), T2 (50% filter material plus standard ingredients, lined), T3 (Zero filter material, lined), T4 = T1 (standard ingredients macerated instead, lined), and T5 = T1 (unlined). All heaps were turned once a week. Enzyme activities were measured weekly using an API ZYM^{TM} kit. Total heterotroph and actinomycete counts were determined by direct plating on appropriate media. Temperature and moisture were monitored weekly.

RESULTS AND DISCUSSION

Heap temperatures in all treatments with filter material were high at the beginning of the trial in late summer, especially in treatments with 100% filter material, followed by the treatment with 50% filter material; these ranged from 40-60^{0}C. The treatment with lowest % filter material had the lowest temperature values. Temperature gradually dropped with time as winter was approached. Conversely, moisture had increased variably. Microbial numbers increase and enzyme activities dropped as a result primarily of the increase in moisture and decrease in temperature.

CONCLUSIONS

Early indications are that microbial numbers and enzyme activities clearly are affected by temperature and moisture in compost heaps. With regards to treatment effect, the higher the filter material the better the heat and moisture were retained. Chemical analyses are underway which should shed further light on the findings.

Keywords: Compost, enzyme activities, microbial numbers, moisture, temperature, winery solid waste

IDENTIFYING SOUTH AFRICAN DRY BEAN CULTIVARS RESISTANT TO ROOT ROT

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INTRODUCTION

Dry bean (*Phaseolus vulgaris* L.) is an important crop in Sub-Saharan Africa including South Africa, on account of its nutritional value and potential role in food security. Soil-borne root rot diseases of dry bean, mainly Fusarium (caused by *Fusarium solani* sp. *phaseoli*) and Pythium (caused by *Pythium* spp.), occur worldwide and may severely damage germinating seeds and radicle emergence, seedlings, and adult plants. Infections reduce plant stand and yield losses of up to 100% have been reported. This study aims to identify root rot resistant dry bean cultivars that are commercially available in South Africa, which could direct cultivar choice for areas prone to the disease.

MATERIALS AND METHODS

A trial comprising 21 South African commercial dry bean cultivars and three negative controls (for Pythium (RWR 719 and MLB 49-85A) and Fusarium (G 2333) root rots) was established during the 2012/13 dry bean growing season at the Agricultural Research Council – Grain Crops Institute's root rot nursery, Potchefstroom. The trial was arranged in a randomized complete block design replicated 3 times, comprising 4 rows per plot, each 4 m long, with 75 cm and 0.75 cm inter- and intra-row spacing, respectively. Weeds were controlled mechanically and manually, and no herbicides or insecticides were applied. Germination percentage was taken 20 days after planting (DAP) and plant stand percentage was taken 55 DAP. Root rot severity was rated using the 1-9 CIAT scale, with 1 being resistant and 9 susceptible, under natural infection. Data were analysed using Statgraphics Plus (Version 5.0).

RESULTS

There were significant differences in germination percentage (P=0.0023), plant stand percentage (P=0.0006) and disease ratings (P=0000). However, percentage variation between germination and plant stand was non-significant (P=0.3040). Cultivar Tygerberg had the highest germination and plant stand of 52% each and a low disease rating of 2, while cultivar RS 6 had low germination and plant stand of 17% and 14%, respectively, and a high disease rating of 7. Eleven cultivars performed better than the negative controls in all parameters measured.

CONCLUSIONS

The study concludes that superior root rot resistance exists among South African dry bean cultivars. This finding provides possibilities of sharing the materials with other Sub-Saharan African countries where root rot diseases of dry beans are a problem.

Keywords: Root rot resistance

EFFECTIVENESS OF THERMOPHILIC COMPOSTING AND VERMICOMPOSTING ON THE BIODEGRADATION OF FLY ASH INCORPORATED INTO COW DUNG-WASTE PAPER MIXTURES

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INTRODUCTION

South African power stations produce more than 26 million tons of fly ash annually. Fly ash contains high total plant beneficial nutrients, but with a very low plant extractable fraction due to low microbial activity. Technologies like thermophilic composting and vermicomposting can be used to increase microbial activity in fly ash and potentially increase nutrient release.

MATERIALS AND METHODS

Fly ash (F) was composted with cow dung – waste paper (CP) mixtures at ratios of (F: CP) 1:1, 1:2, 1:3, 2:1, 3:1 and 0:1. These treatment ratios were composted with or without earthworms (*Eisenia fetida*) for 14 weeks. Electrical conductivity (EC) and pH were measured in water at a ratio of 1:10 w/v, whilst ash content was measured was measured after ashing at 550 °C. Extractable cations were measured with ICP, whilst extractable P and ammonium, nitrate and nitrite were measured with a Skalar CFA. Total C and N were measured using a Truspec C:N auto analyzer.

RESULTS AND DISCUSSION

From zero to 8 weeks, pH and EC showed an increase with pH reaching a maximum of more than 10. However, pH started decreasing from 8 weeks with the lowest pH being observed in the 1:3 (vermicompost) mixture at 8.58, whilst EC started to decrease from 4 weeks during vermicomposting and at 10 weeks under thermophilic composting. The highest EC was observed in the CP alone treatment being 1706 and 2047 µS/cm in the vermicompost and thermophilic compost, respectively. The treatments 1:1; 1:2; 1:3 and CP alone showed the highest potential in increasing the ash content with or without earthworms. All extractable cations showed a slight increase, with thermophilic composting yielding significantly greater increases than vermicomposting. Extractable P increased during incubation with a significant ($P < 0.05$) difference between vermicomposting and thermophilic composting after 14 weeks of incubation. The mean percentage increase in extractable P was in the order CP alone > 1:2 > 1:3 > 1:1 > 2:1 > 3:1. For the fly ash incorporated treatments, the highest mean increase for extractable P (41.6%) was observed under vermicomposting in the 1:2 treatment. An increase in extractable nitrogen was observed with a significant difference being observed between vermicomposting and thermophilic composting. The treatments 1:3 and 1:2 proved superior at increasing extractable P with or without earthworms contrary to reports by Bhattacharya and Chattopadhyay (2006).

CONCLUSIONS

Vermicomposting proved to be superior to thermophilic composting for the stabilization of fly ash- cow dung-waste paper mixtures. The ratio of 1:2 is the most appropriate for incorporation of fly ash into cow dung-waste paper mixtures for effective vermicomposting.

ACKNOWLEDGEMENTS

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

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Keywords: Cow dung, fly ash, thermophilic composting, vermicomposting, waste paper

PHYSIOLOGICAL AND MOLECULAR CHARACTERIZATION OF FAST AND SLOW GROWING RHIZOBIA NODULATING SOYBEAN [*Glycine max* (L.) Merr] IN SOUTH AFRICA

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INTRODUCTION

Soybean is a major commercial grain legume produced worldwide for its high protein and oil. The specie has the ability to form a symbiotic association with soil rhizobia, which enables it to meet its N requirements, as well as contribute N to cropping systems. However the growth, survival and symbiotic effectiveness of the soil rhizobia are affected by abiotic stress. To increase soybean production in Africa requires characterization of native rhizobia for tolerance of abiotic stress. The aim of this study was to isolate and characterize indigenous soybean rhizobia for tolerance of temperature, pH, salinity and antibiotics, followed by molecular characterisation.

MATERIALS AND METHODS

Root nodules were collected from soybean plants growing on farmers' fields in Mpumalanga Province. Rhizobia were isolated using the procedure described by Vincent (1970). The bacterial isolates were authenticated to be rhizobia, and screened for tolerance to temperature, pH, salinity, and antibiotics. The DNA of rhizobial strains was isolated by the CTAB method (Ausubel *et a*l. 1994) and 16S rDNA region of rhizobial genome was amplified using PCR with respective primer. The PCR amplified product was digested by different restriction endonucleases.

RESULTS AND DISCUSSION

The rhizobial isolates exhibited differences in growth rate, colony colour, shape, size and texture, as well as reaction to bromothymol blue. The isolates' colonies took 2-15 days to visually appear on YMA plates. The colony characteristics differed markedly, with 36.3% being translucent, 63.7% milky, 98.6% round-shaped, 1.4% oval, 34.2% gummy and 65.8% non-gummy. Colony sizes varied from 0.5 to 6 mm. From bromothymol blue test, 12.3% of all isolates were acid-producing, while 87.7% were alkaline producers. Tolerance to abiotic stress factors varied strongly amongst strains. A single homogeneous band of about 1500 bp of 16S rDNA was observed on agarose gel. The analysis of 16S RFLP showed considerable variation among isolates.

CONCLUSION

The soybean-nodulating rhizobia isolated from Mpumalanga Province were genetically diverse, and varied in their tolerance to different abiotic stresses.

ACKNOWLEDGEMENTS

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Keywords: Abiotic stress, genetic diversity, rhizobial isolates, root nodules

GENETIC ANALYSIS OF YIELD IN SWEETPOTATO (*Ipomoea batata* (LAM))

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INTRODUCTION

Sweetpotato is a dicotyledonous plant that belongs to the Convolvulaceae family. The root crop combines high edible energy and micronutrients making it ideal as a food security crop in developing countries. In South Africa, The Agricultural Research Council–Vegetable and Ornamental Plant Institute is involved in the breeding of sweetpotato mainly for increased root yield and higher beta-carotene content. Even though substantial accomplishments have been achieved through conventional breeding which has culminated with the release of superior cultivars, information on the inheritance of the traits are limited. This study is aimed at establishing the genetic control of root yield across five selected breeding lines.

MATERIAL AND METHODS

A 5 x 5 full diallel was performed and F_1 progenies evaluated in two environments alongside the parents. Data on root yield was collected and analysed through Statistical Analysis Software (SAS) *proc glm*-Analysis of Variance (ANOVA) to test the null hypothesis of no genotypic difference among parental lines and hybrids and Agrobase-diallel analysis according to Griffing's method 1 to determine heterosis, general combining ability (GCA) of the parental lines and specific combining ability (SCA) of the crosses. Heterosis was computed as a percentage of the superiority of the hybrid over its mid parent value.

RESULTS

Preliminary results have shown significant difference between the genotypes (parental lines and the hybrids). The yield of genotypes ranged from 0.352 kg $plot^{-1}$ to 11.22 kg $plot^{-1}$. The ANOVA for GCA and SCA has shown significant differences for GCA of the parents and SCA of the crosses at 5% probability. The cultivar *Ndou* presented the highest GCA while *Khano* had the lowest GCA among the five parental lines. The best specific parental combination was between cultivars *Khano* and *W119* and the worse combination was between cultivars *Khano* and *Ndou*.

CONCLUSION

The findings of this study will contribute to a better and informed selection of parental and hybrid lines to be used in future sweetpotato breeding programs at the ARC.

ACKNOWLEDGEMENTS

The study is a partnership between the University of Pretoria and Agricultural Research Council (Roodeplaat)-Vegetable and Ornamental Plant Institute.

Keywords: General and specific combining ability, heterosis, sweetpotato, yield

EFFECT OF PLANT DENSITY ON LEAFY YIELD OF KALE (*Brassica oleracia* L.) AND RAPE (*Brassica napus* L.) GROWN IN A CLOSED HYDROPONIC SYSTEM

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INTRODUCTION

Rape (*Brassica napus* L.) and kale (*Brassica oleracea* L.) are biennial leafy vegetables and forage crops that are fast gaining popularity and consumed widely in South Africa (SA). Soilless cultivation of leafy vegetables gained popularity in recent years in SA due to improved yield and quality (Maboko and Du Plooy, 2013). There is no information available on plant spacing of kale and rape when grown in a closed hydroponic system. The objective of the study was to evaluate the effect of plant density on leafy yield of hydroponically grown kale and rape.

MATERIALS AND METHODS

The experiment was conducted at the ARC–VOPI experimental farm from 24 June to 20 August 2013 in a 40% white shade-net structure. Four week old seedlings of kale and rape were transplanted to a closed hydroponic system (Gravel-Film Technique), as reported by Maboko and Du Plooy (2013). There were four plant spacing levels; 20 x 20 cm (25 plants/m^2), 20 x 25 cm (20 plants/m^2), 25 x 25 cm (16 plants/m^2) and 40 x 25 cm (10 plants/m^2). Each plot size was 2 x 1m. The experiment was arranged in a randomised complete block design, with five replicates. The first harvest with measurements of leaf area, leaf fresh and dry mass, and number of leaves was done 30 days after transplanting. Thereafter, harvesting was done on a biweekly basis, by removing the outer matured leaves and leaving the inner four leaves.

RESULTS AND DISCUSSION

Plant density resulted in a significant difference in yield parameters of kale and rape. The optimum leafy yield of kale and rape was obtained at a plant density of 20 plants/m^2, although it did not differ significantly from the highest plant density of 25 plants/m^2. The leaf yield per unit area increased due to increased plant density, while leaf yield per plant was not significantly affected by plant density.

CONCLUSIONS

A plant density of 20 plants/m^2 (20 x 25 cm) in a closed hydroponic system improved yield of kale and rape.

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Keywords: Gravel-film-technique, plant density, leaf fresh mass

RAINFALL INTENSITY EFFECTS ON CRUSTING AND MODE OF SEEDLING EMERGENCE IN SOME QUARTZ DOMINATED SOUTH AFRICAN SOILS

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INTRODUCTION

Predicted changes in rainfall intensity due to climate change are likely to influence key soil health parameters especially the structural attributes and crop growth. In South Africa, work simulating effects of climate change on soil structural attributes such as crust formation is scant. The effects of rainfall intensity on soil crust formation and mode of seedling emergence in soils dominated by primary minerals were studied.

MATERIALS AND METHODS

Three maize seeds of equal size were planted in plastic pots, pre-wetted by capillary action and then subjected to simulated rainfall at three intensities 30, 45 and 60 mm h^{-1} for 5 min.

RESULTS AND DISCUSSIONS

Rainfall intensity significantly ($P < 0.05$) affected crust strength and mean emergence day (MED) but not emergence percentage (EMP) and shoot length ($P > 0.05$). The 60 mm h^{-1} rainfall intensity resulted in the highest crust strength and MED. The strength of crust for all three rainfall intensities was influenced by quartz content, soil organic matter, clay and hematite. Most seedlings emerged through cracks, which resulted rainfall intensity having no significant effects on seedling EMP and shoot length.

CONCLUSIONS

We concluded that soils with extensive cracking are likely to have higher EMP and lower MED and more vigorous seedlings despite the strength of the crust.

ACKNOWLEDGEMENTS

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

Keywords: climate change, mineralogy, penetration resistance, soil organic matter

THE ROLE OF INSECTICIDES IN REDUCING FUSARIUM EAR ROT AND FUMONISIN PRODUCTION IN MAIZE

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INTRODUCTION

Fusarium verticillioides is frequently associated with maize and it causes Fusarium ear rot (FER) and produces fumonisin mycotoxins that are toxic to humans and animals. Maize production is also affected by *Busseola fusca*, one of the most damaging stem borers in Africa. The aim of this study was to determine the effect of systemic and non-systemic insecticide applications on FER development and fumonisin production.

MATERIALS AND METHODS

Field trials were conducted at Potchefstroom and Buffelsvallei, with two planting dates (October and late December 2013) in Potchefstroom. Each field trial consisted of eight treatments with six replicates planted in a randomised complete block design. The treatments were: 1) Bulldock® (non sysytemic) x *B. fusca* infestation x *F. verticillioides* inoculation, 2) Oncol® (systemic) x *B. fusca* x *F. verticillioides*, 3) *B. fusca* x *F. verticillioides*, 4) *F. verticillioides* only, 5) *B. fusca* only, 6) Bulldock® x *B. fusca*, 7) Oncol® x *B. fusca*, and 8) a control treatment. Oncol® was applied to maize seed prior to planting, while Bulldock® was applied into maize whorls weekly, begining 2 weeks after plant emergence. Maize whorls were inoculated with *B. fusca* neonate larvae at the 12-13th leaf growth stage. Maize ears were inoculated with *F. verticillioides* MRC 826 by injecting 2 ml of conidial spore suspension containing 2 x10^{6} spores ml^{-1} into the silk channel at the blister (R2) growth stage. All primary maize ears in each experimental row were harvested at physiological maturity. *Busseola fusca* damage was determined by measuring tunnel length (cm) on each ear. FER was visually rated and expressed as percentage symptoms per ear. Fumonisin contamination was analysed using HPLC. Quantification of fumonisin-producing *Fusarium* species was performed using qPCR. An ANOVA and linear regression analysis were performed using Statgraphics® 5 Plus.

RESULTS AND DISCUSSION

Results showed that the incidence of FER was significantly reduced in the presence of Oncol® and Bulldock® application. Fumonisin production significantly increased in the *F. verticilliodes* x *B. fusca* treatment without insecticide applications. There was a positive correlation ($r = 0.23$; $P < 0.05$; $n = 144$) between fumonisin production and *B. fusca* damage suggesting that ear damage, possibly increases plant stress, increases fumonisin production. *Busseola fusca* infestation also increased fungal biomass in maize ears, suggesting that the insect possibly vector fungal spores and also that sporulation and fungal growth increases in wounds made by insects.

CONCLUSIONS

The application of insecticides to control *B. fusca* indirectly reduces FER and fumonisin production.

ACKNOWLEDGEMENTS

The Maize Trust, NRF and the ARC.

Keywords: Busseola fusca, Fusarium verticillioides, Fusarium ear rot, fumonisins, maize

EFFECT OF TEMPRERATURE ON GERMINATION OF MAIZE (*Zea mays* L.) OBTAINED FROM VARIABLE NPK OMISSIONS AS COMPARED TO HYBRID SEED

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INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop in the world after wheat and rice. Farmers in most rural parts of South Africa save grain for use in subsequent seasons, a practice known as brown-bagging (Govender *et al*. 2008). This often results in poor seed germination and emergence; leading to sparse and uneven stands. In addition these farmers seldom apply nutrients according to soil analysis or any nutrients at all, which may cause the plants to experience nutrient deficiencies which might be reflected in the saved grain. Germination conditions in the field is not always ideal, especially temperature, again leading to poor germination The study therefore aimed at quantifying the effect of temperature on germination of maize harvested from plots with different NPK omissions.

MATERIALS AND METHODS

The experiment was conducted on a thermo-gradient table at Phytotron B at the University of Pretoria's Hatfield Experimental Farm during the spring of 2013. A randomized complete block design (RCBD) was used. Seeds harvested from the long-term fertilizer trial in the 2012/2013 maize season and original hybrid (DKC 7374 BR) seeds were placed in Petri-dishes; five seeds per replicate, with nine replicates per treatment. The seeds used were harvested from plots receiving either N, P, K, NP, NK, PK, NPK or no fertilizer for the past 76 years. Three temperature gradients; 0 to 12^0C, 13 to 23^0C and 24 to 35^0C were used for 7 days. Germination count was taken daily and data expressed as germination index (GI). Analysis was done SAS package and means were separated using Duncan Multiple Range Test ($P<0.05$).

RESULTS AND DISCUSSION

At the lower temperature gradient (0 to 13^0C), NPK-obtained seed had significantly ($P < 0.0001$) the highest mean GI (1.07), while seed from control plots had the lowest GI of 0.2. At the medium temperature gradient (14 to 23^0C), the original hybrid seed had significantly the highest mean GI (5.18) which was statistically similar to that of NPK-obtained seed (5.14) but differed from all the other treatments while K-obtained seed had the lowest GI (0.7). At 24 to 35^0C, NPK-obtained seed had significantly the highest mean GI (3.4) while P-obtained seed had the lowest (0.4).

CONCLUSIONS

This experiment showed that there is a positive association between balanced NPK fertilization and seed tolerance to increasing temperature conditions. This data needs to be verified under field conditions.

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Keywords: germination, fertilizer, maize, temperature, thermo-gradient-table

EFFECT OF ETHYL METHANE SULPHONATE CONCENTRATION, TREATMENT TEMPERATURE AND DURATION ON THE GERMINATION, EMERGENCE AND SEEDLING HEIGHT OF WHEAT

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INTRODUCTION

Genetic variation could be enhanced through various techniques including the use of chemical mutagens such as ethyl methane sulphonate (EMS). Use of EMS has been reported in various major crops such as wheat (*Triticum aestivum* L.), rice *(Oryza sativa* L.*),* barley (*Hordeum vulgare* L.), cotton (*Gossypium hirsutum* L.), peanuts *(Arachis hypogea* L.*)* and beans (*Phaseolus vulgaris* L.) (Ilirjana *et al.,* 2007). Key factors in inducing mutation with EMS include concentration, test varieties, temperature and duration of treatment (Maluszynsk et al., 2000). The objective of this study was to determine the optimum EMS concentration, treatment temperature and duration that would provide desired germination percentage and vigorous and healthy seedlings for effective mutagenesis in wheat.

MATERIALS AND METHODS

Seeds of four selected genotypes of wheat (B936, B966, SST387 and SST875) were surface sterilized with sodium hypochlorite and ethanol and soaked in distilled water for 18 hours. The seeds were treated in two replicates using three EMS concentrations (0.3, 0.5, and 0.7%), three temperature regimes (30, 32.5 and 35ºC) at four time durations (0.5, 1, 1.5 and 2 hrs). The treated seeds were planted in seedling trays and germinated in a Controlled Environment Facility (CEF) at the University of KwaZulu-Natal, Pietermaritzburg campus, South Africa. Seedling emergence (%), germination (%) and seedling height (mm) were recorded for each treatment combination.

RESULTS AND DISCUSSION

Results showed highly significant interactions ($P<0.01$) among varieties, EMS concentrations, temperature and exposure time on emergence, germination and seedling height. Seeds treated with the highest EMS dose (0.7%) and temperature (35ºC) and longest exposure time (2 hr) delayed emergence by 18 days. At 30ºC, 0.5 hr and 0.3% EMS varieties B936, B966 and SST875 emerged early (after 6 days). B936 and SST387 had 50% germination, while B966 and SST875 had 53% and 57% germination, respectively. These results were observed at EMS level of 0.7%, 30°C and 1.5 hr exposure time in B936; EMS at 0.5%, 35ºC and 1.5 hr (B966); and EMS at 0.5%, 32.5ºC and 1 hr in SST387. SST875 required EMS dose at 0.5%, 32.5ºC and 2 hr treatment time. Other low or high treatment combinations were invariably ineffective compared to the untreated control. All considered traits decreased with increase in EMS dose, temperature and exposure time.

CONCLUSIONS

The study established the requirement of variety specific EMS dose and treatment temperature and duration that could be used for inducing large scale mutation to select targeted mutant individuals in wheat.

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ACKNOWLEDGEMENTS

The study was financially supported by the National Research Foundation of South Africa.

Keywords: Ethyl methane sulphonate, mutagenesis, seed germination, *Triticum aestivum* L.

IN-SITU CALIBRATION OF DFM CAPACITANCE PROBES

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INTRODUCTION

A key short term benefit of conservation agriculture (CA) is more efficient water use through enhanced infiltration and reduction in evapotranspiration. Quantifying the water use and water use efficiency is however important when encouraging adoption of CA. DFM capacitance probes are multilevel soil water content and temperature logging devices. These probes are promoted as being accurate, affordable and user friendly. A standard version of the probe consists of 6 sensors at 10, 20, 30, 40, 60 and 80 cm depth respectively. The manufacturer's calibration of the probes is a straight line between dry air (0%) and a free water body (100%). From first evaluations of the measured data it was clear that the readings don't follow a straight line and the manufacturer's calibration is therefore not suitable. For this reason it was necessary to re-calibrate the probes *in-situ*. This paper addresses three important questions namely: is there a generic calibration equation for all installed sensors; can one calibration be applied to all sensors in one probe; are the calibrated sensors consistent and reliable in measuring water contents?

MATERIALS AND METHODS

A total of 48 DFM probes were installed on a CA trial at the University of Fort Hare's experimental farm. After installation the probes were left to settle for approximately 2 months. Although each probe has six sensors only calibrations of the top three (i.e. 10, 20 and 30 cm depths) are reported on in this paper. Gravimetrical water contents were determined of samples taken at the same intervals as the sensors in question. Samples were taken at six different time-steps (i.e. 864 samples), under various environmental conditions (rainfall and temperature) to capture differences in water contents. Bulk densities were determined, using core samples at each probe at the depth intervals in question. The gravimetrical water contents were converted to volumetric water contents and expressed as the % of porosity (the probes express water contents as % of porosity). Field measured and probe measured water contents were compared statistically to derive calibration equations from the first five sample times. The last sample time was used to validate the calibration equations.

RESULTS AND DISCUSSION

The results revealed that a generic calibration for all sensors does not exist (R^2 = 0.05). The best correlation obtained using one calibration for a single probe was R^2 = 0.24, implying that each sensor in each probe should have its own calibration equation. Once the sensors were calibrated they proved to be accurate (R^2 = 0.92 for all sensors).

CONCLUSIONS

DFM probes can reflect the actual water content accurately. Each sensor of each probe should however be calibrated to individually.

ACKNOWLEDGEMENTS

My acknowledgement goes to the Govan Mbeki Research Development Centre.

Keywords: Conservation Agriculture, Calibration, Soil water contents

GROWTH AND YIELD RESPONSE OF KENAF (*Hibiscus cannabinus* L) CULTIVARS TO NITROGEN REGIMES

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INTRODUCTION

Kenaf (*Hibiscus cannabinus* L), responds well to added fertilizers depending on the soil nutrient status, cropping history and other environmental and management factors. Sufficient nitrogen fertilization will enhance growth and bast fibre production. High levels of nitrogen may promote the uptake of other essential nutrients, but can also have a negative effect on fibre content. The economic balance between these factors needs to be determined. Although it is important to grow strong healthy plants, the main aim is to produce a large amount of good quality fibre. Therefore, the objective for this study is to determine minimum N fertilization rate that produce optimum Kenaf yield under rainfed conditions.

MATERIAL AND METHODS

The study was conducted under varied climate and rainfall conditions at Winterton (KZN) and Rustenburg (NW) during the 2012/2013 growing season. The trials were laid in split-plot design with the main plot being cultivar: Tainung 2 and Everglades 41 and sub plot being nitrogen level (0, 40, 80, 120, 160 kg N ha^{-1}). The application of nitrogen fertilizer was split into two, 80% of required nitrogen was applied four weeks after planting and 20% 8 weeks after planting. Plants were harvested manually at flowering stage (Duke and Ducellier, 1993). A sample dry stem yield (kg.ha^{-1}) of one meter stalk was put into an oven to dry for 5 days at 60^{o}C. Then fibre yield (%)The weight of bast in the above ground dried stalk divided by dry stalk mass x100 fibre quality was measured in terms of reed length, bundle breaking tenacity and elongation at break.

RESULTS AND DISCUSSION

There was a significant difference (P=0.05) in fresh biomass, green stem and dry stem yield and fibre yield of cultivars as affected by nitrogen and cultivar x nitrogen interaction. Kenaf yield tends to increase with increase in nitrogen level for both cultivars at both localities. Tainung 2 (138.1 t ha^{-1}) and Everglades 41 (144.1 t ha^{-1}) obtained the highest fresh biomass yield with 160 kg N ha^{-1}. These yields were respectively 38.5% and 29.5% higher than when 0 kg N ha^{-1} was applied. However, it should be noted that cultivars did not vary significantly in fresh biomass yield. Fibre yield varied significantly as affected by nitrogen level (P=0.05) at both localities. At Winterton, Everglades 41 obtained the highest fibre yield of 7.8 t ha^{-1} with 160 kg N ha^{-1} followed by 6.5 t ha^{-1} with 120 kg N ha^{-1}, whereas Tainung 2 obtained 6.2 tha-1 and 6.1 t/ha respectively.

CONCLUSION

The minimum nitrogen rate to produce optimum yield at Rustenburg was observed to be 120 kg N ha^{-1} for Tainung whilst for Everglades 160 kg N ha^{-1}. A Winterton, minimum nitrogen level to be applied for optimum yield was found ranging from 40 -120 kg N ha^{-1}.

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Keywords: Kenaf, Nitrogen regimes, Tainung 2, Everglades 41

RURAL DEVELOPMENT IN LIMPOPO: ARC INFRUITEC-NIETVOORBIJ STRATEGY

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INTRODUCTION

Agricultural development will help alleviate unemployment and poverty in Limpopo. The ARC Infruitec-Nietvoorbij was contracted by DRDLR to assist with deciduous fruit tree establishment and processing of the fruit.

MATERIALS AND METHODS

The ARC Rural Development team conducted a strategic analysis on the potential for deciduous fruit production in Limpopo from early 2013. In the first phase, small farmers in rural communities identified by the DRDLR, DAFF and Municipalities were visited and rated for further assistance.

RESULTS& DISCUSSION

The most eligible small farmers during the first phase were found in the Waterberg, Capricorn and Mopani districts. These farmers and demonstration sites at research stations each received eight peach and nectarine trees as well as two plum and two apricot cultivars during August 2013. Additional small farmers in Limpopo are continuously being identified and rated for further help. Technical assistance and training on fruit tree management will be provided to stakeholders, students and small farmers to help promote sustainable multi-crop production systems. Challenges being faced are marketing of produce and the need for value adding.

CONCLUSIONS

Small farmers are very enthusiastic about the potential for deciduous tree fruit production to help balance their current cash crop cycle. The success of this project relies on developing a model based on communication and consultation without prescription.

ACKNOWLEDGEMENTS

Funding from the ARC and DRDLR is gratefully acknowledged.

Keywords: Deciduous fruit, rural development

EFFECT OF RYEGRASS SEED AGE ON GERMINATION

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INTRODUCTION

Ryegrass is the biggest problem in the Western Cape and it has been worsen by it becoming resistant to herbicides. The repeated use of herbicides over the years to control grass weed on wheat resulted to the evolution of resistant ryegrass. The increase in weed population rate would results to decrease in crop yield due to high competition. This raised the need to develop new weed control measures. The aim of this study was to determine the effects of seed age on germination percentage and dormancy of ryegrass. In order to control this weed in the field is it important to know its life cycle and viability period.

MATERIALS AND METHODS

Ryegrass seeds were collected annually in October from 2009, 2010 and 2011 at Langgewens research farm and the experiment was conducted in May 2012. The harvested seeds were cleaned and then stored in sealed paper bags at room temperature. The trial was repeated three times with four week intervals using Petri dishes laid out in a Randomised Block Design with ten replicates of 10 seeds each and moistened with five milliliters of distilled water, and then placed in an incubator set at 12hours/12hours day/night cycle and a day temperature of 22°C and a nigh temperature of 14°C. Germination was determined after seven and fourteen days of incubation respectively, by counting the number of seeds germinated.

RESULTS AND DISCUSSION

Results showed that ryegrass seeds collected in 2009 and 2010 had a higher germination percentage (80% and 73% respectively) as compared to seed from 2011 (42%). In all experiments, cumulative germination percentage after fourteen days of incubation for 2009, 2010 and 2011 seeds showed figures of 75-87%, 66-81% and 39-44%, respectively. The low germination of 2011 seeds was probably caused by primary dormancy as dormancy inhibitor release increase with age of the seed.

CONCLUSION

Older seed had a lower dormancy due to its loss over time resulting in a higher germination rate than freshly harvested seed. Knowledge with regard to ryegrass germination and dormancy period obtained in this study can certainly help to improve weed control in the field crops of the Western Cape.

Keywords: Ryegrass dormancy, germination, incubation

FREQUENCY OF STEM RUST RESISTANCE GENE *Sr2* IN HISTORIC SOUTH AFRICAN WHEAT CULTIVARS

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INTRODUCTION

Stem rust, caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks& E. Henn (*Pgt*), is one of the most important wheat diseases worldwide. The stem rust resistance gene *Sr2* is known as a slow rusting gene which provides partial and broad spectrum resistance against all races of *Pgt* (McIntosh *et al.,* 1995). *Sr2* confers adult plant resistance which is non-race specific resistance and the gene has been used in several wheat breeding programs for more than 60 years. Unlike race specific resistance genes, *Sr2* is still effective against all *Pgt* isolates including Ug99 and its derivatives. This study will evaluate the frequency of *Sr2* in historic South African wheat cultivars.

MATERIALS AND METHODS

The CTAB method was used to extract DNA from leaf material harvested from 255 historic South African wheat cultivars grown at ARC-SGI nursery in Bethlehem, Free State. The DNA samples were screened with diagnostic cleaved amplified polymorphic sequence (CAPS) marker *csSr2* according to published *csSr2* polymerase chain reaction (PCR) protocol. The PCR products were separated electrophoretically on 1% (w/v) agarose gel.

RESULTS AND DISCUSSION

The amplification of 337-bp DNA fragment was diagnostic of cultivars carrying *Sr2* and the absence of amplification was recorded as absence of the gene. The presence of *Sr2* was observed in approximately 55% of the evaluated historic cultivars. Pretorius *et al.* (2012) reported that *Sr2* is not common in current South African wheat germplasm, and suggested that it was inherited from historic cultivar Hoopvol. Large number of historic cultivars with presence of *Sr2* implies that the gene is present in high frequency in adapted germplasm and efforts to re-introduce this gene in current germplasm should be explored.

CONCLUSIONS

The presence of *Sr2* in historic wheat cultivars will assist the South African breeding programs to re-introduce the gene in the current and future germplasm by pyramiding *Sr2* with other resistance genes to increase broad spectrum rust resistance against all *Pgt* races.

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ACKNOWLEDGEMENTS

We would like to acknowledge the National Research Foundation, Winter Cereal Trust and Agricultural Research Council for financial support.

Keywords: csSr2, *Puccinia graminis*, South African wheat, Stem rust resistance

VARIABLE GERMINATION AND HIGH COST OF COMMERCIAL CHILLI SEED: IMPLICATIONS FOR COMMUNAL AREA CASH CROP CHILLI PRODUCTION IN NORTHERN KWAZULU-NATAL

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INTRODUCTION

Chillies have the potential to increase the income of subsistence farmers in South Africa, since almost the whole produce is sold and there exists a ready market. Although there is growing demand for African chillies in Europe, South African farmers have not been able to meet the demand, due to high production costs. Among the production problems are poor seed germination coupled with low seed counts per packet for seed sold commercially, which contributes to high seed costs. The reasons for poor germination in South Africa are not well understood.

MATERIALS AND METHODS

The study was conducted in a laboratory at the University of Zululand. All cultivars evaluated were randomly selected and purchased from reputable agro-dealer shops. Fifty seeds were placed in Petri dishes containing filter paper and treatments were arranged in a completely randomised design. Each treatment was replicated five times and placed in an oven at 29°C. Data collected were subjected to analysis of variance (ANOVA. Differences among treatment were separated using the least significant different (LSD) at the 5% significance level.

RESULTS AND DISCUSSION

There were significant differences ($p<0.05$) in the time to final germination. Fury had significantly ($p<0.05$) faster germination followed by Long Red Cayenne and Hot Chilli Mix. There were significant differences ($p<0.01$) in the final germination percentage. Prolonged germination is also known to reduce seedling vigour resulting in weaker plants with low yield potential. (Ziaf *et al*. 2007; Demir *et al*. 2008). Low germination percentages result in high seed costs.

CONCLUSIONS

We concluded that there was variability in the germination percentage and rate of germination of commercial chilli seeds sold in northern Kwazulu-Natal. Both the percent germination and the number of seeds sold in packets varied. Poor germination capacity and small seed numbers per packet caused the cost seed to rise.

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ACKNOWLEDGEMENTS

We thank the University of Zululand Senate Research Committee for funding this study.

Keywords: seed germination, chilli seed cost, cultivar, subsistence farmers, KwaZulu-Natal

WATER FOOTPRINT OF GROWING VEGETABLES IN SELECTED SMALLHOLDER IRRIGATION SCHEMES IN SOUTH AFRICA

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INTRODUCTION

Agriculture is under intense pressure to reduce its impact on the environment. Unsustainable agriculture has contributed to soil infertility, erosion, and contamination of water sources. Fresh water resources in sub Saharan Africa are in a constant decline mainly due to climate change and increasing demand. The demand placed on these water resources is on the increase triggering reduction in the quantity of available water particularly in the smallholder irrigation schemes (SIS) in South Africa. Population growth, ignorance, and improper measurement and monitoring of water use within SIS have all contributed to water availability issues, thus raising the need to better manage existing water resources through the promotion of water footprinting (WF).

MATERIALS AND METHODS

The WF assessment framework by Hoekstra & Chapagain (2011) was used to estimate the full impact of vegetable production on water resources in selected SIS case studies in South Africa. Evapotranspiration from SIS fields was calculated with the CROPWAT model; the distinction between green and blue water evapotranspiration was based measured data on precipitation and irrigation. The study focused on nitrogen (N) as the critical pollutant in the grey water footprint calculations. The N values used were based on application rates obtained from responsible local extension officers. The water footprint of vegetable consumption was estimated for each SIS by aggregating the water footprints and yields of different farmers within the same scheme.

RESULTS AND DISCUSSION

Vegetable crop yields in Zanyokwe were relatively low as compared to the expected yields. Yields of 1.5 t/ha and 1.2 t/ha for potato where recorded in 2007/8 and 2009/10 seasons, respectively. Potato yield obtained was incorporated into the model to calculate the water footprint for each vegetable crop within the different SIS.

CONCLUSION

Preliminary results indicate a relatively low crop output per drop of water used. Additional research that includes the processing of the vegetable crops as well as some field crops that are grown in the gardens would create a more complete assessment of water resources use within the SIS in South Africa

ACKNOWLEDGEMENTS

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Keywords: Smallholder Irrigation Scheme, water footprint, consumption, evapotranspiration

SIMPLIFIED TOOLS TO AID SUGARCANE WATER MANAGEMENT

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INTRODUCTION

In irrigated sugarcane agriculture, water is often withheld either before harvesting to reduce soil compaction and stool damage from harvesting machinery (when chemical ripeners were applied), or to enhance sucrose accumulation in stalks in the absence of chemical ripening. This practice of "drying off" is not commonly regarded as a water saving measure but, if implemented correctly, can save a considerable amount of water whilst increasing stalk sucrose content. Currently there is a lot of confusion regarding best drying off practice which often results in cane and sucrose yield losses due to excessive drying off. The objective was to improve the adoption of existing drying off recommendations by presenting these to growers in a more user friendly format.

MATERIALS AND METHODS

Multiple regression analysis was applied to the existing database and used to calculate drying off recommendations for a range of soils of varying total available soil moisture (TAM) content which were previously not included in the drying off decision support program (DSP) (Donaldson and Bezuidenhout, 2000). In addition, a TAM calculator, with soil depth and clay content as input values, was added to the DSP. Simplified tables and a pocket size drying off calculator or "drying off wheel" was subsequently produced for several locations, soils and different harvest months.

RESULTS AND DISCUSSION

In the simplified tables and "drying off wheel" the user only needs to select the appropriate TAM value and harvest month in order to determine the recommended drying off period for a specific location, whether it be for enhancement of sucrose or simply to facilitate mechanical harvest operations. For example, to enhance sucrose content in the absence of a chemical ripener, a field in Pongola with a TAM of 70 mm scheduled for harvest in November will require 31, 38 and 43 drying off days, respectively, in a dry, average and wet rainfall year. Similarly, if harvested in August, 41, 46 and 52 drying off days will be required, respectively. The improved internet based DSP, simplified tables and "drying off wheel" will be demonstrated at grower workshops.

CONCLUSIONS

Not only can these simplified drying off tools be used to facilitate improved water management and increased profitability in large-scale sugarcane production, but small-scale grower communities should also benefit from water saving practices.

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Keywords: Chemical ripener, decision support program, drying off, sucrose, technology transfer, water saving

SYMBIOTIC PERFORMANCE AND WATER-USE EFFICIENCY OF SOYBEAN VARIETY PAN1666 GROWN IN FARMERS' FIELDS AROUND BELFAST AND CAROLINA IN SOUTH AFRICA

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INTRODUCTION

The soybean variety PAN1666 is commonly cultivated by commercial farmers in South Africa because of its high grain yield and greater resistance to shattering. Agronomic practices used by farmers during soybean cultivation include P and K fertilization and bradyrhizobial inoculation. It is however unclear whether inoculation promotes plant growth and increases grain yield. The water-use efficiency of this genotype on farmers' fields is equally unknown. The selected farmers' fields for this study had rainfall ranging from 0 to 6.6 mm per month and mean temperatures ranging from 14.8 °C to 19.2°C. The aim of this study was to assess plant growth, symbiotic performance and plant water relations of soybean genotype PAN1666 on different farmers' fields.

MATERIALS AND METHODS

At flowering, 10 plants of soybean variety PAN1666 were randomly sampled from seven farmers' fields located around Generaalsdraai, Geluk, Wonderfontein (fields 1 and 2), Leeubank, Carolina, and Rietvalley. The shoots were oven-dried (60°C) for 72 h, weighed, and ground to fine powder (0.50 mm) for analysis of ^{15}N and ^{13}C using mass spectrometry.

RESULTS

Plant growth (measured as dry matter yield) was much greater at Generaalsdraai followed by Geluk, and lowest at Carolina, Rietvalley. Although N concentration was highest at Wonderfontein, shoot N content was much greater at Generaalsdraai due to higher shoot biomass. The $\delta^{15}N$ of shoots was lowest at Carolina and, as a result, %Ndfa of was highest in plants sampled from that field. The highest $\delta^{15}N$ value (+4.53‰) was recorded at a farm near Leeubank. The %Ndfa values ranged from 25 to 94%, while the actual amounts of N-fixed varied from 57 to 153 kg $N.ha^{-1}$. The N contributed by PAN1666 in farmers' fields was much greater at Wonderfontein and Generaalsdraai (153 and 144 kg kg $N.ha^{-1}$, respectively), and lowest at Leeubank and Geluk (57 and 75 kg kg $N.ha^{-1}$). Although soybean plants contributed more N at Generaalsdraai, they also took up more soil N compared to the other farmers' fields. Carbon content was greater in shoots at Generaalsdraai, and lowest at Rietvalley. The soybean plants at Geluk showed relatively higher $\delta^{13}C$ values, and hence greater water-use efficiency, followed by those sampled from Wonderfontein field 1. This was in contrast Rietvalley where the plants exhibited very low $\delta^{13}C$ values, and hence poor water-use efficiency.

CONCLUSION

Supplying PAN1666 at Generaalsdraai with P and K plus inoculation, improved plant growth and shoot C and water-use efficiency. However, it contributed the least symbiotic N and took up the most soil N. Without fertilization or inoculation at Carolina, the same variety showed the least dry matter yield and C content, but depended highly on atmospheric N_2 fixation for its N nutrition. At that site, it also contributed more N and took up the least N from soil. These results suggest that P and K fertilization together with bradyrhizobial inoculation does affect symbiotic performance and water-use efficiency of PAN1666 under the conditions in farmers' fields.

ACKNOWLEDGEMENTS

The Bill and Melinda Gates Foundation, South African Research Chair in Agrochemurgy and Plant Symbioses, the National Research Foundation, and Tshwane University of Technology are acknowledged for their financial support.

Keywords: Plant growth, d15N, N contribution, dry matter yield, C content, d13C values

CROP SUITABILITY MAPPING USING LAND TYPE DATA

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INTRODUCTION

The suitability of an area of land for a particular crop depends on how well the attributes of the land match the parameters of the crop. These involve a suitable soil for the crop to grow and develop, along with a slope angle that is not excessive and a climatic regime that will allow optimum growth. If the land parameters are inadequate in one or other aspect, then the degree of suitability for a crop will be reduced.

MATERIALS AND METHODS

The land type survey, carried out by ARC-ISCW from 1972-2002, has mapped the soils of South Africa at 1:250 000 scale. Along with terrain information from digital elevation models, as well as climate parameters supplied from the weather station network, this information allows suitability for crop production to be assessed. Each unique land type mapping unit comprises a number of soils, with defined properties and qualities, each of which occupies a known percentage of the mapping unit. These soil qualities, coupled with the proportion of the land type where they occur, are combined with the climatic and terrain suitability using an algorithm. In this way, each mapping unit can be assessed for suitability of any crop or agricultural enterprise where known parameters are available.

RESULTS AND DISCUSSION

The number of classes used in the suitability assessment can be defined as the user requires, due to the nature of the data involved in the algorithm. The most common subdivision used is to use five classes (high, suitable, moderate, marginal and not suitable) and to define land types where >50%, 30-50% and 10-29% of the area respectively is dominated by these classes. In addition, by omitting the rainfall parameter within the climatic regime from the algorithm, the specific soil and terrain parameters can be used to determine suitability for crop production under irrigation, rather than under rain-fed agriculture.

CONCLUSIONS

The land type survey is a national coverage, compiled at 1:250 000 scale. This scale makes it generally impractical for use in farm planning, but the empirical data available, along with GIS capabilities currently available, allow rapid mapping of crop suitability classes over a wide area. In addition, by altering the parameters slightly, provision may be made for different scenarios, such as yield reduction, climate change and comparison between different crops. The results of the crop suitability algorithms provide a valuable tool in agricultural planning and natural resource utilization.

Keywords: crop suitability, land type survey

CARBON CREDIT: A CASE FOR COMMUNITY FOOD GARDENS IN EASTERN CAPE PROVINCE OF SOUTH AFRICA

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INTRODUCTION

A carbon credit represents the reduction of one tonne of CO_2 equivalent emissions (Amanda, 2012). Carbon projects aim to reduce emissions and sell credits that result from the savings made (BUSA, 2012). Soil management using conservation agriculture technique can improve soil organic carbon stocks and contribute to atmospheric carbon mitigation (Lal, 2007). Currently the government of South Africa and other stakeholders are involved in several conservation agriculture projects in Eastern Cape, which can be linked to carbon projects. The objective of this study was to investigate the linkages between conservation agriculture and carbon projects in Eastern Cape Province.

MATERIALS AND METHODS

This study was a desk top review investigating the linkages between conservation agriculture and carbon projects in Eastern Cape Province.

RESULTS AND DISCUSSION

Conservation agriculture practice in the Eastern Cape involves no-till (100%), with minimal application of crop rotation (33%) and crop residue retention (45%) (Conservation South Africa, 2012). Several carbon projects are in Eastern Cape (GBG., 2013; WFSA., 2013) but they often do not involve conservation agriculture.

CONCLUSION

Conservation agriculture, which also has great potential to mitigate CO_2 should be adopted as a carbon project and farmers rewarded for contributing to CO_2 mitigation through carbon credit.

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Keywords: Carbon, conservation, mitigation

PHYSICO-CHEMICAL CHARACTERISATION OF SOILS IN THE RESEARCH BLOCK AT UNIVERSITY OF LIMPOPO EXPERIMENTAL FARM, SYFERKUIL, LIMPOPO PROVINCE

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INTRODUCTION

Agricultural sustainability depends largely upon improvements in soil physical, chemical and biological properties. Understanding the in-field distribution and nature of soil properties is essential in refining agricultural management practices while minimizing environmental damage. Soil characterisation provides detailed information about the soil spatial variability within a given land area and thus allows for the implementation of appropriate crop and soil management practices that align with the soil condition.

OBJECTIVE

To investigate the spatial variability of the soil of the research block at the University of Limpopo Experimental Farm, Syferkuil.

MATERIALS AND METHODS

The study was conducted at the University of Limpopo Experimental Farm, Syferkuil (23°50'36.86"S and 29°40'54.99"E). Twelve profile pits were dug across the research block at selected areas. Soil sample was collected from each diagnostic horizon for every soil profile and analysed for selected soil physical and chemical properties using standard analytical procedures. Soil depth, structure and consistency were documented in the field. Data generated were subjected to classical statistical methods to obtain the minimum, maximum, mean, median, skewness (Shapiro and Wilk, 1965), and standard deviation at each horizon (n = 22). A one way analysis of variance was also performed using Statistix 8.1 to compare each variable across the soil profiles using LSD test at 5%.

RESULTS AND DISCUSION

The depth of the pits ranges from 0.28 m to 1 m and this was categorized as shallow soils. The soil colour (dry and moist) varies from dark brown to very dark greyish brown. The structure and consistency of the soil were predominantly blocky and firm/friable respectively. The sand, silt and clay of the samples fall in the range 61-87%, 1-15% and 7-27%, respectively; and these soils were categorised as sandy loam, loamy sand and sandy clay loam. The pH of all the twenty two soil samples was slightly alkaline. Soil pH (KCl & water), bulk density, Bray1 P, organic carbon and electrical conductivity varied significantly ($p<0.05$) with depth for every profile across the field.

CONCLUSION

It was found that there is spatial variability of soil physico-chemical properties across the research block. All the parameters showed the variable distribution along the profiles which is a clear indication of the heterogenic nature of soil. The variation differed among the soil physical and chemical properties which may be a result of land uses or natural factors such as climate. This study provided quantitative information for monitoring changes in soil properties and improving soil management practices.

Keywords: Bulk density, soil fertility; spatial variability; sustainable crop production

EVALUATION OF ECLIPSE FOR REDUCING SUNBURN IN 'QUEEN' PINEAPPLE, SOUTH AFRICA

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INTRODUCTION

Sunburn on 'Queen' pineapple fruit in South Africa can cause crop losses as high as 25% and in extreme cases even as high as 70%. Damage mostly occurs as the fruit matures and usually peaks during January and February, but can occur any time of the year. Temperatures higher than 32°C in windless conditions are often experienced in cases of severe sunburn damage. Factors such as growing conditions, plant characteristics, nutritional status of the plant and vegetation of the area surrounding the pineapple field also effect the severity of sunburn damage. Eclipse, a calcium carbonate and boron colloidal liquid forming a sunshield film, was evaluated over the past two seasons on Queen pineapples. It has a sun protection factor of 42, protects the fruit against UV (sunburn) and infrared radiation (heat) and can thereby reduce sunburn by up to 90%.

MATERIAL AND METHODS

Six pineapple fields, to be harvested weekly for a 6-week period during January and February 2013, were selected at two growers in the Hluhluwe pineapple production area. Eclipse was applied with a boom spray 4 and 2 weeks before harvest at 18 L/ha and 9 L/ha respectively and compared to an untreated control. Fifty fruit in four replicates were evaluated in both treatments for each week. External sunburn damage was rated according to severity (1 = slightly damaged, fruit still marketable; 2 = fruitlets show more severe browning with sunken peel and often cracking between fruitlets – fruit rejected; 3 = fruitlets are damaged and severe cracking between fruitlets occur allowing easy access for diseases, flesh also shows damage and fruit will be rejected). Data were evaluated by students t-test and Chi square (SAS/STAT software)

RESULTS AND DISCUSSION

Sunburn in these trials varied between 3.5 and 27% in the control treatment and the application of Eclipse reduced sunburn to between 0.5 and 14.4%. Eclipse especially reduces the more severe forms of sunburn (rating 2 and 3) and therefore fewer fruit are rejected.

CONCLUSION

Is seems that Eclipse has considerable potential for sunburn control in 'Queen' pineapple under South-African conditions.

ACKNOWLEDGEMENT

These trials were funded by Villa Crop Protection (Pty) Ltd, the South African distributor for Eclipse.

Keywords: Eclipse, 'Queen' pineapple, sunburn, particle film

COMPARISON OF LIVELIHOOD VULNERABILITY INDEX FOR SUBSISTENCE FARMERS IN THE WATERBERG DISTRICT OF LIMPOPO PROVINCE

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INTRODUCTION

In most of the developing countries around the world, agriculture is a major sector of the economy and South Africa is not an exception. Extreme meteorological events such as droughts and floods have a potential to increase pest and disease infestations, which can cause significant economic losses depending on the stage of agricultural activities that occur. Timely availability of meteorological information and services could facilitate both strategic and tactical decisions in increasing and sustaining agricultural production (Sivakumar, 2006). A clear quantification of the livelihood vulnerability can be used to quantify the effect of agrometeorological information disseminated. With an ability to predict and mitigate climate variability through strategic planning, food security could be improved in Southern Africa according to user surveys (Harrison and Graham, 2001).

MATERIALS AND METHODS

A Livelihood Vulnerability Index (LVI) was developed to estimate livelihood vulnerabilities of subsistence farmers in six municipalities in the Waterberg District of Limpopo Province. A total of 137 households were surveyed and data was collected on socio-demographics, livelihoods, social networks, health, food, water security, natural disasters and climate variability. The data was aggregated using a composite index and different vulnerabilities were compared.

RESULTS AND DISCUSSION

The results showed a high level of livelihood vulnerability in all six municipalities. This practical approach may be used to monitor vulnerability, programme resources for assistance in policy or project effectiveness in data scarce regions by introducing scenarios into the LVI model for baseline comparisons.

CONCLUSIONS

Therefore a thorough understanding of the vulnerability index can be used by resource managers to better implement their management strategies to improve food security and minimize the impact of weather related disasters.

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Limpopo Department of Agriculture, Disaster and Risk Management office

Keywords: Subsistence farmers, vulnerability assessment

THE ROLE OF WATER STRESS ON *Fusarium verticillioides* INFECTION AND FUMONISIN SYNTHESIS IN MAIZE KERNELS

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INTRODUCTION

Maize (Zea *mays* L.) is one of the most important cultivated crops worldwide, and is a host of many plant pathogens, such as *Fusarium verticillioides,* also occurring worldwide. This fungus produces secondary metabolites, fumonisins, which when ingested cause mycotoxicoses in animals and humans. The World Health Organization for cancer research classified fumonisins as a group 2B toxin, which means it can possibly cause cancer in humans.

MATERIALS AND METHODS

In a glasshouse trial two cultivars, PAN6P-110 and CRN3505, were planted in 80 l black bags and treated with five watering regimes (35 l, 30 l, 25 l, 20 l- and 15 l per pot per week). Maize ears were inoculated at silking with *F. verticillioides* isolate MRC826, to investigate the effect of water stress on fumonisin producing fungal biomass and fumonisin production. After harvest, fumonisins and fumonisin producing fungal biomass were quantified with HPLC and qRT-PCR, respectively. Chlorophyll fluorescence was measured at five different growth stages namely 8-leaf, silking, two days after inoculation and soft dough to monitor the effect of the water regimes on the photosynthetic efficiency of the plants. Chlorophyll fluorescence data was analysed with a Hansatech Handy Pea chlorophyll fluorimeter and data were analysed with the PEA plus software version p1.30 from Hansatech. Data were statistically analysed with GenStat (14th Edition) using an ANOVA to determine the effect of watering regime on fungal biomass infection and fumonisin synthesis.

RESULTS AND DISCUSSION

ANOVA indicated significant treatment effect for fungal biomass (P=0.01) and cultivar (P=0.00) effects for fungal biomass and fumonisins. Mean fungal biomass was 25.25 pg at 35 l - and 45.12 pg at 15 l - per week. Mean fungal biomass and fumonisins for PAN6P-110 was 20.49 pg and 4.04 ppm, for CRN3505, 38.33 pg and 7.72 ppm respectively. Analysis of variance indicated a significant watering regime x cultivar interaction (P=0.01) for fungal biomass. Chlorophyll fluorescence data indicated PAN6P-110 to withstand water stress better than CRN3505 at certain growth stages.

CONCLUSIONS

This trial was inoculated, which could have attributed to the significant water regime x cultivar interaction regarding fungal biomass. Previous studies confirmed fungal biomass is not a direct reflection of fumonisin synthesis which may explain the significant treatment effect on fungal biomass, but not fumonisin synthesis.

Keywords: Fusarium verticillioides, fumonisin

THE EFFECT OF SIX *Fusarium verticillioides* ISOLATES ON FUMONISIN PRODUCTION AND FUSARIUM EAR ROT SEVERITY ON MAIZE

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INTRODUCTION

Fusarium ear rot of maize is caused by *Fusarium verticillioides* which produces mycotoxigenic metabolites, fumonisins, which are harmful to human and animal health. Total fumonisins consist primarily of three analogues FB_1, FB_2 and FB_3 of which FB_1 is the most abundant and toxic. *Fusarium verticillioides* isolates can be divided into high (above 2 ppm) and low fumonisin producers. The Fusarium ear rot symptoms and fumonisin levels vary when exposed to different growth conditions. In this study high and low fumonisin producing *F. verticillioides* isolates were inoculated *in planta* at different localities in South Africa. The variables contributing to fumonisin contamination and Fusarium ear rot symptoms development under environmental conditions were examined.

MATERIALS AND METHODS

Three field trials were planted at localities with different environmental conditions; Cedara (KwaZulu-Natal), Ermelo (Mpumalanga) and Potchefstroom (North West), over two seasons. The cultivar CRN3505 was planted and inoculated with six *F. verticillioides* isolates (GCI 51, GCI 282, GCI 340, GCI 432, MRC 826 and GCI 1608) in a randomised block design with three reps per isolate. Maize ears were injected with the same spore suspension ($1x10^6$ conidia/ml) of each isolate at silk stage. A water control was included. Disease severity was determined as visual percent ear infection and biomass of *F. verticillioides* in ears was quantified by real time PCR using species-specific primers. Fumonisin levels were quantified by high performance liquid chromatography.

RESULTS AND DISCUSSION

In the three field trials at different localities all isolates differed in Fusarium ear rot severity, indicating that some isolates were more virulent than other. The isolates' ability to infect and cause visual symptoms was influenced by environmental conditions at the localities. Total fumonisin, FB_2 and FB_3 production were significantly influenced by isolate and locality interaction. FB_1 production was significantly influenced by season, isolate and locality interaction. Isolate GCI 340 produced high fumonisins in Potchefstroom and Cedara, while GCI 282 was a low producer at the same localities. In all trials FB_1 was the dominant fumonisin analogue produced.

CONCLUSION

Fumonisin production per isolate is highly variable and influenced by the toxigenic potential and virulence of the isolate under varying environmental conditions.

Keywords: Fusarium verticillioides, qPCR, Fusarium ear rot, fumonisin

ASSESSMENT OF GENETIC VARIATION OF SOUTH AFRICAN *Fusarium verticillioides* ISOLATES USING MICROSATELLITE MARKERS

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INTRODUCTION

Fusarium verticillioides occur in all maize-producing areas worldwide and produces mycotoxigenic metabolites that negatively influence human and animal health. Microsatellites are DNA-based molecular markers that can be used to evaluate genetic variation. These short simple sequence repeats (SSRs) are usually 20-60 bp in length, with tandem repeats of 1 - 6 base pairs. These SSRs have high mutation rates which provide information on genetic relationships among closely related species or subpopulations within a species. The aim of the study was to determine the genetic diversity and population structure of *F. verticillioides* isolates collected throughout South Africa from maize roots, stems and ears using SSR markers.

MATERIALS AND METHODS

A total of 296 *F. verticillioides* isolates were collected from various localities in South Africa. The four geographically separated populations were designated as K (KwaZulu Natal), E (Eastern Cape including mountainous regions), M (Mpumalanga and Limpopo) and F (Free State and North West). Twelve polymorphic SSR markers were selected and genetic diversity within and between these sampling populations were estimated, as well as gene flow and migration. The presence of the mating type genes *MAT*-1 and *MAT*-2 in the population was also evaluated using a PCR-based method.

RESULTS AND DISCUSSION

All populations were significantly different from each other with the most significant difference observed between populations K and F. Population F represented the *F. verticillioides* isolates from both stems and roots and were genetically distinct from all other populations. Gene flow was low between populations except for populations M and K, which clustered together on the Factorial Correspondence Analysis (FCA) plot. Migration of genotypes between population M and K was therefore high. These results suggest that gene flow and grouping of isolates could be influenced by climatic conditions. For example, population F experienced dry and warm conditions, while population K and M experienced more tropical conditions. The *MAT*-1 gene was present in 56% of *F. verticillioides* isolates from South Africa suggesting sexual recombination occurs regularly in these populations.

CONCLUSION

The study has shown that *F. verticillioides* contains high genetic diversity within each population. Sexual reproduction is the driving force behind the genetic variation in *F. verticillioides* and the genotypic selection could be influenced by adaptation to different climatic conditions.

Keywords: Fusarium verticillioides, SSRs, recombination, gene flow, genetic variation

FOLIAR UPTAKE OF Mn AND Zn FORMULATIONS AT VARIOUS TIME INTERVALS BY VALENCIA TREES

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INTRODUCTION

Perennial fruit crops like citrus can benefit from foliar nutrition since the deep roots can deplete the soil nutrients in time and soil amendments are not easily applied without damaging roots (Abd-Allah, 2006). Rising production costs are urging farmers to look at cost effective ways of supplying their crops with the necessary micronutrients. Manganese has a low phloem mobility (Fageria *et al*., 2009), although foliar applied Mn^{2+} can alleviate Mn deficiency symptoms. Zn, which is reportedly deficient for citrus in South Africa, reduces fruit drop and granulation in citrus (Srivastava & Singh, 2005).

MATERIALS AND METHODS

Young, non-bearing *Citrus sinensis* (L. Osbeck) cv. Valencia treeswere used. Zn was applied to leaves as $ZnSO_4$, ZnO, Zn-EDTA and Zn-Amino acid at 0.00129g/L Zn. Mn was applied as $MnSO_4$, Mn-EDTA and Mn-Amino acid at 0.549g/L Mn. Solutions were prepared with deionized water, buffer and wetting agent. Leaves were dipped into the solutions and sampled at 12, 24, 48, 96 & 192 hrs after treatment. Treated leaves as well as the leaf directly above and below treated leaves were sampled. Four replications with a control treatment were used in a split-split plot design in completely randomized block design (CRBD) layout. Waxy layer and residues on leaves were removed. Plant material was oven-dried, digested and analysed for elemental concentrations.

RESULTS AND DISCUSSION

Leaf Zn levels were highest for the Zn-Amino acid treatments at all sampling times. The $ZnSO_4$ treatments showed the second highest leaf Zn levels in all cases. The ZnO treatments showed Zn levels in the same region than the control treatments at all sampling times. The $MnSO_4$ treatment showed the highest leaf levels throughout the time period. Highest leaf Zn and Mn levels for all the treatments were detected at the 96hr sampling time.

CONCLUSIONS

Optimum sampling time for Zn and Mn treatments was at 96hrs after treatment application. Leaf Zn uptake, in descending order, were: Zn-Amino acid, $ZnSO_4$, Zn-EDTA, ZnO, Control. Mn uptake in descending order, were: $MnSO_4$, Mn-EDTA, Control, Mn-Amino acid.

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Keywords: Manganese, foliar uptake, Zinc, Citrus, formulations

COWPEA CRUDE PROTEIN AS AFFECTED BY CROPPING SYSTEM, LOCATION AND NITROGEN FERTILIZATION

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INTRODUCTION

Cowpea is a major source of protein in the diet of many people of sub-Saharan Africa. Some people eat both fresh pods and leaves and the dried seeds are popular ingredients in various dishes. The tender green leaves are an important food source in Africa. The immature snapped pods are used in the same way as snap beans; often mixed with other food crops. The aim of the study was to determine the effect of cropping system, location and nitrogen fertilizer on cowpea crude protein content.

MATERIALS AND METHODS

The study was conducted at Potchefstroom, Taung and Rustenburg in the North West province of South Africa during 2011/12 and 2012/13 planting seasons. It featured three cropping systems namely maize and cowpea monocropping, a maize cowpea rotation and a maize cowpea intercropping. Nitrogen fertilizer was applied in plots of cowpea at two rates of 0 and 20 kg N ha^{-1} at Potchefstroom, 0 and 23 kg N ha^{-1} at Taung and 0 and 17 kg N ha^{-1} at Rustenburg, due to the recommended dosages after soil analysis per location. The experimental design was 3 x 3 x 2 factorial experiment laid out in randomized complete block design with three replications. The protein content was determined from green leaves, immature green pods and harvest mature grains. Crude protein content (%) was estimated on the basis of N% x 6.25.

RESULTS AND DISCUSSION

Cropping system and location had significant effects ($P < 0.05$) on cowpea leaf protein content. Leaves of cowpea derived from intercropping showed a significantly ($P < 0.05$) higher protein content than leaves of cowpea from other systems. Leaves of cowpea planted at Taung had significantly ($P < 0.05$) higher protein content than leaves of cowpea from other locations. Immature pod protein content of cowpea planted at Rustenburg and Taung was significantly ($P < 0.05$) higher than immature pod protein content of cowpea from Potchefstroom. Immature pods harvested from cowpea plots treated with nitrogen fertilizer had significantly ($P < 0.05$) higher protein content than immature pods from plots without nitrogen fertilizer application.

CONCLUSIONS

Cowpea protein content differed among the different locations and cropping systems. Nitrogen fertilizer contributed to higher protein content of immature pods.

ACKNOWLEDGEMENTS

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Keywords: Immature pod, leaf protein, location, seed protein

DEVELOPMENT OF GENOTYPE REFERENCE DATABASES FOR CULTIVAR VERIFICATION AND GENETIC DIVERSITY ANALYSIS FOR TROPICAL AND SUBTROPICAL CROPS

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INTRODUCTION

Characterisation of fruit crop accessions is usually based on important morphological or agronomical features when accessions are added to germplasm collections. These characteristics are not always expressed phenotypically and are often influenced by the environment. Verification of trueness-to-type is therefore not always possible and may prevent the detection of misidentifications or duplicates within germplasm collections. Besides the importance of cultivar verification in germplasm maintenance, the estimation of the genetic diversity within the collections is required to optimise the use of their genetic potential.

MATERIALS AND METHODS

Sequence Related Amplified Polymorphism - (SRAP), Simple Sequence Repeat (SSR) - as well as Expressed Sequence Tag-SSR (EST-SSR) markers for citrus, litchi, and macadamia were selected and assessed for their ability to distinguish between accessions for each fruit crop in the study. PCR amplification products generated were analysed using capillary electrophoresis. The results obtained for each accession were verified and captured together with phenotypic characteristics in a reference database. GenAlEx 6.3 was used to calculate frequency, distribution of alleles, principle component analysis as well as determine polymorphism information values. The web-based program Dendro-UPGMA was used to calculate genetic distance- and or similarity matrices employing the Pearson, Jaccard, Dice, MSD and RMSD mathematical models and UPGMA cluster analysis was carried out thereafter. The cluster analysis was validated through bootstrapping and the calculation of the co-phenetic correlation coefficient (CCC).

RESULTS AND DISCUSSION

The litchi genotypic reference database, currently containing 44 accessions was used to determine the parentage of several open-pollinated selections, identify duplicate or misidentified accessions and estimate the genetic diversity of the current germplasm collection. The citrus database with a total of 324 accessions was divided into 4 groups containing clementine, mandarin hybrid and Satsuma accessions; lemons, limes and grapefruit; sweet oranges and rootstock accessions, respectively. This database will mainly be used for routine cultivar verification by the Citrus Improvement Scheme. Forty seven macadamia accessions were included in the initial reference database and will be used in future to confirm parentage of crosses made.

CONCLUSION

The genotype information generated will not only contribute significantly towards genebank maintenance but will also provide a valuable tool for the optimization of germplasm utilization and breeding through the effective selection of core collections.

ACKNOWLEDGEMENTS

We would like to recognize the ARC, CRI, and THRIP for funding and support received.

Keywords: Genotype reference databases, litchi, macadamia, citrus

UNCONVENTIONAL METHODS USED BY SUBSISTENCE FARMERS TO CONTROL PRE-HAVERST PESTS OF MAIZE (*Zea mays* L) IN THE EASTERN CAPE PROVINCE

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INTRODUCTION

Insect pests have been reported as one of the major constraints to maize production in the Eastern Cape Province (Waladde *et al*., 2001). Subsistence farmers often do not afford pesticides such that they tend to adopt alternative atypical control methods. These methods are not always documented and as a result, factors such as efficacy, human, animal and environmental health issues are unknown. This study was aimed at identifying pests that farmers perceive as important in maize and further document unconventional methods farmers use to manage these pests.

MATERIALS AND METHODS

Surveys were conducted between July and November 2012 through questionnaires consisting of structured, semi-structured and unstructured sections. A total of 217 IsiXhosa speaking rural farmers from five of the six districts of the Eastern Cape Province were interviewed. The data collected included personal information (age, gender and locality of respondent), demographic information (level of education and marital status) and insect pest status. Data on prevention and control methods were also collected. Descriptive statistics was applied and SPSS was used to analyze for associations within the data.

RESULTS AND DISCUSSION

Farmers identified six insect species as pests of maize. Amongst these, 80 % of respondents named maize stalk borers as major constraints followed by cutworms at 51 %. The use of alternative methods other than chemicals and/or botanicals was cited by 34% respondents. In these, Madubula (Tar acid), normally used as a detergent, cattle dip (deltermethrin 5%), ash and agricultural lime were cited frequently by respondents either as ingredients to a mixture or used solely. The most preferred method to apply these mixes was by hand or to sprinkle them all over the infested plant using a grass broom. Choice of control method was not affected by marital status, occupation or place of residence. Age and level of education were found to have a significant effect on methods employed ($p=0.05$).

CONCLUSION

Methods did not differ significantly amongst farmers residing in different areas. Age and level of education played a significant role on which method farmers employed.

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Keywords: Control methods, Maize, Pests, Subsistence farmers

OPTIMIZATION OF EISENIA FETIDA STOCKING DENSITY FOR THE BIOCONVERSION OF PHOSPHATE ROCK ENRICHED COW DUNG-WASTE PAPER MIXTURES

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INTRODUCTION

Vermitechnology is gaining recognition as an environmentally friendly waste management strategy. Its successful implementation requires that key operational parameters like earthworm (Epigeic species e.g. *Eisenia fetida* commonly known as Red wigglers) stocking density be established for each target waste/waste mixture. One target waste mixture in South Africa is waste paper mixed with cow dung and phosphate rock (PR) for P enrichment. This study sought to establish optimal *Eisenia fetida* stocking density for maximum P release and rapid bioconversion of PR enriched cow dung- paper waste mixtures.

MATERIALS AND METHODS

The trial was carried out in worm boxes having a volume measuring (0.50m x 0.40m x 0.30 m) with an exposed exterior vicinity of 0.2 m^2. Feedstock (5kg on dry weight basis) consisting of cow dung mixed with waste paper to achieve a C: N ratio of 30 was placed in the vermicomposting boxes and thoroughly mixed with 2% P in the form of PR. *Eisenia fetida* earthworms (juveniles) having approximately the same body weight were introduced into the worm boxes to achieve different stocking densities of (0, 7.5, 12.5, 17.5 and 22.5) g- worms kg^{-1} dry weight of cow dung- waste paper mixtures. Phytotoxicity was assessed through a seed germination test. Aqueous extracts were prepared from the different vermicomposts with distilled water (1:10 w/v).

RESULT AND DISCUSSION

The stocking density of 12.5 g worms kg^{-1} resulted in the highest earthworm growth rate and humification of the PR enriched waste mixture as reflected by a C: N ratio of < 12 and a humic acid/fulvic acid ratio of > 1.9 in final vermicomposts. A germination index of >80% shown by the test revealed that the resultant vermicompost had no inhibitory effect on the germination of tomato, carrot, and radish. Extractable P increased with stocking density up to 22.5 g worm/kg feedstock suggesting that for maximum P release from PR enriched wastes a high stocking density should be considered.

CONCLUSION

The study demonstrated that an *Eisenia fetida* stocking density of 12.5g worms /kg feedstock is ideal for the biodegradation of phosphate rock enriched cow dung waste paper mixtures. Extractable P increased with stocking density up to 22.5 g worm/kg feedstock suggesting that for maximum P release from PR enriched wastes a high stocking density should be considered.

Keywords: Eisenia fetida, humification indices, P enrichment, vermicomposting, stocking density