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INVESTIGATING THE IMPACTS OF CONSERVATION AGRICULTURE PRACTICES ON SOIL HEALTH AS KEY TO SUSTAINABLE DRY LAND MAIZE PRODUCTION SYSTEMS ON SEMI-ARID SANDY SOILS WITH WATER TABLES IN THE NORTH WESTERN FREE STATE

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Investigating the impacts of conservation agriculture practices on soil health as key to sustainable dry land maize production systems on semi-arid sandy soils with water tables in the north western Free State.

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EXECUTIVE SUMMARY

The current project builds on previous projects funded by the Maize Trust, where the main objective had been the implementation and evaluation of various cultivation practice options for sustainable dry land maize production systems on semi-arid sandy soils with water tables in the north western Free State. These sandy soils developed from Aeolian parent material and were deposited between 1.8 and 5 million years ago on a Palaeolithic surface consisting of poorly drained clayey components of weathered dolerite, mudstone, calcrete and shale. These soils are known for their proneness to wind erosion, inherent compaction problem, low organic matter content and low nutrient and water retention capability. However, the presence of a shallow water table above the Palaeolithic surface, to serve as a water reservoir, contributes to stable crop yields under the highly variable rain fall conditions.

During the evaluation and planning sessions of 12, 22 August and 12 September 2016, several challenges (problems) that still remain in terms of implementing conservation agriculture (CA) practices for sustainable and profitable crop production on sandy soils were identified and prioritized. A shift to practices that improve and maintain soil health was emphasized. On the semi-arid sandy soils of the north western Free State a major portion of the maize yield of South Africa is produced. Against this background, new and innovative production practices should continuously be tested and implemented on these very unique and fragile soils to enhance and maintain their productivity in view of national food security.

For this purpose four farmers made available trial sites and agreed to implement trials under controlled traffic systems to evaluate/assess:

- *Trial 1: Regenerative CA crop-livestock integrated system with rotations of maize-summer-winter diverse ley crops (Farmer co-worker: Danie Crous, Deelpan).*
- *Trials 2 & 3: Local CA, ROR and reduced tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat, as well as maize/soybean, compared to mono culture maize cultivation (Farmer co-workers: Thabo van Zyl, Christinasrus; Lourens van Zyl, Klein Constantia).*
- *Trials 4 & 5: Interactions of plant row width, population density and cultivar as component to the sustainable cultivation of mono culture maize on sandy soils (Farmer co-workers: Thabo van Zyl, Doornbult; Danie Minnaar, Vlakvlei).*
- *Trial 6: The optimum depth of ripping for the sustainable cultivation of mono culture maize on sandy soils (Thabo van Zyl, Doornbult).*

The very good seasonal rainfall at the trial localities varied between 521 and 746 mm and led to an expectation of exceptional growth and yields of crops. High winds in December led to damage of the young maize and led to replanting in some lands. Exceptionally high rainfall (350-511 mm) was experienced in December and January that caused waterlogging in some lands.

Trial 1 (Deelpan - Danie Crous): Regenerative CA crop-livestock integrated system with rotations of maize/summer/winter diverse ley crops:

Growth and yield of crops: *The summer and winter annual cover crop mixtures established well due to the favourable rainfall and exceptional yields were obtained. Dry matter yields (DM) of all plant components of the summer cover crops ranged from 14.5 to* 17.1 t ha^{-1}, while *DM yields of all plant components of the winter cover crops ranged from 11.3 and 16.1 t ha^{-1}. With an average N content of 2%, a total of 226 to 322 kg N ha^{-1} was captured by the winter cover crops of which 40% will hopefully be available for the next crop. The winter cover crops gave the highest water use efficiency (WUE) compared to the summer cover crops (36.6 vs. 25.9 kg dry matter mm^{-1} ha^{-1}), while the monoculture maize attained a WUE of 14.3 kg grain mm^{-1} ha^{-1}.The monoculture maize yielded 8.71 t grain ha^{-1} (hand harvested) and 7.11 t grain ha^{-1} (combine harvester).*

Soil water and temperature studies: *The ability of a summer cover crop mixture to produce enormous amounts of roots, as well as litter fall, led to a build-up soil organic carbon (SOC) in the 0-100 mm layer of 0.74% C compared to, for example, 0.49% C under a grass land. The use of capacitance probes to measure soil water content (SWC) proved to be very successful. The results indicate that between rainfall events SWC quickly approached the permanent wilting point of these sandy soils. Soil water content was much lower under the summer cover crop mixture compared to the maize (row crop), immediately after a rain event. This is probably due to the interception of the rain by the closed canopy of the former crops, followed by evaporative losses directly from the crop canopy. A full SWC profile was measured on the fallow land before planting of the winter cover crops. Seasonal soil temperature fluctuations show that the soil was the coolest under the summer and the warmest under the winter cover crop mixture, respectively. The conclusion can be made that the cultivation of the former crop mixtures can, inter alia, contribute to the reduction of earth warming.*

The periodic measurement of two water tables in the trial area revealed very high NO_3 values, varying from 84 to 504 mg L^{-1}, while very low soil NO_3-N values, ranging from 4-5.5 mg kg^{-1} were observed. At the same time, the maize showed marked N deficiency symptoms. The leaching of costly and health threatening NO_3-N on these sandy soils appears to be a serious problem. Another health threatening component that was present at high concentrations was NO_2 (nitrite). Other plant nutrients, like PO_4, K, Ca and Mg were also present in both water tables at all dates of sampling. A study of a salt crust in the trial area revealed the presence (sometimes at high concentrations) of costly plant nutrients, such as NO_3, PO_4, K, Ca and Mg. Soil bulk densities were lower under ROR compared to no tillage. Between-the-row bulk density on the ROR (maize) was at 1.72 g cm^{-3} much higher than on-the row density (1.44 g cm^{-3}), indicating soil compaction due to implement traffic. Consequently, *soil porosity was higher under ROR compared to no tillage (46% vs. 40%), indicating more air/water-filled soil pores.*

Soil sampling and analysis by OMNIA: *Topsoil pH, Ca and Mg were below the norm required for maize. Very low NO_3-N values, ranging from 4-5.5 mg kg-1 in the topsoil, were measured. Relatively high NH_4-N values, ranging from 22-35 mg kg^{-1} in the topsoil, were measured. Top- and subsoil P were, respectively, above and below the minimum requirement for maize, while soil K was adequately supplied. Topsoil cation exchange capacity was very low at 1.78 $cmol_c$ kg^{-1}. Sand, silt and clay contents were 84%, 3% and 13%, respectively, indicating a loamy sand soil texture.*

Root and crown rot severity study: *The average root rot severity and crown rot index scores were low at 120 and 10, respectively. The average plant biomass obtained was 1.54 kg $plant^{-1}$ and the average root mass achieved was 0.21 kg $plant^{-1}$. The results are regarded as baseline data as it was the first year of the trial.*

Plant-parasitic nematode study: *Nematode species present in the root samples included root-knot nematodes and lesion nematodes, with a higher infection rate than at Trial 2 at Christinasrus. Lesion, ring and spiral nematodes were maintained in the soil samples. The lesion and spiral nematode numbers differed significantly in the soil samples for the different treatments, while the ring and root-knot nematode numbers in the soil samples were not statistically different. Since this is the first season for the trial, statistical analysis was only done on the data collected from the soil samples, and will serve as base line for the coming seasons. The soil samples are currently being analysed for free-living nematodes.*

Soil microbiological study: *The results suggest that differences could be detected among microbial counts under cover crops compared to monoculture maize. This was also the case for glucosidase and alkaline phosphatase enzyme activities that were significantly higher in cover cropping systems compared to monoculture maize. However, urease activity was not affected by any of the cropping systems.*

Trial 2 (Christinasrus - Thabo van Zyl): Local CA, ROR tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat compared to monoculture maize cultivation:

Soil sampling and analysis by OMNIA: *In general soil pH values were rather low with some subsoil values below the norm of 4.5 for maize. High acid saturation values indicate serious subsoil acidity. It is advised that soil acidity should be ameliorated with dolomitic agricultural lime because of the sub-optimal topsoil Mg status. Very low NO_3-N values, ranging from 4.3-7 mg kg^{-1} in the 0-60 soil layer, were measured. Relatively high NH_4-N values, ranging from 38-49 mg kg^{-1} in the 0-60 soil layer, were measured. The use of urea or NH_4-fertilizers as N carrier on these sandy soils with their very poor acid buffer capacity should be discouraged.*

Topsoil P values are above the minimum P requirement for maize, while, in general, subsoil residual P is inadequately supplied. Both top and subsoil K are, in general, well-supplied. Both soil Ca and Mg are inadequately supplied in both the topsoil and subsoil. Organic soil C was generally very low and ranged from 0.34-0.58%. Topsoil c*ation exchange capacity was very low (1.86 $cmol_c$ kg^{-1}). Sand, silt and clay contents were 87%, 5% and 8%, respectively, indicating a sand soil texture.*

Root and crown rot severity study: *The average root rot severity and crown rot index scores were low at 151.54 and 36.03, respectively. The average plant biomass obtained* *was 1.56 kg plant^{-1} and the average root mass achieved was 0.16 kg plant^{-1}. There was a tendency of higher levels of root and crown rot in replicate 3. The results are regarded as baseline data as it was the first year of the trial.*

Plant-parasitic nematode study: *Nematode species present in the root samples included root-knot nematodes and lesion nematodes, while lesion, ring, spiral and dagger nematodes were maintained in the soil samples. Nematode numbers in the soil samples did not differ statistically significantly. The soil samples are currently being analysed for free-living nematodes.*

Soil microbiological study: *Bacterial and actinomycetes counts and microbial enzyme activities (glucosidase and phosphatase) were higher in the maize/soybean rotation system, whereas higher fungi levels occurred in the monoculture maize. The results suggest that crop rotations encouraged higher microbial activities. The results are regarded as baseline data as it was the first year of the trial.*

Agronomic observations and measurements: *Maize yield ranged from 2.89 to 9.68 t ha^{-1} with a mean yield of 7.71 t ha^{-1}. Soybean yields ranged from 2.02 to 2.31 t ha^{-1} with a mean yield of 2.21 t ha^{-1}. Both maize and soybean yields were high and it can be assumed that a rotational effect was created which may affect the crops in the 2017/2018 season. Due to a lack of rain during the period of March-June, the emergence and seedling growth of the wheat was very poor and was regarded as a failure.*

Trial 3 (Klein Constantia - Lourens van der Linde): Local CA, ROR and reduced tillage, stubble-mulch, cash crop rotations with maize/soybean compared to monoculture maize cultivation:

The 2016/17-season was marked by severe wind damage in December 2016, followed by excessive rain events in January and February. The latter led to water-logged conditions on the trial site. These events were not conducive to good growth and yields. Relatively low maize grain yields, ranging between 1952 and 4049 kg ha^{-1}, were realized. No clear effects in terms of crop rotation or tillage on maize grain yield could be discerned. For the monoculture maize a better margin (R1249 ha^{-1}) was realized under ROR tillage, compared to a margin of R988 ha^{-1} under reduced tillage (RT).

Trial 4 (Doornbult - Thabo van Zyl): Interaction of plant row width and population density as component to the sustainable cultivation of monoculture maize on sandy soils:

Plants in 1.524 m rows had 2.5 times the number of tillers of plants in the 1.016 m rows. At similar seeding densities, grain yields of the 1.016 m rows were higher than yields of the 1.524 m rows. Assuming a seed price of R3260 per 60000 seeds and a grain price of R1650 t^{-1}, the optimum plant densities were 37 800 and 34300 ha^{-1} for the 1.016 and 1.524 rows, respectively. Maize grain yield was affected by both plant population density and row width. The mean yield of the 1.016 rows was 1.37 t ha^{-1} higher than that of the 1.524 m rows. The results on yield per plant as related to plant population and row width indicate that the cultivar displays tolerance to stress caused by increasing plant densities.

The best margins were realized with narrow rows (1.106 m) at high population densities, compared to wider (1.524 m) rows. For example, R5082 ha^{-1} and R5153 ha^{-1} were realized with narrow rows at a high population densities of 30000 and 50000 plants ha^{-1}, respectively. With wider rows (1.524 m), the highest margin (R3001 ha^{-1}) was obtained at *a population density of 25000 plants ha^{-1}, compared to R1703 and R2356 ha^{-1} for 20000 and 50000 plants ha^{-1} stands, respectively.*

Soil water extraction under a 15 000 plant population density ha^{-1} was only observed in the top two soil layers (i.e. 0-40 cm depth). No effect of row-width on soil water extraction could be measured. Under a population density of 25 000 ha^{-1}, soil water extraction from three soil layers (i.e. 0-60 cm depth) was observed. The 50 000 plant population ha^{-1} plot indicated soil water extraction from five layers (i.e. 0-100 cm depth).

Trial 5 (Vlakvlei - Danie Minnaar): Interaction of population density and cultivar as component to the sustainable cultivation of monoculture maize on sandy soils:

The number of tillers per plant was not affected by seeding density. Each cultivar had a unique yield response to seeding density. Optimum population density appeared to be above 23000 ha^{-1}. The yield of tillers declined as the yield of the main stem increased indicating that tillers had no additional benefit to the yield per ha. Yield that was gained by tillers were lost by the main stems. Analysis of variance results showed no statistical differences in maize grain yield within the density ranges 12000-20000 and 22000-26000, respectively, while yields for the 22000-26000 density range were statistically different from the 22000-26000 density range.

For cultivar 78-87Bt a plant population density of 24000 plants ha^{-1} gave a slightly higher (R12246 ha^{-1}) margin than 26000 plants ha^{-1} (R12187 ha^{-1}). Against the background of the present low farm gate price for maize, it would appear as if the economic optimum stand for cultivar 78-87Bt is 22000-24000 plants ha^{-1}. For cultivar 78-17Bt a plant population density of 26000 plants ha^{-1} yielded a higher (R11443 ha^{-1}) margin than 24000 plants ha^{-1} (R10891 ha^{-1}). Comparing the margins of the two cultivars, it can be seen that cultivar 78-87Bt with a stand of 24000 plants ha^{-1} yielded R803 ha^{-1} more than a 26000 plants ha^{-1} stand of cultivar 78-17Bt.

Trial 6 (Doornbult - Thabo van Zyl): The optimum depth of ripping for the sustainable cultivation of monoculture maize on sandy soils:

Grain yield increased linearly with ripping depths from 45 to 75 cm at a rate of 0.87 t ha^{-1} per 100 mm increase in ripping depth. No significant yield response was found by increasing the ripping depth above 75 cm. The 90 cm deep ripping yielded a slightly higher margin than the 75 cm ripping. However, the additional capital cost (not included in the present analysis) will eliminate this financial advantage. It can be concluded that a 90 cm deep ripping would not have a financial gain over the current farm practice of ripping to 75 cm depth. It can be concluded that ripping shallower than 75 cm will not be economically viable.

Ripping to 45 cm resulted in soil water extraction in the top three soil layers (i.e. 0-60 cm depth). Ripping to 90 cm depth resulted in water extraction from five layers (i.e. 100 cm depth).

In summary it can be concluded that:

Although it was the first experimental season, valuable results were obtained that will form the base line for follow-up seasons. All six on-farm trials proved to be viable and showed the potential to contribute to practical conservation agriculture practices that will improve soil health as key to sustainable dry land maize production systems on semi-arid sandy soils with water tables in the north western Free State.

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LIST OF ABBREVIATIONS

ANOVA	analysis of variance
ARC	Agricultural Research Council
CA	conservation agriculture
DAP	days after planting
D	drainage
DM	dry matter
ECEC	effective cation exchange capacity
ET	evapotranspiration
FWC	field water capacity
K	potassium
LSD	least significant difference
N	nitrogen
NT	no-till
P	phosphorus
p	statistical probability
R	rainfall
$R_{off/on}$	run-off/run-on
RDI	root disease index
ROR	rip-on-row
SOC	soil organic carbon
Senwes	agricultural business company
SWC	soil water content
ΔSWC	change in soil water content
WUE	water use efficiency

1 IDENTIFICATION OF THE PROJECT AND THE PROJECT LEADER

1.1 Background

The current project is a continuation of previous projects funded by the Maize Trust, where the main objective has been the implementation and evaluation of various cultivation practice options for sustainable dry land maize production systems on sandy soils in the North Western Free State. During the evaluation and planning sessions of 12, 22 August and 12 September 2016, several challenges (problems) that still remain in terms of implementing CA practices for sustainable and profitable crop production on sandy soils were identified and prioritized. A shift to practices that improve and maintain soil health was emphasized. On the semi-arid sandy soils of the north western Free State a major portion of the maize yield of South Africa is produced. Against this background, new and innovative production practices should continuously be tested and implemented on these very unique and fragile soils to enhance and maintain their productivity in view of national food security.

Earlier investigations have shown that good maize yields can be obtained on the sandy soils of the North Western Free State, even in dry years. This is due to the pedogenesis of these soils where they developed on a slightly impervious Palaeolithic surface (Harmse 1963). The latter gives rise to temporary, or perched, water tables for well-developed maize root systems to utilize these water reserves. For many years cultivation research has focussed on tillage practices that not only ensured a soil profile that is physically conducive to good root development, but also practices that combat wind erosion and soil compaction, as well as providing good soil nutrient supply. The implementation of crop rotation systems in the 1970s and 80s to reduce production risks and improve profitability waned because of the lack suitable cultivars and economic viability. However, with the implementation of conservation agriculture practices in South Africa in the 1990s, a revival in interest in crop rotation systems developed (Nel 2005). The present project is a continuation of the quest to find suitable cultivation and tillage practices that will improve soil health and productivity, as well as enhance sustainable dry land maize production on the semi-arid sandy soils with water tables in the North Western Free State.

It has been envisaged that the project trials will bring together various leader farmers, experienced agriculturists and other role players in the search and implementation of sustainable production systems on the sandy soils.

1.2 Problem description and literature overview

The sandy soils of the North Western Free State developed from Aeolian parent material and were deposited between 1.8 and 5 million years ago on a Palaeolithic surface consisting of poorly drained clayey components of weathered dolerite, mudstone, calcrete and shale (Harmse 1963). These soils are known for their proneness to wind erosion, inherent compaction problem, low organic matter content and low nutrient and water retention capability. However, the presence of a shallow water table above the Palaeolithic surface, to serve as a water reservoir, may contribute to stable crop yields under the highly variable rain fall conditions.

Since the 1970's research has been focussed to overcome the compaction problem (Koch 1974, Koch and Badenhorst 1977, Bennie et al. 1982, Mallett et al 1985, Bennie and Burger 1988), in order to stimulate root development, and consequent improved growth and maize yields. Deep tillage would enable the maize roots to utilise the capillary water and promote maize production. Henning and Stofberg (1990) found that root development and maize yields increased with an increase in tillage depth down to 800 mm when a water table was present. In a comprehensive study Henning (1991) found that shallow water tables can eliminate the advantageous effects of deep tillage. Furthermore, since the 1970's, agricultural machines used by farmers have increased dramatically in size and mass, thereby worsening the compaction problem with consequent increase in costs to break compaction layers. Bennie and Hensley (2001) reported a reduction in growth with shallow sweep tillage plus residue retention and no-till, compared to conventional tillage and attributed this result to poorer root development due to the shallower tillage depth. The forgoing research results led to the implementation of the rip-on-the-row cultivation system that has been used predominantly by farmers on these semi-arid sandy soils, with the result of higher yields. This system comprised various depths of ripping, mostly on-the-row, in combination with shallow tillage practices. In most cases this system has made retention of crop residue mulch very difficult with resultant extreme soil losses and seedling damage due to wind erosion. Unfortunately the short term residual effect of the system has been forcing farmers to annually repeat the action.

In a study on an Aeolian sandy soil, Bennie et al (1995) found an increase of 34-80% in maize grain yield in a crop rotation system with maize/wheat, as compared to mono culture maize. In a long-term study on a Clovelly soil form in the Viljoenskroon area, Loubser and Nel (2004) found an increase of 12% in maize grain yield in the first year after soybean, compared to mono culture maize. According to Liebenberg (2012) maize yield increases after a leguminous crop could also be due to other factors than N, like increased microbial activity, reduced incidence of root diseases and pests, all contributing to the improvement of the extent and effectiveness of the root system.

One of the objectives of the previous Maize Trust funded project for the same region was to evaluate the adaptability and suitability of summer and winter cover crops in criss-cross designed crop systems which include maize, as well as to integrate a livestock component. For the 2015/16-season it was found that the previous crops in a rotation could have an effect on crop performance and yield of the follow-up crop. Very good dry biomass yields, ranging from 5000 to 12600 kg ha^{-1}, were obtained for the summer crops following on winter or summer crops. In the livestock integration trial, weaners were used to graze for 21 days a summer cover crop mixture. Their weight gain led to a gross margin of R2000 ha^{-1} (Beukes et al 2016). The latter study has shown that the integration of cover crops and livestock could generate a substantial on-farm income.

Against this background, it has become clear that a more comprehensive investigative initiative should be launched on these semi-arid sandy soils with water tables, based on CA principles and practices with the emphasis, *inter alia*, on: (i) poor soil health, (ii) soil compaction, (iii) diversifying annual cropping systems to include legumes, perennial crops and forages in rotations, (iv) using cover crops in conjunction with row crops, (v) integrating livestock with cropping systems (vi) nematode infestation and prevalence of crown and root rot, (vii) microbial diversity and enzymatic activity, and (viii) lack on profitability information of various CA systems and practices. Scientific and practical evaluation of innovative and alternative cultivation practices, based on CA principles and practices, are needed to address the persistent challenges and problems facing farmers in their efforts to find sustainable and regenerative production systems on the semi-arid sandy soils with water tables of the North Western Free State.

1.3 Project objectives

It was envisaged to achieve the following objective with sub-objectives during the 2016/17 growing season:

- To evaluate regenerative and locally adapted CA systems, e.g. no-till/rip-on-row tillage, permanent organic soil cover with diversified crop rotations, including cash crops, as well as multi-species cover crops with livestock integration with sub-objectives:
    - To evaluate depth and frequency of ripping as ameliorative measures to alleviate soil compaction to optimize root growth of maize and other crops.
    - To quantify nematode infestation as a function of regenerative and locally adapted CA systems on maize and other crops.
    - To investigate the diversity and magnitude of crown and root rot as a function of regenerative and locally adapted CA systems.
    - To investigate microbial diversity and activity infestation as a function of regenerative and locally adapted CA systems.
    - To determine the optimum depth of ripping to alleviate soil compaction under maize.
    - To evaluate plant row width and population density of maize.
    - To determine water use efficiency of maize and other crops as a function of regenerative and locally adapted CA systems.
    - To monitor the quality of free water (water table) as a function of regenerative and locally adapted CA systems.
    - To monitor soil fertility and subsoil acidity as a function of regenerative and locally adapted CA systems.
    - To measure the profitability of the various regenerative and locally adapted CA systems.

1.4 Project leader

Danie Beukes and André Nel

2 ACTIONS THAT HAVE BEEN TAKEN WITH REGARD TO THE PROJECT

The following actions are of note:

- August and September 2016: Planning sessions with stakeholders to develop a project proposal to the Maize Trust that focuses on the impacts of conservation agriculture on soil health as a key factor to sustainable maize production on sandy soils of the north western Free State.
- August – October 2016: Technical meetings to finalize trial lay-outs and project proposal.
- September 2015: Application for financial assistance for the project proposal submitted to The Maize Trust.
- November 2016: Visits to potential farmer co-workers to finalize trial lay-outs.
- November-December 2016: Trial preparation and planting done of the following trials:
    - Trial 1: Regenerative CA crop-livestock integrated system with rotations of maize-summer-winter diverse ley crops (Farmer co-worker: Danie Crous, Deelpan).

      The objective of this trial is to establish if cover crops can improve soil health and accordingly the yield of maize. Due to the important role of a surface mulch on soil health, the 2016/2017 cover crops will be left on the soil for the creation of the mulch. Part of the cover crop area will be utilised by cattle in future seasons to include partial utilisation of the cover crops. The yield and economy of maize produced in a conventional mono crop system will be compared with the cover crop-maize system with partial utilisation of the cover crop by cattle.

- Trials 2 & 3: Local CA, ROR and reduced tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat, as well as maize/soybean, compared to mono culture maize cultivation (Farmer co-workers: Thabo van Zyl, Christinasrus; Lourens van Zyl, Klein Constantia).

  The objective of these trials is to compare the sustainability and profitability of mono cropped maize with two rotation systems a maize/wheat/soybean rotation and a maize/maize/wheat rotation system. The expectation is that soil health will improve due to crop rotation with consequent improvement of the sustainability and profitability of the systems.

- Trials 4 & 5: Interactions of plant row width, population density and cultivar as component to the sustainable cultivation of mono culture maize on sandy soils (Farmer co-workers: Thabo van Zyl, Doornbult; Danie Minnaar, Vlakvlei).

  The objective of these trials is to find the optimal combination of row width, plant population and cultivar of maize on a sandy soil. Yields from two row widths with plant populations varying from 15 000 to 50 000 plants ha^{-1} will be compared to determine optimal values.

- Trial 6: The optimum depth of ripping for the sustainable cultivation of mono culture maize on sandy soils (Thabo van Zyl, Doornbult).

  The objective is to find the optimal ripping depth for maize production on the sandy soil of the north-west Free State. Ripping depths varying from 0.45 to 0.90 m will be compared in terms of the yield of maize.

- December 2016: Approval of the project proposal.
- December 2016: The project team notified of the approval.
- December 2016-March 2017: Maintenance of trials in terms of N top-dressing, weeds and pests.
- January-March 2017: Four visits were paid to all the trials at the four localities to view, discuss the seasonal progress with the farmer co-workers and with the Senwes co-worker.
- January-March 2017: Measurements of soil and crop parameters on selected trials by the technical team.
- February 2017: Meeting with ARC-SGI researchers to plan and coordinate their sampling and studies.
- March 2017: ARC-Grain Crops Institute: Sampling of root and plant material of cover crop trial at Deelpan for microbiological, pathological and nematological studies.
- March 2017: Annual soil sampling of cover crop trial at Deelpan by OMNIA; Measurements at Deelpan of soil and water parameters.
- March 2017: Farmers Day at Doornbult – attended by 24 people.
- March 2017: Collation of inputs, data processing, compilation of interim progress report.
- April 2017: ARC-Grain Crops Institute: Sampling of root and plant material of crop

rotation trial at Christinasrus for microbiological, pathological and nematological studies.

- April 2017: Annual soil sampling of crop rotation trial at Christinasrus by OMNIA.
- April 2017: Determination of crop parameters of trials at Doornbult and Vlakvlei. Soil and water monitoring at Deelpan. Harvesting of summer cover crop of cover crop trial at Deelpan.
- April 2017: Visited trials of all farmer co-workers and discussed elapse of season.
- May 2017: Monitoring soil and water parameters at Deelpan. Determine soil bulk densities at Deelpan.
- May 2017: Harvesting of soybean on crop rotation trial at Christinasrus.
- June 2017: Harvesting of population density trial at Vlakvlei. Harvesting of maize and winter cover crops at Deelpan. Soil and water monitoring at Deelpan. Removal of capacitance probes on cover crop trial at Deelpan.
- July 2017: Harvesting of maize on crop rotation trial at Christinasrus.
- August 2017: Harvesting of population x row width and rip trials, respectively, on Doornbult.
- August 2017: Visited ARC-SGI researchers for reporting on the elapsed season and planning of the 2017/18-season.
- September 2017: Visits by Boet van Zyl to farmer co-workers to collate inputs for economic analyses. Compilation of enterprise financial statements.
- September 2017: Report back (2016/17) and planning (2017/18) meetings with all role players Collation of inputs, data processing, compilation of interim progress report.
- September 2017: Collation of inputs, data processing, compilation of final progress report.

3 PROGRESS THAT HAS BEEN MADE WITH THE PROJECT

3.1 General farm operations and trial establishment

Secondary tillage and cultivation operations were performed at all trial sites according to the preferred practices on the particular farm. Agronomic practices (e.g. N top-dressing, fertilizer type and application, seed variety) that are standard on farm at planting were followed. Primary tillage (deep ripping) was performed as specified in the trial plans. All trials were planted according to the agreed technical specifications. Maintenance operations (e.g. herbicide and pesticide) were carried out according to on-farm specifications.

Planting dates were as follows:
Trial 1: Danie Crous: Maize: 28 Nov 2016; Summer cover crops: 1 December 2016; Winter cover crops: 15 February 2017.
Trial 2: Thabo: Maize/soybean/wheat: Maize and soybean: 13 December 2016.
Trial 3: Lourens: Maize/soybean rotation: Maize: 28 December 2016.
Trial 4: Thabo: 30 November 2016.
Trial 5: Danie Minnaar: 23 November 2016.
Trial 6: Thabo: 30 November 2016.

The farmer co-workers were visited in November 2016 to finalize trial lay-outs. Ten follow-up visits to the trials were made from January to June 2017 to view and discuss the seasonal progress with the farmer co-workers, as well as assist in harvesting operations.

3.2 Research and technical activities

A list of monitoring and measuring of various soil, water and crop parameters is given in Table 1. These activities are being performed by research personnel from ARC-GCI, Mr P van Staden from Senwes, personnel from OMNIA, as well as Drr Beukes and Nel.

Table 1: Progress with research and technical activities.

Activities	Deliverables	Progress
1. Trial 1: Seasonal monitoring and measurements of cover crops.	Yield and dry matter data.	Completed.
2. Trials 1, 2, 4, 6: Installation of capacitance probes (Nov 2016-Feb 2017).	Continuous records of soil capacitance and temperature.	Completed.
3. Trials 1, 2, 4, 6: Monthly download of probe readings.	Processed data.	Completed.
4. Trial 1: Regular gravimetric soil water sampling and laboratory work to calibrate capacitance sensors.	Calibration equations.	Completed.
5. Trials 1, 2, 4, 6: Presentation of soil water and temperature data in graphs.	Soil water and temperature graphs as function of trial treatments.	Completed except for temperature data processing of Trials 2, 4 and 6.
6. Trial 1: Calculation of soil water balances.	Data on water use characteristics and water productivity of crops as function of trial treatments.	Completed.
7. Trials 1 & 2: Soil sampling and analysis by OMNIA.	Soil fertility and soil carbon data.	Completed.
8. Trial 1: Regular sampling and analysis of water table water.	Data on temporal chemical composition of water table.	Completed.
9. Trial 1: Sampling in March 2017 of plant biomass and root rhizosphere for root pathogens, microbiology and nematology.	Plant biomass data and soil samples.	Completed.
10. Trial 2: Sampling in April 2017 of plant biomass and root rhizosphere for root pathogens, microbiology and nematology.	Plant biomass data and soil samples.	Completed.
11. Laboratory work: Screening of plant material for root pathogens, as well as soil microbiological and nematological analyses.	Report on root and crown rot screenings, microbial populations and activity, as well as characterization and occurrence of nematodes.	Completed except for free living nematodes and microbial C biomass determination.
12. Collation and processing of economic data	Report on enterprise financial analyses.	Completed.
13. Collation of co-worker inputs and compilation of progress report.	Report on all seasonal activities at all trial sites.	Completed.

3.3 Trial 1: Regenerative CA crop-livestock integrated system with rotations of maize/summer/winter diverse ley crops.

(Deelpan -Danie Crous)

3.3.1 Partners Involved

Farmer co-workers, ARC, Grain SA, Maize Trust.

3.3.2 Objectives

- Trial implementation (trial plot identification, buying of seed and inoculum, getting equipment, planting the trial)
- Seasonal monitoring and measurements (harvesting the trial, determine dry matter
- Project meetings
- Reporting & admin
- Awareness events

3.3.3 Background

Regenerative agriculture CA systems, e.g. no-till, permanent organic soil cover with diversified crop rotations, including cash crops and multi-species cover crops, with livestock integration, utilised through ultra-high density grazing, will build and stabilise soil carbon on water table sandy soils.

Our approach was to adopt regenerative agriculture principles, a holistic land management practice that leverages the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density. Regenerative agriculture improves soil health, primarily through the practices that increase soil organic matter. This not only aids in increasing soil biota diversity and health, but increases biodiversity both above and below the soil surface, while increasing both water holding capacity and sequestering carbon at greater depths.

A plot was identified for the establishment of the trial at farmer co-worker, Mr Danie Crous. Seed for the summer annuals and the winter annuals was bought at reputable seed companies such as Agricol and Barenburg.

3.3.4 Trial establishment and measurements

A mixture of 10kg sorghum; 4kg babala; 10kg cowpea; 2kg sunhemp; 1kg tillage radish; 2kg maize; 2kg soybean and 2kg sunflower was established as a mixture on 1 Dec 2016 as shown in Plate 1.

Winter annuals for a hectare consisted of 1kg sweet clover; 1kg tillage radish; 1kg fodder radish; 5 kg black oats; 10kg hairy vetch; 5kg rye; 5kg oats and 1kg turnips. This mixture was planted on the 15 February 2017.

Probes for the measuring of soil water and temperature were installed on the different treatments to monitor these two important variables. Microbiological and disease measurement was the responsibility of the ARC-GCI research personnel and soil and plant sampling was done 100 days from the planting date.

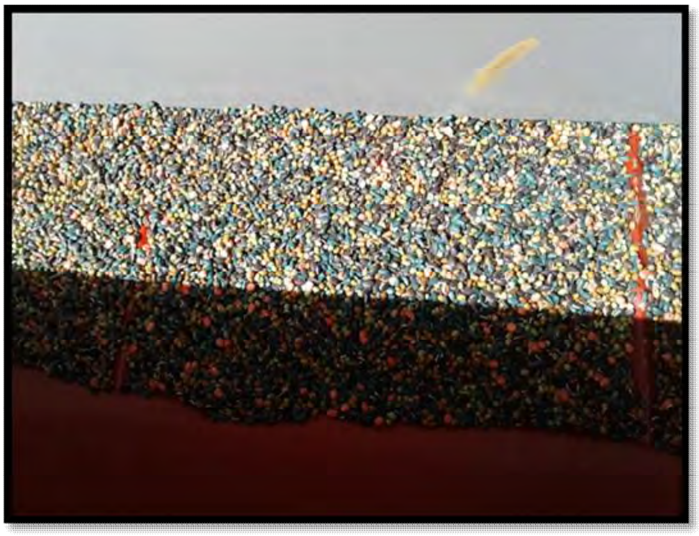


Plate 1: Mixture of summer annual crop seeds.

3.3.5 Soil water, soil temperature and water table measurements

3.3.5.1 Soil water and soil temperature
Conducted by Drr DJ Beukes and AA Nel

Two Aquacheck probes were installed on the eastern and western sides on each of the mono culture maize, summer cover crop (no-till), summer cover crop (rip-on-row), winter cover crop (no-till) and winter cover crop (rip-on-row) plots, respectively. These probes have capacitance sensors and thermistors on 10, 200, 300, 400, 600 and 800 mm depth, respectively. Installation dates were 11 Jan and 15 Feb 2017. Field downloading of data to a handheld logger was performed on 1 Feb, 15 Feb, 8 March, 4 April, 26 April, 23 May and 26 June 2017, followed by downloading to a laptop computer.

Soil sampling for the determination of gravimetric soil water was done at six depth intervals on three plots on each of 2 Feb, 8 March and 26 April 2017 for the purpose of calibrating the capacitance sensors. Simple linear regression analyses (Gomez and Gomez 1984) were performed to determine the statistical relationship between soil water content and capacitance readings. Graphical displays of temporal soil water and temperature data were consequently done.

3.3.5.2 Water table sampling
Conducted by Drr DJ Beukes and AA Nel

A hole was augered on 8 March 2017 to a depth of 1200 mm on both the eastern side in a fallow land adjacent to the winter cover crop land, and on the western side of the experimental block in an adjacent commercial maize stand. The holes were covered with plastic sheeting to keep out frogs, mice and insects. As the season progressed, the sampling holes were augered deeper (up to 2250 mm by 26 June 2017). These holes were left overnight for the equilibration of the perched water table. The water table depths were measured and samples taken on 9 March, 4 April, 26 April, 24 May and 27 June 2017 at depths of 100 and 300 mm measured from the top of the water table surface (Plate 2, left). On 9 March a surface (0-200 mm) water sample was also taken on the western side from surface ponded water. A borehole about 350 m from the western water table sample point was sampled on 4 April 2017. On 23 May 2017 the surface salt crust on the western side close to the water table sample point was sampled (Plate 2, right). All water samples were analysed by the ARC-ISCW laboratory in Pretoria for chemical properties and elemental contents.

Plate 2: Taking a water table sample (left) and salt crust sample (right).

3.3.5.3 Soil bulk density and soil porosity
Conducted by Drr DJ Beukes and AA Nel

On 23 May 2017 profile soil bulk density was determined (Blake and Hartge 1986) on two plots (mono culture maize (ROR) and winter cover crop (No-till)) at depths of 150, 300, 450, 600, 900 and 1200 mm, respectively (Plate 3, left). Plate 3 (right) shows cover crop root hairs at 1200 mm depth on the surface of a soil prism. Total soil porosity (soil pore volume) was calculated according to Danielson and Sutherland (1986).

Plate 3: Taking soil bulk density samples (left) and root hairs on soil prism surface (right).

3.3.6 Evapotranspiration and water use efficiency

Conducted by Dr DJ Beukes

A water use efficiency (WUE, water productivity) study was done on the Cover Crop Trial (Trial 1) for the mono culture maize, summer and winter cover crops, respectively. The classical soil water balance was used to calculate evapotranspiration (ET, crop water use) and hence, WUE, for the growing seasons of the various crops, i.e. from planting to harvesting:

$$ET = R + \Delta SWC - D \pm R_{off/on} \qquad (1)$$

Where ET = evapotranspiration (crop water use), R = rainfall; ΔSWC = change in soil water content; D = drainage; $R_{off/on}$ = run-off/on

Drainage losses and $R_{off/on}$ were regarded as negligible, reducing the equation used in the study to:

$$ET = R + \Delta SWC \qquad (2)$$

Soil water content data for the growing seasons was calculated from the capacitance probe readings. Water use efficiency (WUE), or water productivity, was calculated as follows:

$$WUE = \text{Grain yield or Dry biomass yield (kg ha}^{-1}\text{)}/\sum \text{(seasonal ET (mm))} \qquad (3)$$

3.3.7 Soil sampling and analysis by OMNIA

Transect soil sampling was done by OMNIA, Drr Beukes and Nel on 9 March 2017. For soil fertility analysis, samples were taken at 0-300 and 300-600 mm depth intervals, respectively. For SOC analysis, samples were taken at 0-50, 50-100, 100-200 and 200-400 mm depth intervals, respectively, on some experimental plots, as well as in the adjacent natural grass stand. Standard soil fertility analyses (e.g. pH, P, cations, NH_4- and NO_3-N) were performed, as well as Walkley-Black (Allison 1965) analyses for SOC.

3.3.8 Root and crown rot severity study

Conducted by Dr M Craven, ARC-Grain Crops Institute, Potchefstroom

3.3.8.1 Materials and Methods

3.3.8.1.1 Treatments sampled

As per request by Dr Beukes, 30 randomly selected maize plants were sampled at 100 DAP from the plot planted with maize. Sampling was conducted on the 8th of March 2017.

3.3.8.2 Sampling procedures

Thirty plants were randomly selected per designated plots during 2016/17. The aboveground biomass (hereafter referred to as plant biomass) was determined for the plants sampled within each plot and expressed as kg plant^{-1}.

Roots were washed under running water and visually rated for disease symptoms on both roots and crowns. Percentage of the plants sampled for each treatment and replication that demonstrated some degree of rot (visual discoloration) for roots and crowns separately was used to established disease incidence. A root disease index (RDI) was used to record disease ratings, based on an adjusted scale of 0-4 (Soonthornpoct et al., 2000; 0 = no symptoms, 1 = >1-25% rot, 2 = 25-49% rot, 3 = 50-74% rot, and 4 = 75-100% rot). Disease severity was accordingly calculated as the product of disease incidence x RDI (Soonthornpoct et al. 2000).

3.3.8.3 Statistical analysis

Data generated for the various parameters represent baseline results, and statistical analysis would accordingly not be relevant. Box plots were, however, created to visualise variances observed over replicates, as well as over treatments.

3.3.8.4 Interpretation of box plots

See Fig 1 as an example of a Box plot interpretation. A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall.

For example, the 20th percentile is the value (or score) below which 20% of the observations may be found.

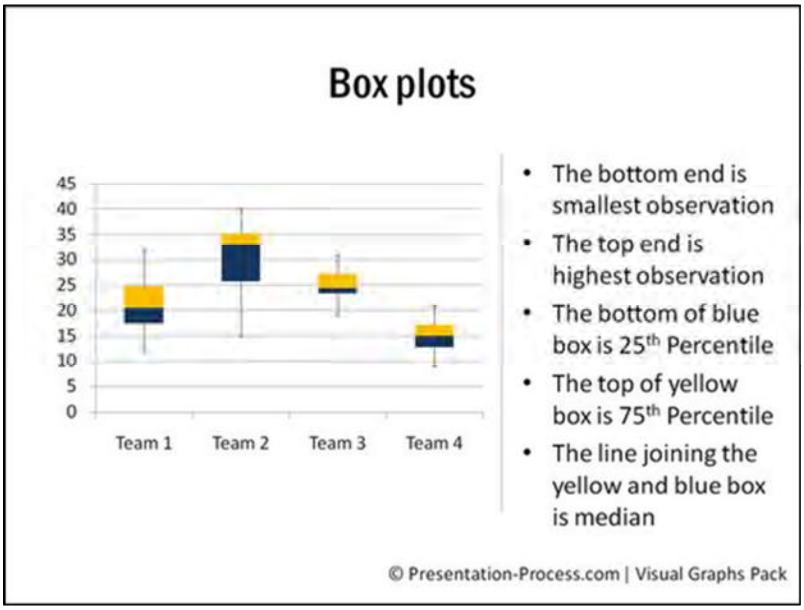


Fig 1: Basic interpretation of Box plots.

3.3.9 Plant parasitic nematode study

Conducted by Dr S Steenkamp, ARC-Grain Crops Institute, Potchefstroom

3.3.9.1 Sampling procedures

Each plot was divided into two sub-plots to provide at least 6 replicates necessary for the statistical analysis of the nematode data. Five plants per sub-plot were randomly selected and the aboveground parts removed and discarded. The root system, together with the soil from the root zone still attached to the root system, were placed into a marked plastic bag. Samples were stored at 4°C until extraction.

3.3.9.2 Extraction of the nematodes

3.3.9.2.1 Soil samples

Nematodes were extracted from 200 cm^3 soil samples using the sugar-flotation method (Cobb 1918) followed by the sugar flotation method (Caveness and Jensen 1955) and expressed as nematodes per 200 cm^3 soil.

3.3.9.2.2 Root samples

The method used for the extraction of plant-parasitic nematodes from the roots was described by De Waele et al (1987) and expressed as nematodes per 5 g roots. Root-knot nematodes were extracted from roots using the adapted NaOCl method developed for the extraction of root-knot nematodes described by Riekert (1995). Root-knot nematodes were expressed as root-knot nematodes per 50g roots.

3.3.9.3 Statistical analysis

Analysis of variance (ANOVA) was done using Genstat for Windows (2009) for plant-parasitic nematodes on the soil samples collected from all of the plots. All nematode data was log-transformed before being subjected to statistical analysis. Means were separated using the Tukey HSD test at $p<0.05$. Roots were not available on the winter crop plots.

Data will be analysed during the following season as follows:

- Prominence values will be used to determine both the occurrence frequency and population density of the plant-parasitic nematodes.
- Data for the non-parasitic nematode populations will furthermore be subjected to wood-web analysis using the Nematode Indicator Joint Analysis.

3.3.10 Soil microbiological study

Conducted by Mr OHJ Rhode, ARC-Grain Crops Institute, Potchefstroom

3.3.10.1 Materials and Methods

3.3.10.1.1 Sampling

Soil samples were taken approximately 100 days after planting (DAP) on the 8th of March 2017. Thirty soil samples were randomly taken from within each treatment plot, while rhizosphere soil was sampled and combined into six composite samples for microbiological testing. Sampling of maize soil was randomly done on the cover crop (rip on row: ROR and no-till: NT). The below mentioned treatments were sampled for rhizosphere soil as requested by Dr Beukes:

- Maize monoculture rip-on row (ROR)
- Summer cover crop rip-on row (ROR) and no-till (NT)
- Winter cover crop rip-on row (ROR) and no-till (NT)

3.3.10.1.2 Conventional microbial counts

Standard aseptic microbiological procedures were employed for the isolation and enumeration of microbial groups. Different microbial growth media designed to be selective for heterotrophic microbes; actinomycetes and filamentous fungi were used in the microbial analyses. These microbial populations were subjected to the physiological ability of microbes to grow on each of the selective media. General heterotrophic plate counts were done on nutrient agar (NA), (Biolab, Midrand, South Africa). Actinomycetes were isolated and enumerated on Actinomycete isolation agar (Sigma-Aldrich, South Africa). To obtain filamentous fungal counts, malt extract agar (MEA), (Biolab (Merck), South Africa) was used supplemented with 30 mg kg^{-1} chloramphenicol and 50 mg kg^{-1} streptomycin. These various media were all sterilised at 121 ^{o}C for 15 min and placed in pour plates, each consisting of a Petri dish (90 mm in diameter) containing an isolation medium. A soil dilution series ranging from 10-1 (using 1 g of soil in 9 ml of saline solution) to 10-5 was prepared in triplicate and a 100 µL aliquot of each dilution was aseptically spread on the isolation plates for each composite soil sample. The various isolation plates were incubated at room temperature and enumerated after 3 days for the bacteria, and 5-7 days for the actinomycetes and fungi. Values of colony forming units per gram (cfu g^{-1}) soil were transformed for analyses.

3.3.10.1.3 Enzyme assays

The microbial activities of β-glucosidase, and alkaline phosphatase were determined using 1 g of air-dried soil and incubated for 1 h (37 °C) with the appropriate substrate for each enzyme at their respective optimal pH values (Tabatabai, 1982). In the case of urease 5g of air-dried soil was used. Methods used are summarised in Table 2. These selected enzymes have been implicated in the carbon (β-glucosidase), nitrogen (urease) and phosphorous (alkaline phosphatase) soil cycles, respectively. Each of these enzymes plays a crucial role in carbon, nitrogen and phosphate conversion in soil, respectively.

Table 2: Methods used to determine enzyme activity in soils.

EC number[a]	Recommended name[b]	Assay conditions[c] [Substrate]	Optimum pH
3.1.3.2	Alkaline phosphatase	*p*-Nitrophenyl phosphate [25mM]	11.0
3.2.1.21	β-glucosidase	*p*-Nitrophenyl- β-glucopyranoside [25mM]	6.0
3.5.1.5	Urease	Urea [80mM]	Non-buffered

[a]EC number denotes enzyme class

[b]Methods according to Tabatabai (1982) and Tabatabai (1994)

[c]Values in parentheses are substrate concentrations under the respective assay conditions. The product of reactions for glucosidase and phosphatase is *p*-Nitrophenol = PN

3.3.10.1.4 Statistical analysis

The experimental layout of the cover crop trial is a randomized complete block design. For this study the treatment design that was sampled was as follows for the cover crop trial: Factorial design (two factors) with four replicates. Analysis of variance was performed on the data using Statgraphics software package to test for statistically significant differences between treatments using Fisher variance ratios (F), as well as to test for least significant differences (LSD) at $p \leq 0.05$ between treatment means.

3.4 Trials 2 and 3: Local CA, ROR and reduced tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat, as well as maize/soybean, compared to mono culture maize cultivation.

(Trial 2 at Christinasrus-Thabo van Zyl: Trial 3 at Klein Constantia-Lourens van der Linde)

3.4.1 Rationale and trial establishment

The objective of this trial is to compare the sustainability and profitability of maize in monoculture with two rotation systems namely, a maize/wheat/soybean, maize/maize/wheat, as well as a maize/soybean, rotation system. The expectation is that the soil health will improve due to crop rotation which will then improve the sustainability and profitability.

A field trial (Trial 2) with the above-mentioned crop systems (excluding maize/soybean) was planned and the trial established on the farm Christinasrus near Wesselsbron on a land where fodder sorghum was grown in 2015/2016. A randomized complete block design with three replicates was used for the layout. Plots were 80 X 24.4 m in size. Crop systems were assigned to plots and each crop within each system, representing a different stage, was assigned to a plot to be able to distinguish between seasonal and rotational effects. Maize (cultivar DKC 77-77 BR at 27 000 seeds ha^{-1}) and soybean (cultivar PAN 1623 at 300 000 seeds ha^{-1}) were planted 13 December 2016 in 1.016 m spaced rows in a rip-on-row (75 cm depth) system. The fertilization rates were as follows: N = 133 kg ha^{-1}, P = 25 kg ha^{-1} and K = 15 kg ha^{-1}.

Wheat was planted in May 2017 on Trial 2 as part of the rotation system.

The maize/soybean rotation system at Klein Constantia (Trial 3) was implemented under two tillage practices *viz*. reduced (rod weeder) and deep rip-on-row tillage. These tillage actions were performed before planting on 28 December 2016 with cultivar DKC 78-87 B at 25000 plants ha^{-1} the monoculture maize part, as well as the maize on the maize/soybean system. A tremline plant row system of 90 x 140 cm was used. A pre-plant fertilizer application consisted of 150 kg LAN ha^{-1}

with 200 kg 3:2:1 (30) ha^{-1} at plant. The herbicide programme consisted of the application of 0.7 L metolachlor ha-1 plus 1 L atrazine ha^{-1}. No pesticides were applied.

3.4.2 Soil sampling and analysis by OMNIA (Trial 2)

Transect soil sampling of selected plots of the maize/wheat/soybean and maize/maize/wheat rotations was done by OMNIA, Drr Beukes and Nel on 5 April 2017. For soil fertility analysis, samples were taken at 0-300 and 300-600 mm depth intervals, respectively. For SOC analysis, samples were taken at 0-50, 50-100, 100-200 and 200-400 mm depth intervals, respectively, on some experimental plots, as well as in the adjacent natural grass stand. Standard soil fertility analyses (e.g. pH, P, cations, NH_4- and NO_3-N) were performed, as well as Walkley-Black (Allison 1965) analyses for SOC.

3.4.3 Root and crown rot severity study (Trial 2)

Conducted by Dr M Craven, ARC-Grain Crops Institute, Potchefstroom

3.4.3.1 Materials and Methods

3.4.3.1.1 Treatments sampled

Sampling was conducted on the 4th of April 2017 (112 DAP). As per reference to the trial plan provided by Dr Beukes the following maize plots were sampled (Table 3).

Table 3: Plots sampled at Trial 2

Plot	Treatment	Replicate	Plot	Treatment	Replicate	Plot	Treatment	Replicate
3	MMM	1	12	MKS 1	2	19	MMM	3
5	MKS 1	1	15	MMM	2	20	MMK 2	3
6	MMK 2	1	16	MMK 1	2	24	MMK 1	3
9	MMK 1	1	18	MMK 2	2	26	MKS 1	3

3.4.3.2 Sampling procedures

Thirty plants were randomly selected per designated plots during 2016/17. The aboveground biomass (hereafter referred to as plant biomass) was determined for the plants sampled within each plot and expressed as kg plant^{-1}.

Roots were washed under running water and visually rated for disease symptoms on both roots and crowns. Percentage of the plants sampled for each treatment and replication that demonstrated some degree of rot (visual discoloration) for roots and crowns separately was used to established disease incidence. A root disease index (RDI) was used to record disease ratings, based on an adjusted scale of 0-4 (Soonthornpoct et al., 2000; 0 = no symptoms, 1 = >1-25% rot, 2 = 25-49% rot, 3 = 50-74% rot, and 4 = 75-100% rot). Disease severity was accordingly calculated as the product of disease incidence x RDI (Soonthornpoct et al. 2000).

Once visual screenings have been finalised, the root mass of the 30 selected plants per plot were obtained and expressed as kg plant^{-1}.

3.4.3.3 Statistical analysis

Data generated for the various parameters represent baseline results, and statistical analysis would accordingly not be relevant. Box plots were, however, created to visualise variances observed over replicates as well as over treatments.

3.4.3.4 Interpretation of box plots

See Section 3.3.8.4 for interpretation of Box plots.

3.4.4 Plant parasitic nematode study (Trial 2)
Conducted by Dr S Steenkamp, ARC-Grain Crops Institute, Potchefstroom

3.4.4.1 Sampling procedures

See Section 3.3.9.1.

3.4.4.2 Extraction of the nematodes

See Section 3.3.9.2.

3.4.4.3 Statistical analysis

Analysis of variance (ANOVA) was done using Genstat for Windows (2009) for plant-parasitic nematodes on the soil samples collected from all of the plots. All nematode data are log transformed before being subjected to statistical analysis. Means were separated using the Tukey HSD test at $p < 0.05$. Roots were not available on the wheat plots.

Data will be analysed during the following season as follows:
- Prominence values will be used to determine both the occurrence frequency and population density of the plant-parasitic nematodes.
- An ANOVA will be used to determine if significant differences exist between the crop rotation systems in terms of the nematode genera during each season. Repeated measures ANOVAs will be done using crop rotation systems as the main effects and seasons as the sub-factor. Means will be separated using the Tukey HSD test at $p < 0.05$.
- Principal component analysis will be done to determine whether there are associations between the nematodes in terms of the different seasons and crop rotation systems.
- Data for the non-parasitic nematode populations will furthermore be subjected to wood-web analysis using the Nematode Indicator Joint Analysis.

3.4.5 Soil microbiological study (Trial 2)
Conducted by Mr OHJ Rhode, ARC-Grain Crops Institute, Potchefstroom

3.4.5.1 Materials and Methods

3.4.5.1.1 Sampling

Soil samples were taken approximately 100 days after planting (DAP) on 4th of April 2017. Thirty soil samples were randomly taken from within each treatment plot, while rhizosphere soil was sampled and combined into six composite samples for microbiological testing. Sampling of maize soil was randomly done on the crop rotation plots. The trail comprised a factorial design consisting of cropping system and seasons as factors. Three replicates were sampled. The below mentioned treatments were sampled for rhizosphere soil as requested by Dr Beukes (Only maize plots were sampled):

MKS = Maize/wheat/soybean
MMK = Maize/maize/wheat
MMM = Monoculture maize

3.4.5.1.2 Conventional microbial counts

See Section 3.3.10.1.2.

3.4.5.1.3 Enzyme assays

See Section 3.3.10.1.3.

3.4.5.1.4 Statistical analysis

The experimental layout of the crop rotation trial was a factorial design (two factors at two and four levels, respectively) with two replicates. Analysis of variance was performed on the data using Statgraphics software package to test for statistically significant differences between treatments using Fisher variance ratios (F), as well as to test for least significant differences (LSD) at $p \leq 0.05$ between treatment means.

3.5 Trials 4 and 5: Interactions of plant row width, population density and cultivar as component to the sustainable cultivation of mono culture maize on sandy soils.

(Trial 4 at Doornbult-Thabo van Zyl; Trial 5 at Vlakvlei-Danie Minnaar)

3.5.1 Rationale and trial establishment

The objective of these trials was to find the optimal combination of row width and plant population, as well as cultivar choice, for maize. Two trials were established: The first at Doornbult near Bothaville and the second at Vlakvlei near Kroonstad where two cultivars were used instead of row widths.

At Doornbult, mean row widths were 1.016 and 1.524 m and seeding densities were 15, 20, 25, 30, 40 and 50 thousand ha^{-1}. A randomised complete block layout was used with two replications. Plot sizes varied from 0.14 to 0.18 ha. Maize cultivar DKC78-87B was planted on 30 November 2016 in a rip-on-row system (75 cm deep). Fertilisation rates were 133 kg ha-1 N, 25 kg ha-1 P and 14.5 kg ha-1 K. This trial was harvested on 1 August 2017 with a combine harvester.

At Vlakvlei, the two cultivars planted were DKC78-87 and DKC78-17 in 1.5 m spaced rows. A complete randomised layout was used and seeding densities varied from 12 000 to 26 000 ha^{-1} with three replications. Treatments consisted of twelve adjacent rows which stretched over the length of the land in a rip-on-row tillage system. The planting date was 23 November 2016 and harvesting date 27 June 2017. The fertilisation rate was 200 kg 15:10:6 (31) + Zn + B at planting while Urea was applied in a pre-plant action. Plant densities and number of tillers were determined during March 2017 while the total grain yield was measured by combine harvester on 26 June 2017. Small plots of 12 m^2 were hand-harvested to determine the yield of main stems and tillers.

3.6 Trial 6: The optimum depth of ripping for the sustainable cultivation of mono culture maize on sandy soils.

(Doornbult-Thabo van Zyl)

3.6.1 Rationale and trial establishment

The objective was to determine the optimal ripping depth for maize. A field trial was established at Doornbult near Bothaville with ripping depths of 0.45, 0.60, 0.75 and 0.90 m. A randomised complete block design with five replications with an individual plot size of 0.11 ha was used. Maize cultivar DKC78-87B was planted on 30 November 2016 in 1.016 m spaced rows at a seeding density of 24 000 ha-1. Diesel consumption was measured during ripping in early spring. Crop height was measured on 1 February 2017 and yields were determined by combine harvester on 1 August 2017.

3.7 Enterprise financial analyses

Data for the enterprise financial analyses for Trials 3, 4, 5 and 6 was collated by Mr Boet van Zyl from Senwes in Aug-Sept 2017 during meetings with the farmer-co-workers. The compiled statements are included in Appendices 2 to 5.

3.8 Soil water content measurements with capacitance probes

Conducted by Petrus van Staden, Senwes

3.8.1 Objective

The objective was to measure soil water content continuously on Trials 2, 4 and 6 in order to get an indication of water extraction under the different treatments.

3.8.2 Actions taken

The trials were planted according to the lay-out proposed in the project proposal. The measurement of soil water content was done with continuous logging probes from DFM Software Solutions. The layout did not allow for statistical analysis of data. Two types of probes were used. The first type was 1.2 in length and connected to an automatic rain gauge. Data was downloaded manually. The other type of probe was a 1.2 m GPRS probe with data on the cloud of DFM software.

One probe each was installed in one replication of the following treatments:

- Trial 2: The maize, soybean and fallow plots of the Maize/Wheat/Soybean rotation trial.
- Trial 4: Narrow and wide row width plots for the 50 000, 25 000 and 15 000 plant population densities ha^{-1}.
- Trial 6: The 450 mm and 900 mm depths of the ripping trial.

The probes were installed on 17 January 2017 (Trial 4: Plant row width and population density trial) and on 18 January (Trial 2: Maize/Wheat/Soybean rotation trial; Trial 6: Depth of ripping trial).

4 RESULTS THAT HAVE BEEN ACHIEVED

4.1 Seasonal rainfall

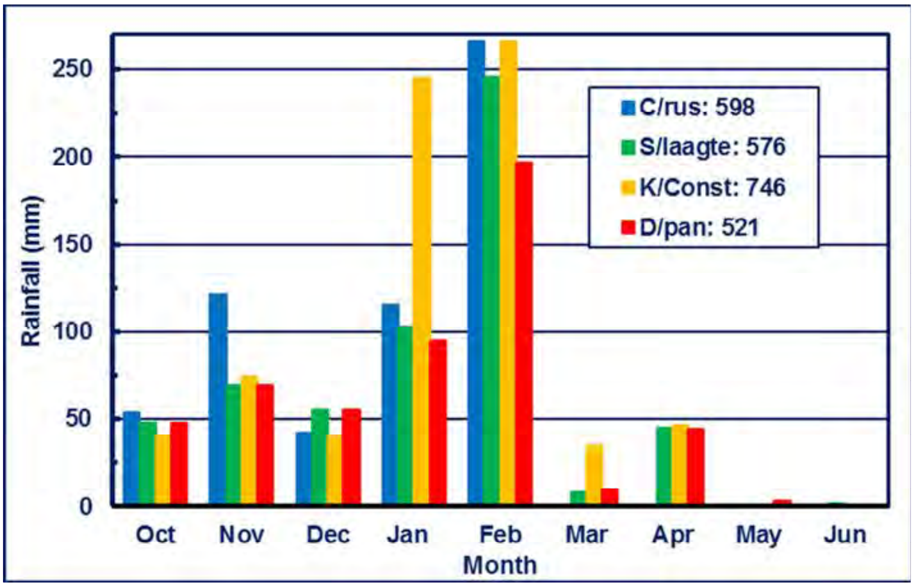


Figure 2: Monthly rainfall at trial localities (C/rus=Christinasrus; S/laagte=Springboklaagte; K/Const=Klein Constantia; D/pan=Deelpan).

The very good seasonal rainfall (Figure 2) for the trial localities varied between 521 and 746 mm and led to an expectation of exceptional growth and yields of crops. At Springboklaagte the total rainfall for Jan+Feb was 350 mm, compared to the long term (111 yr) average of 111 mm. At Klein Constantia the very high rainfall for Jan+Feb of 511 mm led to water-logged conditions. High winds in Dec 2017 at Klein Constantia led to severe damage to the young maize. Replanting of damaged patches was done more than once. Wind damage was also experienced at Doornbult.

4.2 Trial 1: Regenerative CA crop-livestock integrated system with rotations of maize/summer/winter diverse ley crops.

(Deelpan - Danie Crous)

4.2.1 Vegetative growth of cover crops

Reporting by G Trytsman

The 2016/17-year can be regarded as the implementation of the different treatments. At the location such as Ottosdal, research had clearly emphasized the necessity to first develop the mulch and the diversity component of CA before an attempt doing no-tillage should be made. Dr Beukes is busy with monitoring soil water and temperature at the trial site on a continuous base.

Summer annual cover crops established well and Plate 5 serves as a testimony. The photo was taken on 15 February this year.

On 15 February the winter annuals were planted and after the lessons that were learned with the previous planting event everything went rather smooth. Plate 6 is testimony of a good stand and exceptional yield that materialized. The photo was taken on 18 April this year.

Plate 4: Discussions at the summer cover crop trial on 11 Jan 2017.

Plate 5: Remarkable summer mixture at Deelpan.

Plate 6: Remarkable winter mixture at Deelpan.

4.2.2 Yields obtained from summer annuals and monoculture maize

Reporting by G Trytsman

Summer annuals were harvested on 18 April 2017. Green biomass was cut (1 m^2) and separated into the different functional groups and the latter weighed separately. The green biomass samples were dried at 90 ^{0}C to determine dry matter (DM). Yields were then calculated for three different samples from every functional group and are presented in Figure 3. From the figure the DM for samples 1, 2 and 3, when functional group weights were summed up, were 17.1, 14.5 and 15.8 t ha^{-1}, respectively.

The monoculture maize was harvested by hand (selected portions on the NE and NW sides of the maize block) on 27 June, and by combine harvester on 28 June 2017. The maize grain yields were:

By hand: 9.67 t ha^{-1} (NE); 7.76 t ha^{-1} (NW)
Harvester: 7.11 t ha^{-1} (Block of 3.84 ha)

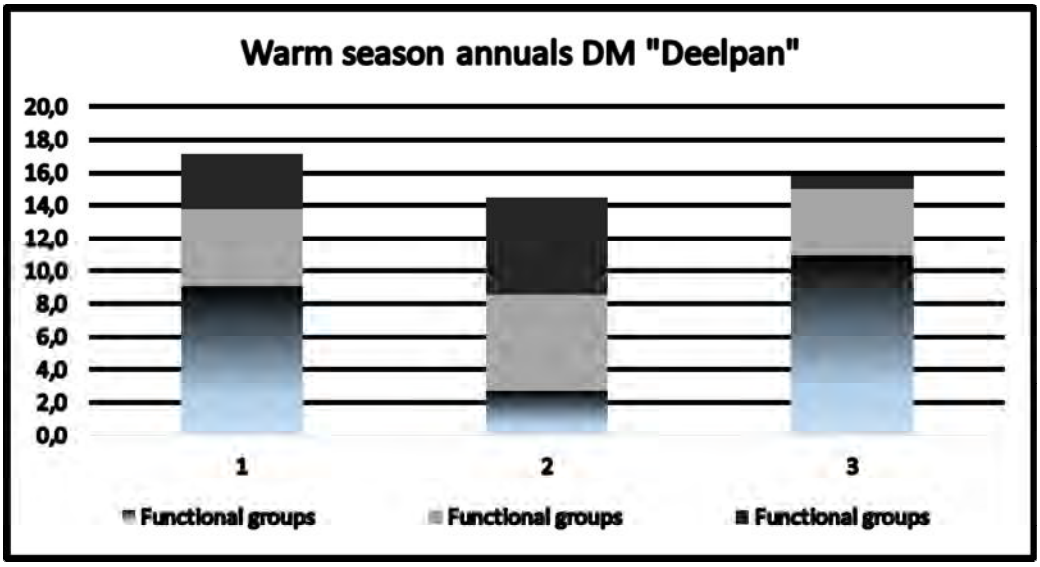


Figure 3: Dry matter yields (t ha^{-1}) for different functional groups of summer annuals.

4.2.3 *Yield obtained from winter annuals*

Reporting by G Trytsman

Winter annuals were harvested on 26 June 2017. The same harvesting procedure as for the summer annuals was used. Winter annuals were separated in below ground biomass (bulbs) and top growth biomass (leaves). The different plant components were sampled separately. Three samples were taken as close as possible to the capacitance probes Measuring soil water and temperature). This was done to better correlate the calculation of WUE with the soil water data obtained from the probes. Figure 4 then is an indication of the DM data that was calculated from the trial sites. The DM yields for samples 1, 2 and 3 were 13.1, 11.3 and 16.1 t ha^{-1}, respectively. With an average N content 2%, totals of 262, 226 and 322 kg N ha^{-1} were captured by the winter cover crops of which 40% will hopefully be available for the next crop.

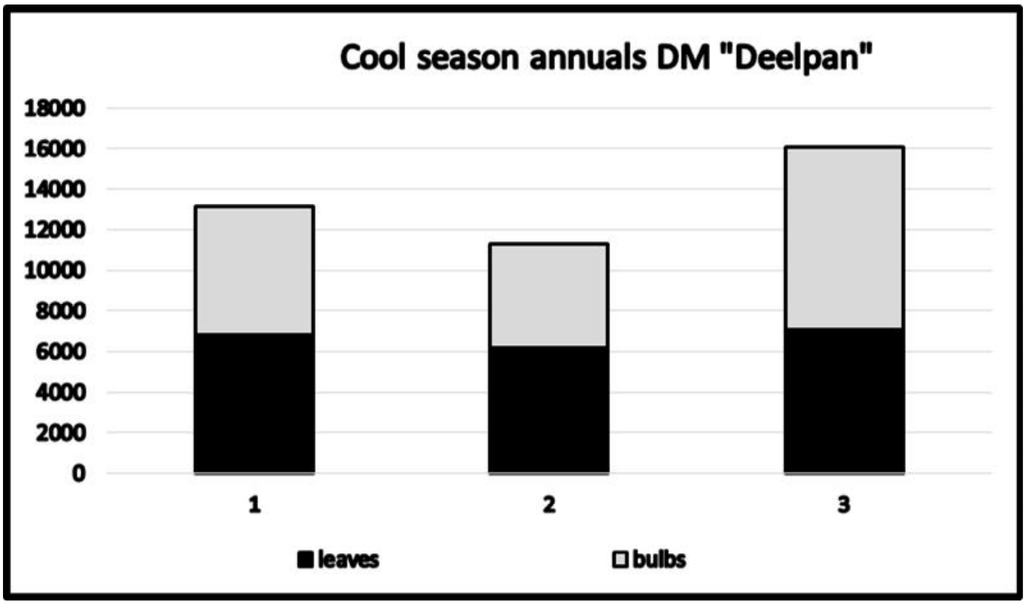


Figure 4: Dry matter yields (t ha^{-1}) for different components of winter annuals.

4.2.4 *Evapotranspiration and water use efficiency*

Reporting by Dr DJ Beukes

Figure 5 shows exceptional high values for WUE, probably due to a very good seasonal rainfall. From the figure, daily ET values of 3, 4.5 and 3.5 mm day^{-1} can be derived for the monoculture maize, summer cover crops (S/Cover) and winter cover crops (W/Cover), respectively. Similar WUE and ET values for the north eastern (N/E) and north western (N/W) of the trial could be calculated. The winter cover crops gave the highest WUE (36.6 kg mm^{-1} ha^{-1}), compared to 25.9 (S/Cover) and 14.3 (maize) kg mm^{-1} ha^{-1}, respectively.

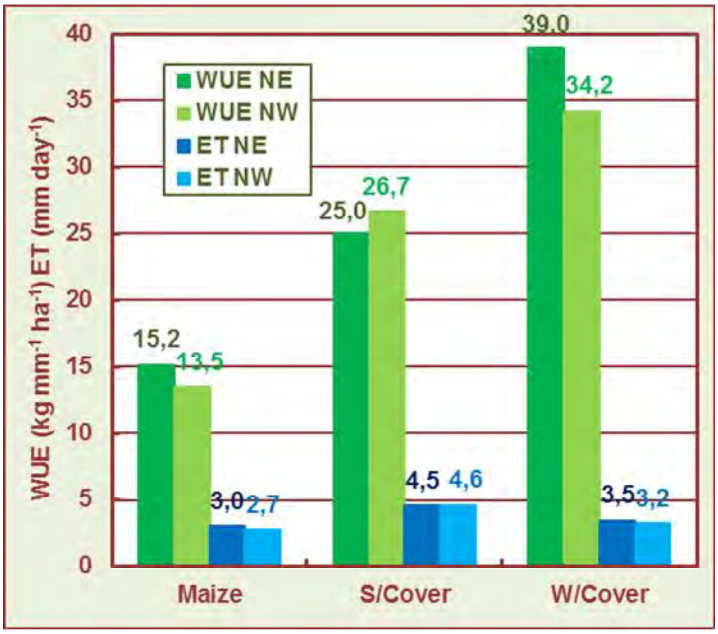


Figure 5: WUE and ET for the different treatments.

4.2.5 Soil organic carbon sequestration

Reporting by Dr DJ Beukes

Plate 7 clearly shows the influence of a summer cover crop mixture to produce enormous amounts of roots, as well as litter fall, to build-up soil organic carbon (SOC) in the 0-100 mm layer of the soil profile (mean of 0.74%C compared to 0.49% under grass land). On the contrary, winter cover crops do not produce the amount of roots in the same zone but rather have an extended tap root system that contribute to the SOC content in the deeper soil zones, as can be seen in the figure. Treatments that include both theses functional groups of plants can thus build SOC through the entire profile. This will be investigated this coming season at trial sites in Vrede. Plates 7 and 8 are testimony of what has been discussed in this paragraph. A decrease in SOC in the 0-50 mm layer, compared to deeper layers, is noticed for all crops except for S/Cover.

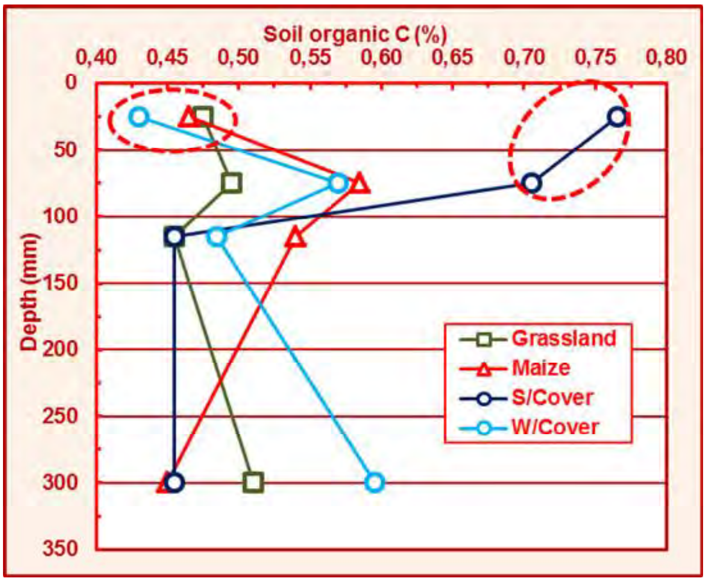


Figure 6: Soil organic carbon for different treatments (Grassland included).

Plate 7: Summer annuals exhibit dense roots in the upper layer.

Plate 8: Winter annuals extend their roots deep into a clay layer.

4.2.6 Soil water, soil temperature and water table measurements

4.2.6.1 Soil water measurements
Reporting by Drr DJ Beukes and AA Nel

In Figure 7 the t-value of 13,87 indicates that the linear response of gravimetric soil water content to capacitance readings within the range of 25,57 to 86,87 mHz, is highly significant at $p \leq 0{,}001$. The regression coefficient (r=0,8733) that is a measure of the closeness of fit between the estimated regression line and the observed points is highly significant at $p \leq 0{,}01$. The computed r value indicates that 76% of the variation (=R^2) in gravimetric soil water content is accounted for by the linear function of capacitance readings. It was decided that the regression equation could be used with confidence to process capacitance readings into soil water content values.

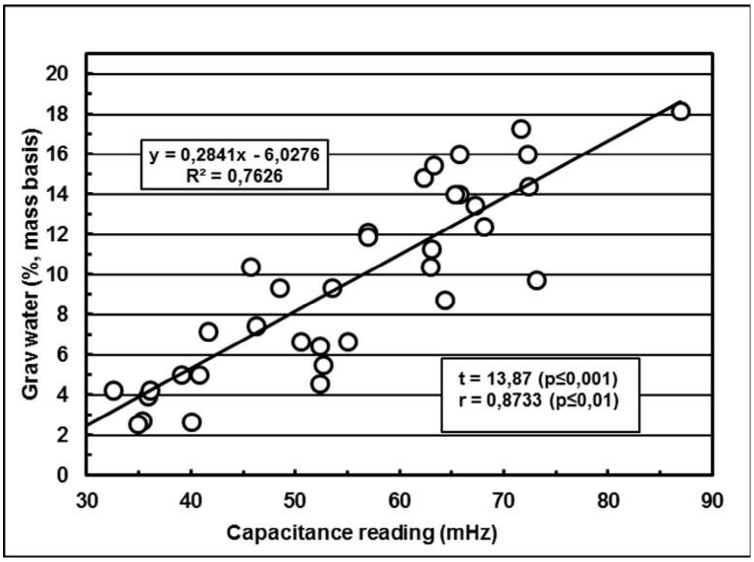
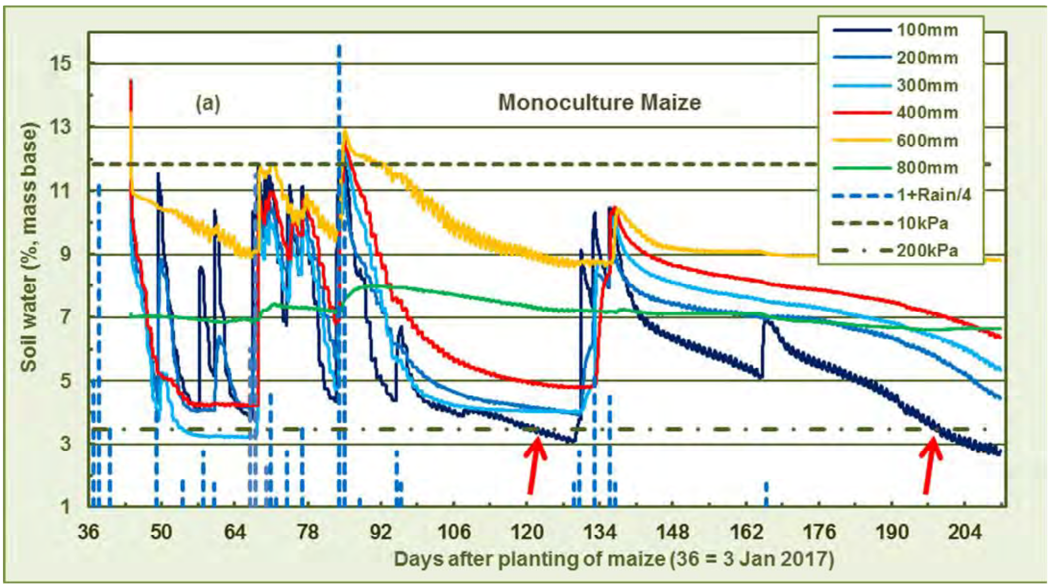
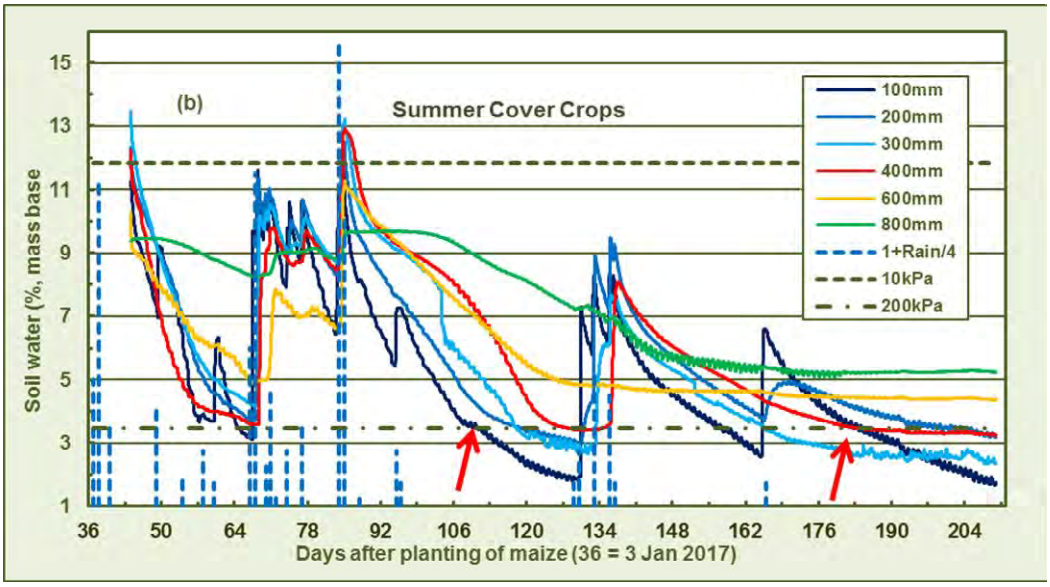


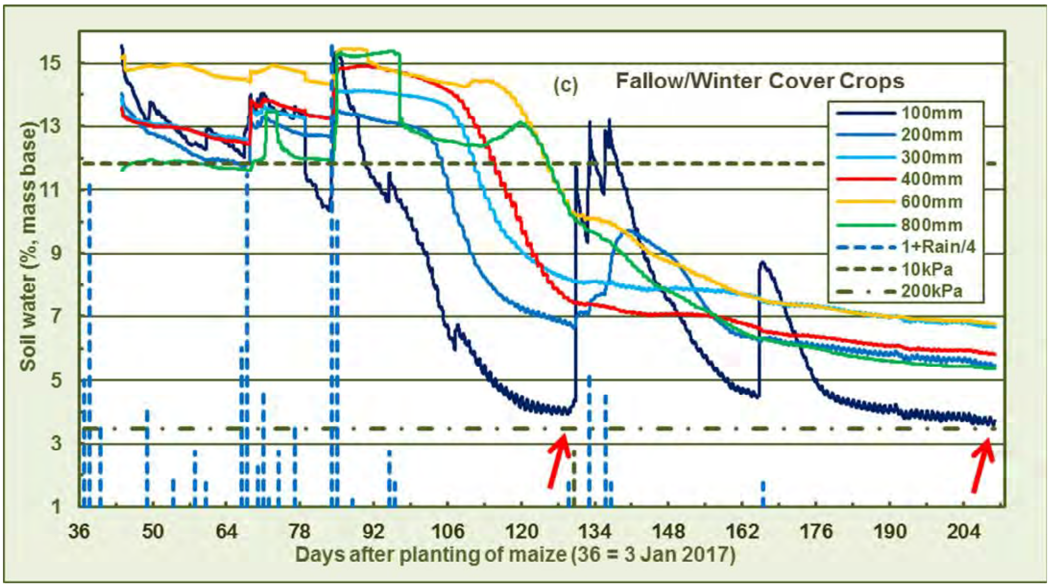
Figure 7: Relationship of capacitance readings vs. soil water content.

Figures 8a-c display seasonal soil water fluctuations at various depths between 100 and 800 mm under monoculture maize (Fig 8a), summer cover crops (Fig 8b) and winter cover crops (Fig 8c), as recorded by capacitance probes. Dotted lines depict soil water contents at 10 kPa and 200 kPa as approximations of the upper ("field water capacity", FWC) and lower ("permanent wilting") limit of plant available water. Actual rainfall is obtained by subtracting 1 from the graph value and multiplying by 4. The following observations can be made from Figures 8a-c:

- The soil profiles under the three crop systems were well recharged after the good rain spells between 40 and 85 days after planting (DAP).
- After good rainfall events, soil water content quickly levelled off at all depths due to crop water uptake and soil surface evaporation and approached "permanent wilting" at, for example, 100 mm depth: (i) at 121 and 197 DAP under monoculture maize; (ii) much quicker under summer cover crops at 109 and 180 DAP; and (iii) much later under winter cover crops at 127and 207 DAP (See arrows in figures).







Figures 8a-c: Seasonal soil water fluctuations under: (a) Monoculture maize; (b) Summer cover crops; (c) Winter cover crops.

Figure 9 depicts early-season soil water fluctuations (up to 80 DAP: 15 Feb) at 100 mm depth under monoculture maize, summer cover crops and winter cover crops. respectively. The following observations can be made:

- Full profile at 100 mm depth (above FWC) on the bare soil (winter cover crop land planted on 15 Feb (80 DAP)).
- Soil water content at 100 mm depth was lower (See arrows - up to 4%) under the summer cover crops (closed canopy; Plate 4), compared to the maize (row crop), immediately after a rain event. This phenomenon can probably be ascribed to interception of the rain by the former crops, followed by evaporative losses directly from the crop canopy.
- The interval between rain events should be less than 18 days to prevent the onset of an empty profile. This time lapse is similar to the on-farm observation that rainfall is needed every 14 days on these sandy soils for successful crop production.

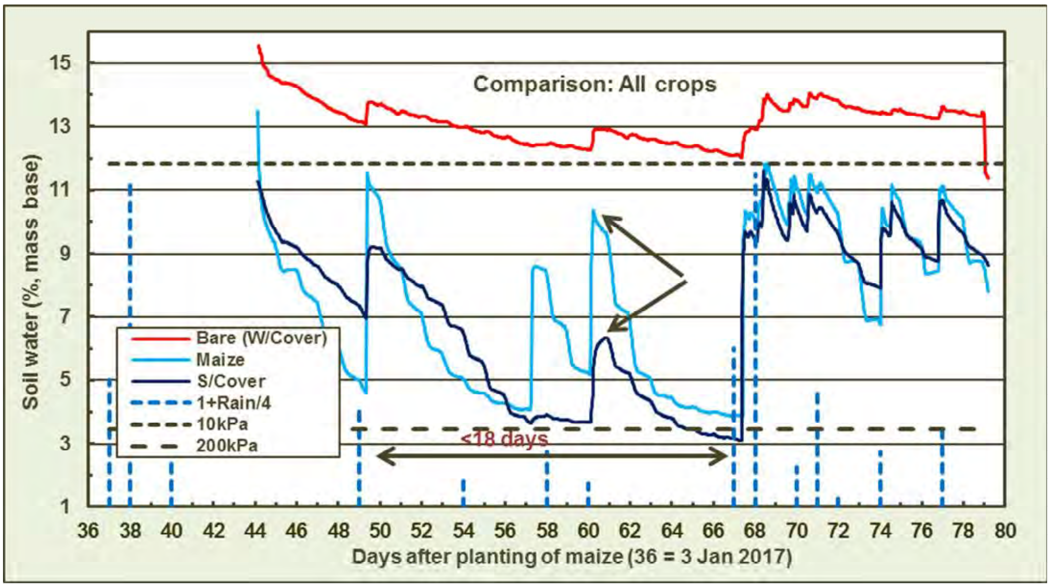


Figure 9: Early-season soil water fluctuations at 100mm depth under monoculture maize, summer cover crops and winter cover crops (W/cover: winter cover crops; S/Cover: summer cover crops).

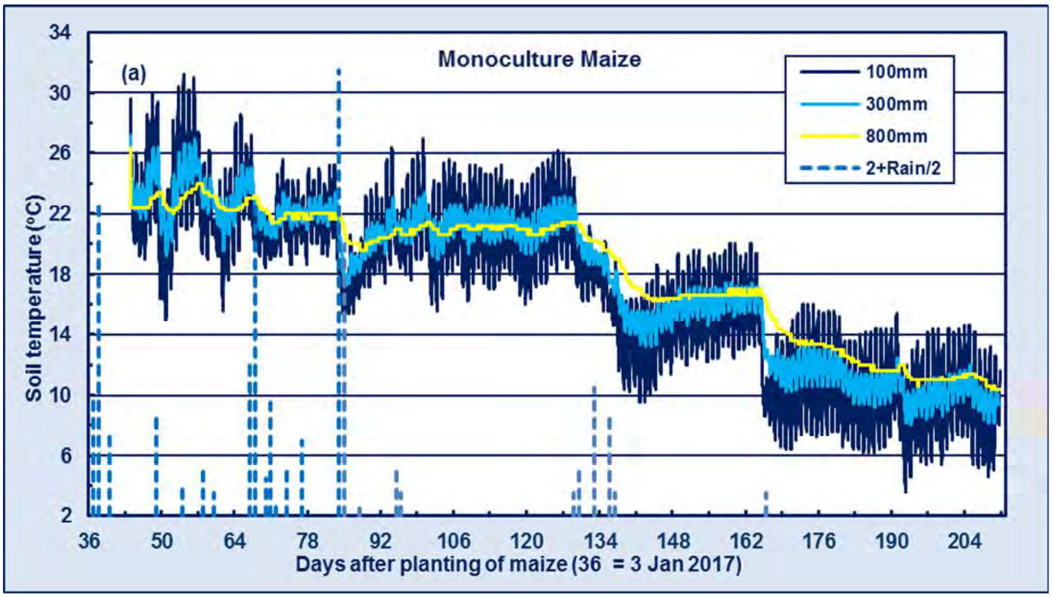
4.2.6.2 Soil temperature measurements
Reporting by Drr DJ Beukes and AA Nel

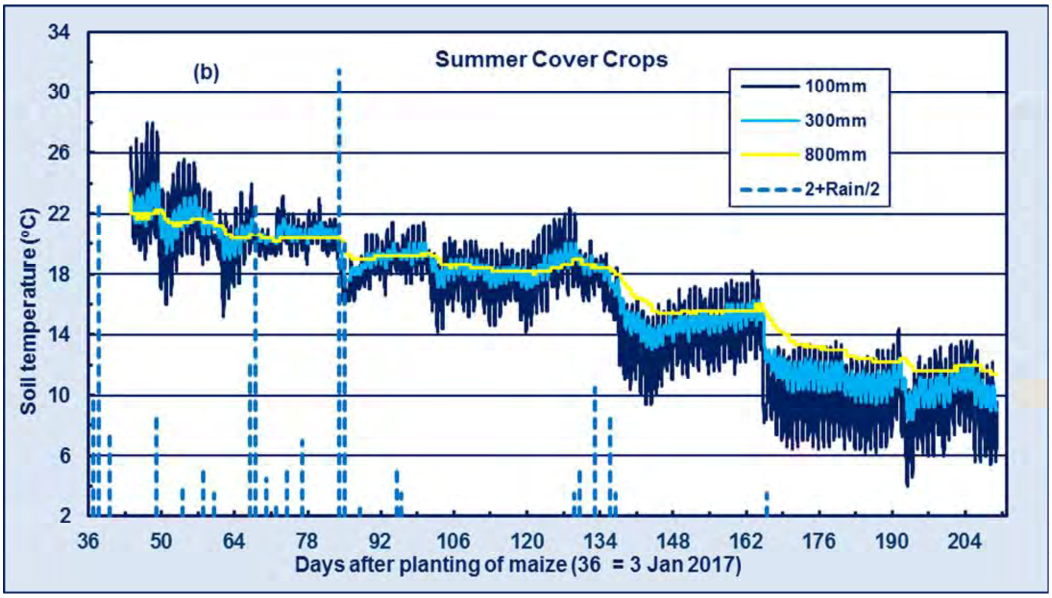
The amount of heat flow in soil influences soil temperature. The temperature of the soil is related to the temperature of the air and *vice versa*. Net radiation from the sun is the source of energy (heat) in the air and environment. Soil temperature is a measure of the intensity of heat in the soil. The heat capacity of a soil is the amount of heat required to raise the soil temperature. The former is determined, *inter alia,* by the soil water content and soil bulk density (Hanks and Ashcroft 1980).

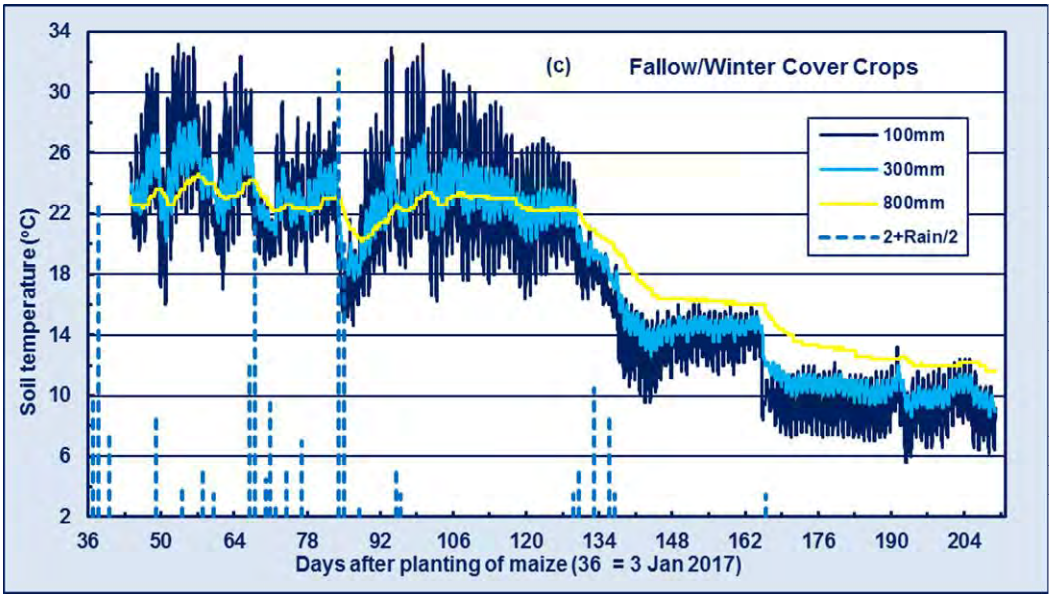
Figures 10a-c display seasonal soil temperature fluctuations at various depths between 100 and 800 mm under monoculture maize (Fig 10a), summer cover crops (Fig 10b) and winter cover crops (Fig 10c), as recorded by capacitance probes. Actual rainfall is obtained by subtracting 2 from the graph value and multiplying by 2. The following observations can be made from Figures 10a-c:

- Maximum soil temperatures at 100 mm depth were reached on 20-22 January ranging from 28^{o}C, 31^{o}C and 33^{o}C for the summer cover crops, monoculture maize and winter cover crops, respectively. Under the winter cover crops peak temperatures (around 33^{o}C) were again registered between 2-8 March.
- The seasonal march of soil temperatures shows a gradual cooling of the soil at 100 mm depth of about 18^{o}C and 24^{o}C under summer and winter cover crops, respectively, from January to June.
- Diurnal temperature fluctuations decreased sharply with soil depth, with much reduced fluctuations at 800 mm depth. This phenomenon is explained by the fact that the resistance of heat conduction in the soil tends to damp the amplitude of the diurnal temperature cycle with depth (Hanks and Ashcroft 1980).
- A close scrutiny of the temperature data will reveal a diurnal time lag of soil temperature with increasing depth. This is explained by the fact that a temperature gradient must develop before heat begins to flow to lower depths, causing a time lag before maximum temperature occurs at the lower depths (Hanks and Ashcroft 1980).
- From 5 April onwards, the cooling of the soil at shallower depths was much more pronounced than at 800 mm depth. This phenomenon is, particularly, visible under the

winter cover crops (Fig 10c) where the soil at 800 mm was much warmer than at the shallower depths.







Figures 10a-c: Seasonal soil temperature fluctuations under: (a) Monoculture maize; (b) Summer cover crops; (c) Winter cover crops.

Figure 11 depicts early-season soil temperature fluctuations (up to 80 DAP: 15 Feb) at 100 mm depth under monoculture maize, summer cover crops and winter cover crops, respectively. The following observations can be made:

- The cooling of soil after rain events.
- The largest diurnal temperature fluctuations were observed for the bare soil (winter cover crops not planted yet). For example, on 56 DAP the bare soil was (on the warmest part of the day) 7.8°C warmer than under the summer cover crops. Under the latter crops the lowest minimum soil temperatures were reached (See arrow).

In Figure 12 the magnitude of the soil temperature regimes under the various crops is presented by means of accumulated temperatures over the period of 44-80 DAP. The highest regime was measured under the bare soil, followed by the maize and the summer cover crops. The conclusion can be made that the cultivation of the latter crops can contribute to the reduction of earth warming.

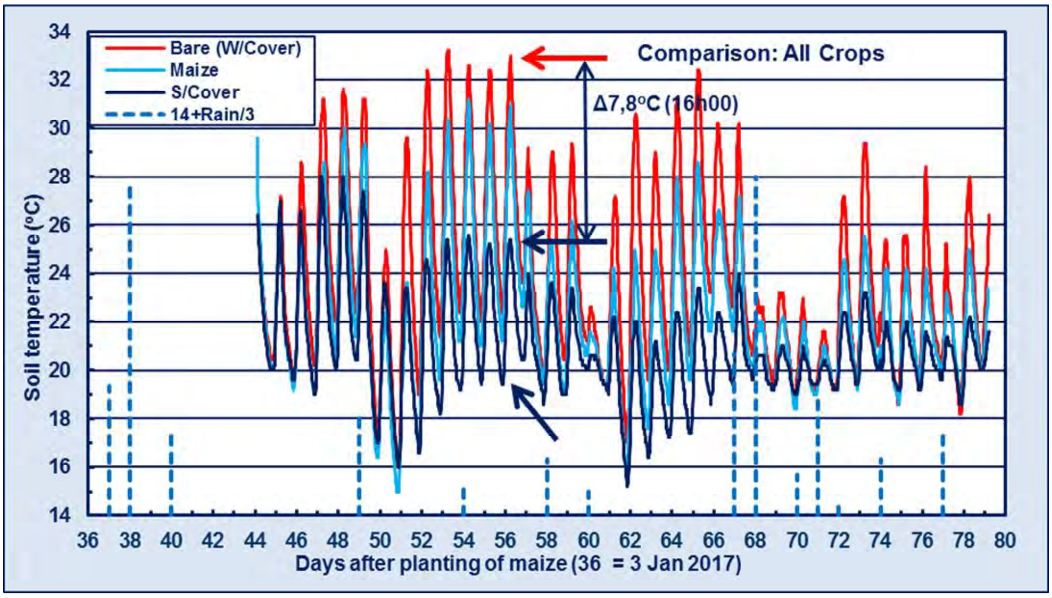


Figure 11: Early-season soil temperature fluctuations at 100mm depth under various crops.

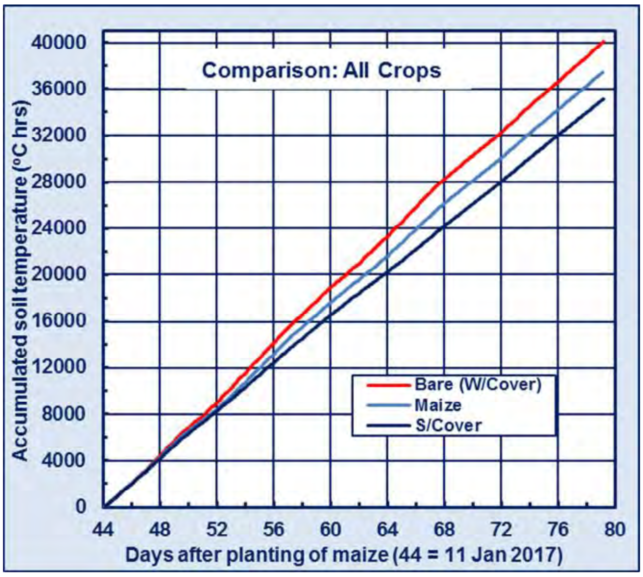


Figure 12: Accumulated soil temperatures for crops (W/Cover: winter cover crops; S/Cover: summer cover crops).

4.2.6.3 Water table sampling

Reporting by Drr DJ Beukes and AA Nel

The sandy soils of the north western Free State were deposited some 1.8-5 million years ago on an undulating Palaeolithic surface consisting of clayey components of weathered dolerite, mudstone, calcrete and shale, all with poor drainage capability (Henning 1991). The latter property may cause temporary, or perched/'hanging' water tables that are common in this region. Although the two water tables that were studied are adjacent to one another on the north eastern (NE) and north western (NW) sides of the trial site, respectively, they are separate water bodies due to the undulating subsurface. Consequently they exhibit different chemical characteristics. The soil surface reliefs are at 1347 and 1344 m, respectively. Values of some chemical properties are shown in Figures 13a-g. The following observations can be made:

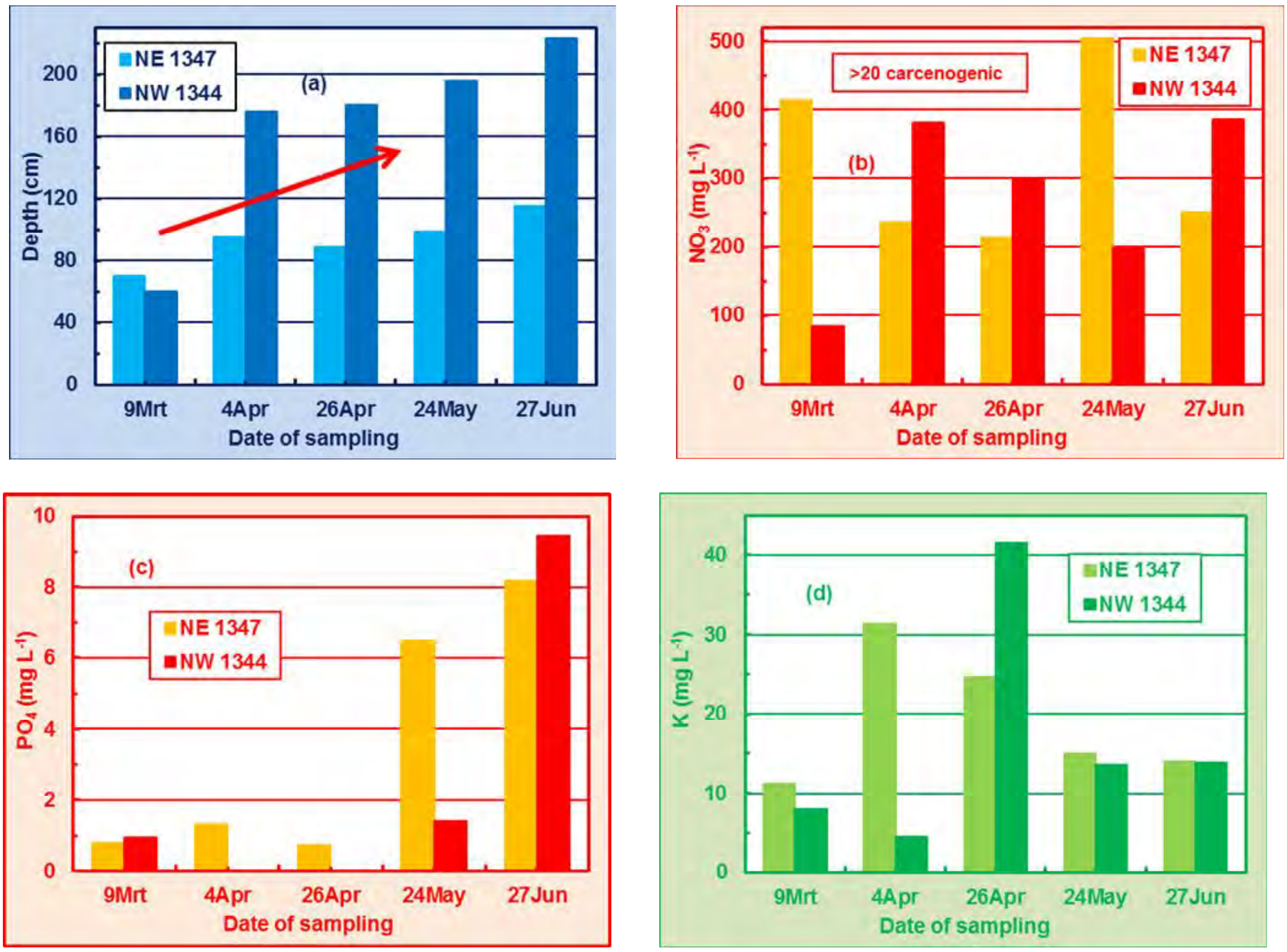
- Water tables levels subsided from 70 to 115 cm (NE), and from 60 to 223 cm (NW), over the period of observation (Fig 13a).
- Very high NO_3 values, varying from 84 to 504 mg L^{-1}, were measured (Fig 13b). Very low soil NO_3-N values, ranging from 4-5.5 mg kg^{-1} were observed (See Section 4.2.7). Leaching of costly and health threatening NO_3-N on these sandy soils appears to be a serious problem. If consumed, water NO_3 concentrations >20 mg NO_3 may be carcinogenic for humans. In a water table study over three years (1987-89) at nine sites in the north western Free State, Henning (1991) reported a mean value of 38.2 mg NO_3 L^{-1} for January and a single occurrence of a maximum value of 80 mg NO_3 L^{-1}.

  Plate 9 shows serious N deficiency on maize leaves on 9 March 2017. On the same day, soil NO_3 and NH_4-N contents were 5 and 28 mg kg^{-1}, respectively, in the 0-60 cm layer. In other words, the low NO_3-N caused N deficiency despite the high NH_4 content. On the same day the water table NO_3-N at 70 cm depth was 412 mg kg^{-1}.

  Although not included in the presented data, nitrite (NO_2) was found in four of the eight sampling events at concentrations ranging from 17 to 68 mg L^{-1}. Values >4 mg L^{-1} may cause methaemoglobinaemia in infants, a condition where NO_2 combines with blood haemoglobin, reducing its oxygen carrying capacity.

- Figure 13c shows that even PO_4 ended up in the water tables and measured 8 to 9.5 mg L^{-1} by 26 June.
- Other plant nutrients, like K, Ca and Mg were also present in both water tables at all dates of sampling, with Ca and Mg at relatively high concentrations (Fig 13 d-f). Both the latter elements are inadequately supplied in the topsoil (See Section 4.2.7).
- Extremely high SO_4 concentrations were measured, ranging from 960 to 4467 mg L^{-1} (Fig 13 g). If consumed, concentrations >200 mg L^{-1} may cause diarrhoea in humans. The trial site has a history of the cultivation of potatoes in rotation with maize. It is a farm practice to apply gypsum to boost soil Ca for successful potato cultivation. The trial site received 2t gypsum ha^{-1} a few years ago, probably explaining the high SO_4 levels in the water tables.

The salt crust (Plate 2) close to the NW water table may be regarded as a direct consequence of the capillary rise of water, carrying the above-mentioned salts, from the water table with consequent surface deposition of salts. Analysis of the salt crust (Figure 13g) reveals the presence (sometimes at high concentrations) of costly plant nutrients, such as NO_3, PO_4, K, Ca and Mg. The undesirable high concentrations of Na and Cl cannot be explained yet. As expected (See bullet 5 above), SO_4 was present in an extremely high concentration.



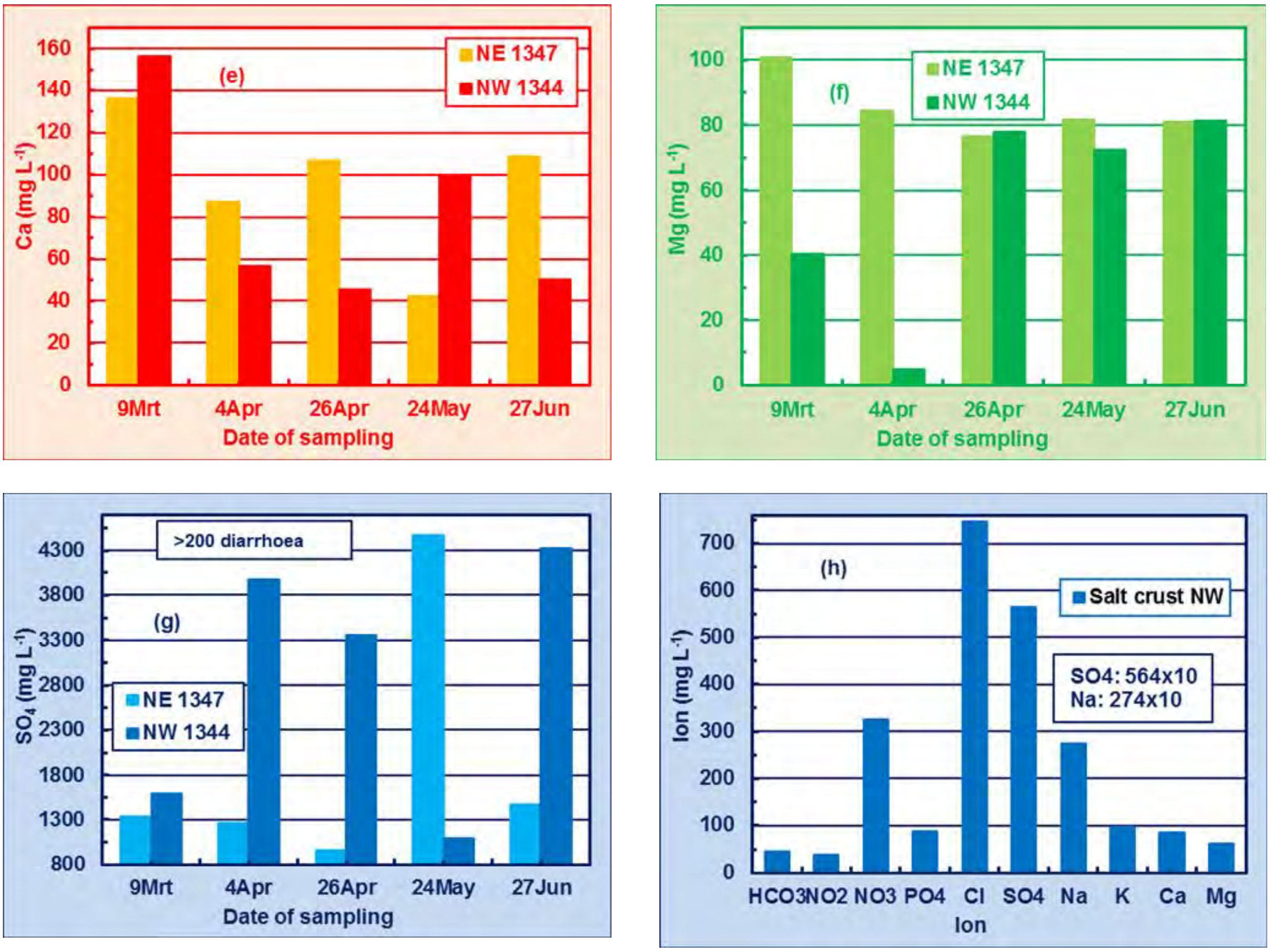


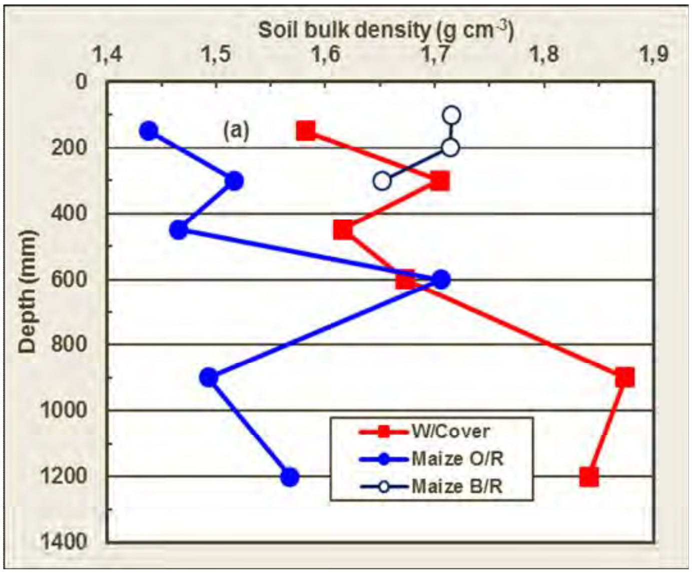
Figure 13a-h: Chemical characteristics of water table and salt crust.

Plate 9: Nitrogen deficiency on maize stand.

4.2.6.4 Soil bulk density and soil porosity

Figure 14a shows how much more compacted the soil was under No-till (winter cover crop) compared to ROR (maize): At 150 mm: 1.58 *vs.* 1.44 g cm^{-3}; at 900 mm depth: 1.87 vs 1.49 g cm^{-3}. Noticeable also is the compacted layer (1.71 g cm^{-3}) at 600 mm depth under ROR (maize). Could it be an indication that the deep ROR ripping only extended to 600 mm? Between-the-row bulk density on the ROR (maize) was at 1.72 g cm^{-3} much higher than on-the row density (1.44 g cm^{-3}), indicating soil compaction due to implement traffic.

Soil porosity values under No-till (winter cover crop) was lower compared to ROR (maize) (e.g. at 150 mm depth: 40% *vs.* 46%), due to the negative effect of soil compaction on air/water-filled soil pores. Due to between-the-row soil compaction, soil porosity decreased at shallow depths to 35% compared to 46% for ROR (maize) (Figure 14b).



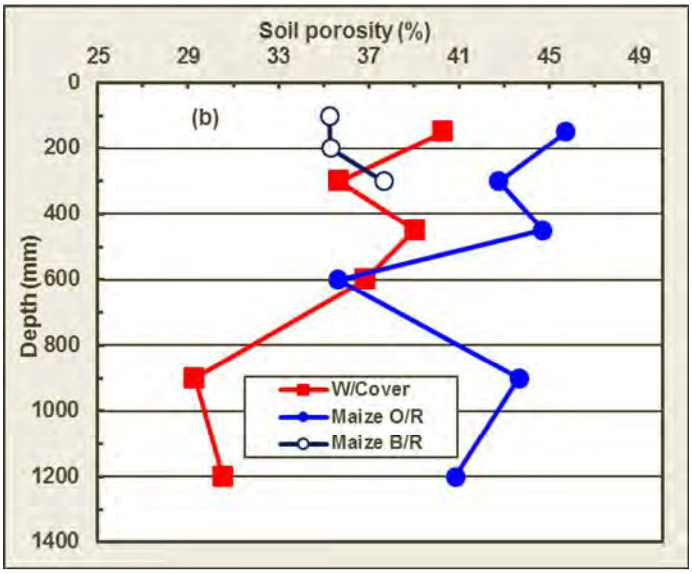


Figure 14a-b: Soil bulk density and porosity.

4.2.7 Soil sampling and analysis by OMNIA

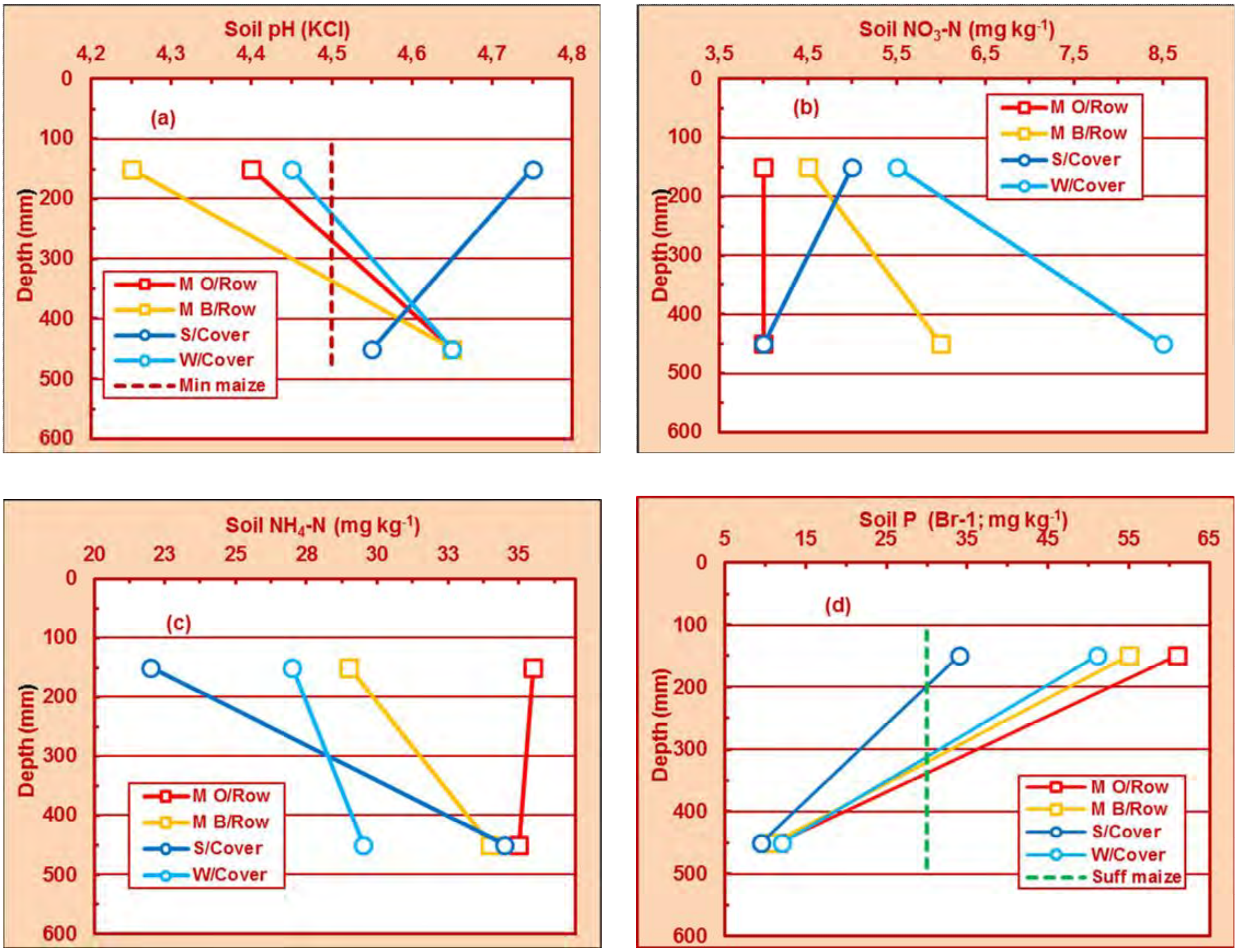
Soil pH (KCl) and some soil nutrient values are displayed in Figures 15a-g. The interpretation of the values in terms of sufficient or minimum requirements for maize growth is based on norms from the FSSA (2007) and does not necessarily represent the viewpoints of OMNIA.

- Soil pH (KCl) (Fig 15a): Topsoil and subsoil pH values were below and above the critical norm of 4.5, respectively. It is not clear why the pH under the summer cover crop did not follow the trend set by the other crops. It is advised that topsoil acidity should be ameliorated with dolomitic agricultural lime because of the sub-optimal topsoil Mg status (5^{th} bullet).
- Inorganic N (NO_3 and NH_4) (Fig 15b-c): Very low NO_3-N values, ranging from 4-5.5 mg kg^{-1} in the topsoil, were measured. Leaching of NO_3-N on these sandy soils appears to be a serious problem (See Section 4.2.6.3). Relatively high NH_4-N values, ranging from 22-35 mg kg^{-1} in the topsoil, were measured. The N carrier for the liquid fertilizer applications at planting and as top dressing is apparently 75% NH_4-based, probably explaining the high residual soil NH_4-N. These sandy soils exhibit very poor acid buffering. The use of NH_4-fertilizers, therefor, should be discouraged.
- Phosphorus (P): Topsoil P values are above the minimum P requirement for maize, while subsoil residual P is inadequately provided (Figure 15d).
- Potassium (K): Figure 15e shows that both top and subsoil K values are above the minimum

requirement for maize. The increase in soil K with depth is probably due to leaching of K, a phenomenon well-known on sandy soils (Also see Section 4.2.6.3).

- Calcium (Ca) and magnesium (Mg): Both soil Ca and Mg are inadequately supplied in the topsoil, but both increase with depth (Fig 15f-g). Application of 2t gypsum ha^{-1} was done a few years ago to boost soil Ca for potato cultivation. It is well-known that Ca replaces Mg on the adsorption complex, leading to leaching of Mg – hence the increase of Mg with depth (Also see Section 4.2.6.3).

Mean effective cation exchange capacity (ECEC) was very low (1.78 $cmol_c\ kg^{-1}$) in the topsoil, but increased somewhat to 3.44 $cmol_c\ kg^{-1}$ in the subsoil. Mean sand, silt and clay contents were 86%, 1% and 13% in the topsoil, and 82%, 4% and 14% in the subsoil, respectively.



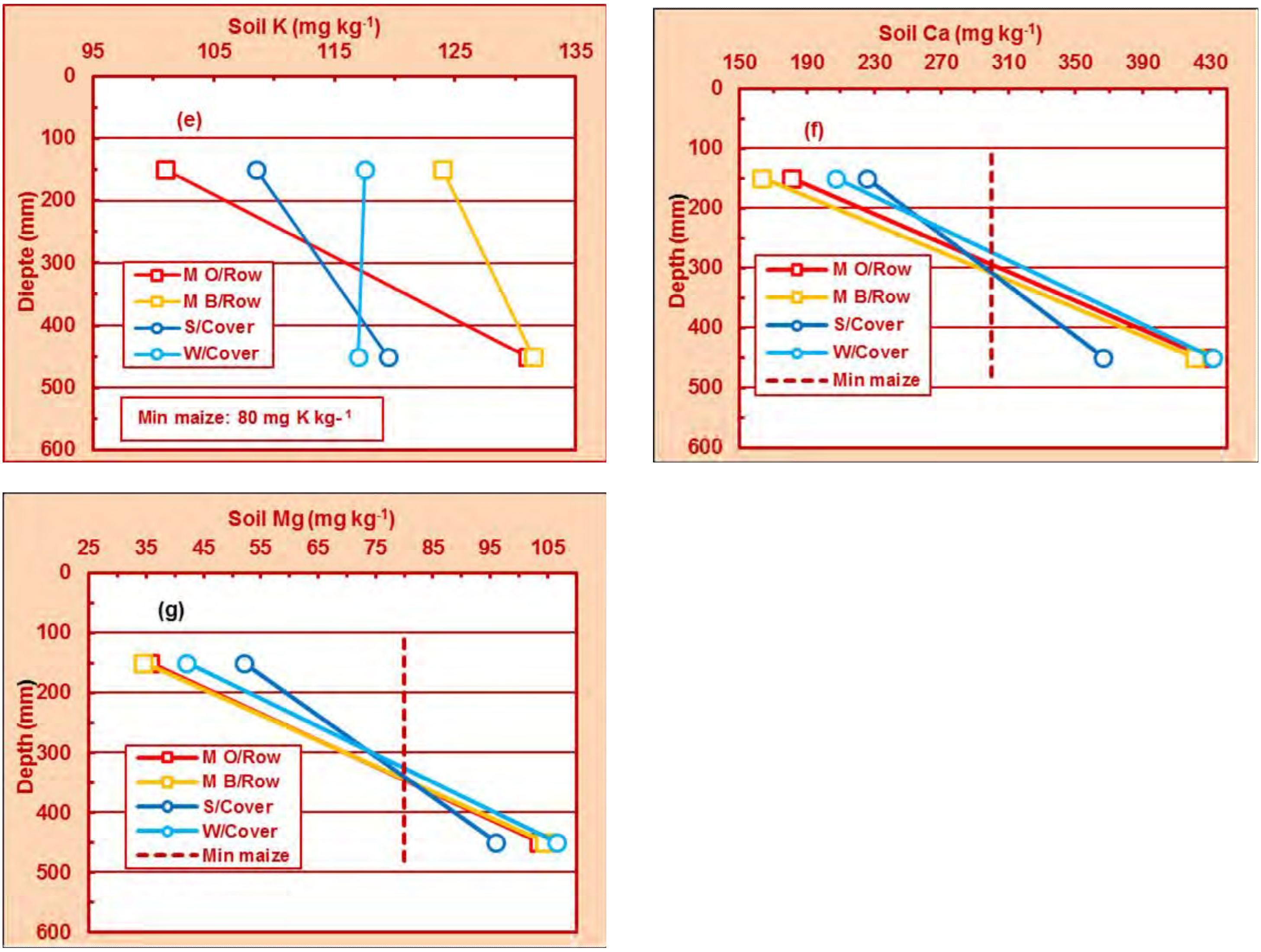


Figure 15a-g: Soil analysis values on Trial 1 (cover crops).

4.2.8 Root and crown rot severity study

Reporting by: Dr M Craven, ARC-Grain Crops Institute, Potchefstroom

Root and crown rot severities as observed on sampled plants from the Cover Crop Trial (Trial 1) were, in general, very low (15% and 0.5% respectively- Plate 10). When relayed to the root disease index scale, which translates to a score out of 400, the average root rot severity of the 30 plants sampled was 120, whilst the crown rot index score was 10. The average plant biomass obtained was 1.54 kg plant^{-1} and the average root mass achieved 0.21 kg plant^{-1}.

Plate 10: Some examples of root rot severities observed on maize plants sampled from Trial 1.

4.2.9 Plant-parasitic nematode study

Reporting by: Dr S Steenkamp, ARC-Grain Crops Institute, Potchefstroom

4.2.8.1 Treatments sampled

Since this is only the first season for this project, these results will serve as a baseline for the statistical analyses of the follow-up seasons.

Treatments for the Cover Crop Trial (Trial 1) trial consisted of:

1. ROR maize – Rip on rip (ROR) maize – ROR maize – ROR maize
2. Summer cover crop – No till (GB) maize – winter cover crop – GB Maize
3. Summer cover crop – ROR maize – winter cover crop – ROR Maize
4. Winter cover crop – GB maize – winter cover crop – GB Maize
5. Winter cover crop – ROR maize – winter cover crop – ROR Maize

4.2.8.2 Nematode numbers in the soil

The current nematode population in soil samples collected from Kroonstad consist of a mix of *Pratylenchus* spp, *Criconema* spp, *Meloidogyne* spp and spiral nematodes. Nematode numbers of these nematode genera present in the soil samples are provided in Table 4.

Table 4: Nematode numbers in soil samples of the Cover Crop Trial.

Treatment	Nematodes per 200 cm^3 soil			
	[1]*Pratylenchus* spp	[2]*Criconema* spp	[3]*Meloidogyne* spp	Spiral nematodes
1	2.8 (903*) b**	0.7 (21) a	0.37 (14) a	2.7 (623) b
2	3.1 (1575) b	0.4 (9) a	1.0 (53) a	1.5 (88) b
3	3.1 (1295) b	0 (0) a	0.5 (56) a	1.4 (119)ab
4	0.6 (14) a	0 (0) a	0.4 (28) a	0 (0)a
5	0.4 (14) a	0 (0) a	0 (0) a	0 (0) a

[1]Lesion nematodes [2]Ring nematodes [3]Root-knot nematodes

*Actual nematode numbers provided in brackets after the log transformed numbers

** Numbers followed by the same letters do not differ significantly from each other

Pratylenchus spp numbers ranged from 14 (treatments 4 & 5) to 1575 (treatment 2) nematodes per 200 cm^3 soil (Table 4). Treatments 4 and 5 showed a significantly lower *Pratylenchus* spp number compared to the rest of the treatments, which did not differ significantly from each other (Table 4). In terms of *Criconema* spp, soil from treatments 1 and 2 maintained 21 and 9 *Criconema* spp, respectively (Table 4). The *Meloidogyne* spp numbers in the soil ranged from 0 to 56 nematodes per 200 cm^3 soil (Table 4). No significant differences were observed between the treatments. Spiral nematode numbers ranged from 0 to 623 spiral nematodes per 200 cm^3 soil sample (Table 4). Treatments 4 and 5 had significantly lower spiral nematode numbers compared to treatments 1 and 2 (Table 4). Treatment 3 did not differ significantly from any of the other treatments in terms of spiral nematode numbers in the soil samples (Table 4).

4.2.8.3 Nematode numbers in the roots

Nematode numbers observed in root samples from the Cover Crop Trial are provided in Table 5.

Table 5: Nematode numbers in root samples of the Cover Crop Trial.

Treatment	Nematodes per 50g roots	Nematodes per 5g roots	
	[1]*Meloidogyne* spp	*Meloidogyne* spp	[2]*Pratylenchus* spp
1	1708	0	630
2	11084	70	569
3	680	70	665
4	No roots available		
5			

[1]Root-knot nematodes [2]Lesion nematodes

Meloidogyne spp and *Pratylenchus* spp were maintained in the root samples from the Cover Crop Trial. In terms of the 50g roots, *Meloidogyne* spp numbers ranged from 680 (treatment 3) to 11084 (treatment 2) nematodes per 50g roots (Table 5). Seventy *Meloidogyne* spp were in 5g root samples from treatments 2 and 3 while the *Pratylenchus* spp numbers ranged from 569 (treatment 2) to 665 (treatment 3) (Table 5). Treatments 4 and 5 had no plants, therefore no root samples were collected at sampling time.

4.2.10 Soil microbiological study

Reporting by: Mr OHJ Rhode, ARC-Grain Crops Institute, Potchefstroom

4.2.9.1 Microbial groups

The cover crops had significant effects (Table 6: F ratio = 3.97 (p = 0.04); 2.87 (p = 0.08); 4.85 (p = 0.02)) on bacteria, actinomycetes, filamentous fungi counts, respectively. Compared to actinomycetes and fungi, bacteria had the highest incidence of occurrence under summer cover crops (Table 6; Figure 16). Filamentous fungi counts were the highest under monoculture maize.

4.2.9.2 Enzyme activity

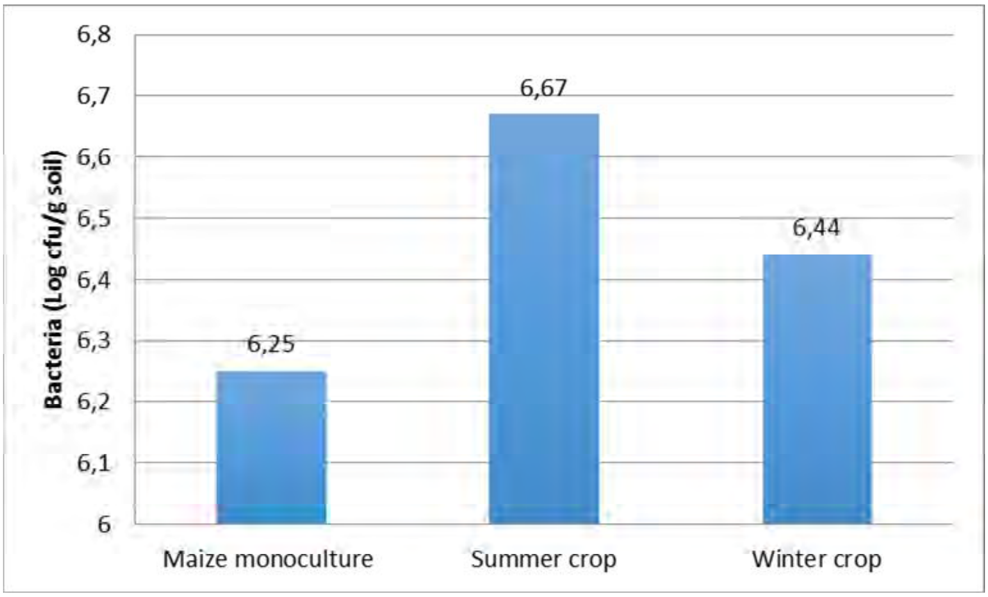
The cover crops had a significant effect on glucosidase, phosphatase and urease activity (Table 7: 7.58 (p = 0.003); 12.29 (p = 0.00); 0.68 (p = 0.52)), respectively. Fields under summer and winter cover crops showed higher activities for glucosidase and phosphatase compared to monoculture maize (Table 7; Figure 17). Urease activity was not significantly affected by cover crops and monoculture maize (Table 8; Fig 17).

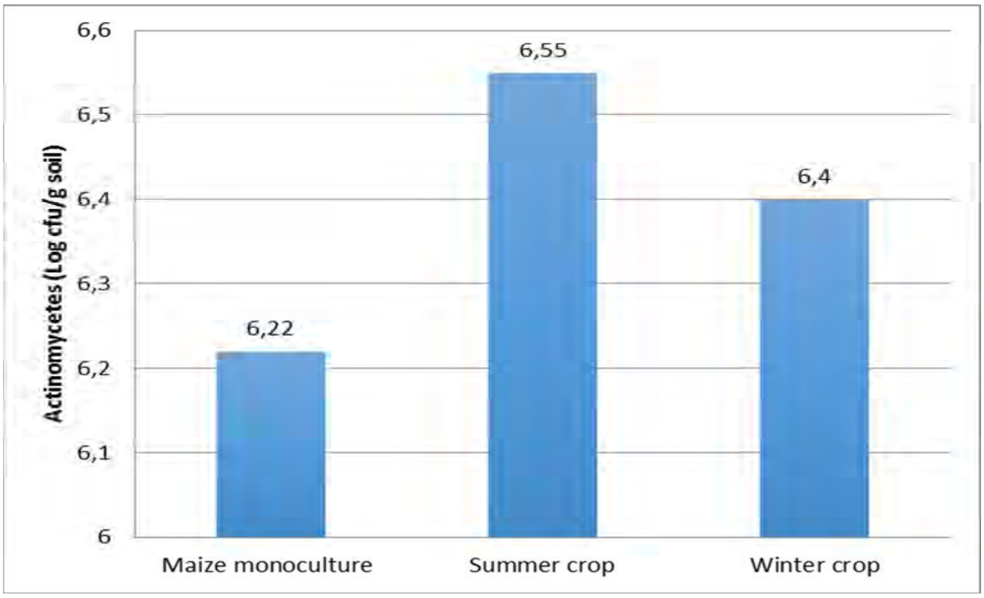
Table 6: Statistical parameters for microbial counts.

Source of variation	F ratio (probability, *p*)		
	Property		
	Bacteria	**Actinomycetes**	**Fungi**
Cover crop	3.97(0.04)	2.87(0.08)	4.85(0.02)
Practice	**Treatment means**		
	(cfu g soil^{-1})	**(cfu g soil^{-1})**	**(cfu g soil^{-1})**
Monoculture maize	6.25b	6.22b	4.96a
Summer crops	6.67a	6.55a	4.27b
Winter crops	6.44ab	6.4ab	4.1b
LSD (0.05)			

Table 7: Statistical parameters for enzymatic activity.

Source of variation	F ratio (probability, *p*)		
	Property		
	Glucosidase	**Phosphatase**	**Urease**
Cover crop	7.58 (0.003)	12.29 (0.00)	(0.68) 0.52
Practice	**Treatment means**		
	(mg kg $^{-1}$ hr^{-1})	**(mg kg $^{-1}$ hr^{-1})**	**(mg kg $^{-1}$ 2hr^{-1})**
Monoculture maize	510.4b	104.46b	16.33a
Summer crops	862.36a	167.73a	24.23a
Winter crops	774.22a	107.14b	21.22a
LSD (0.05)			





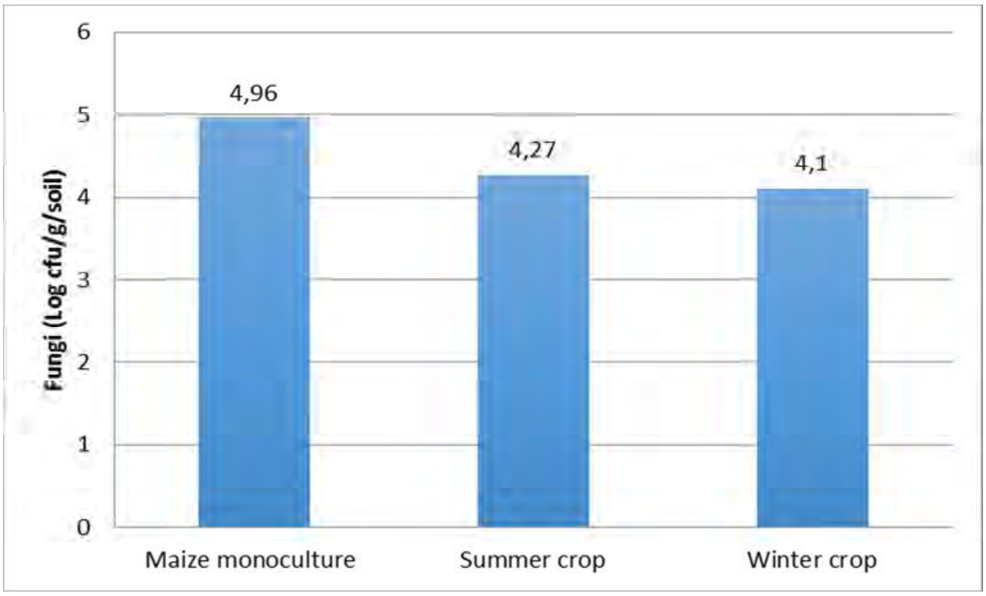
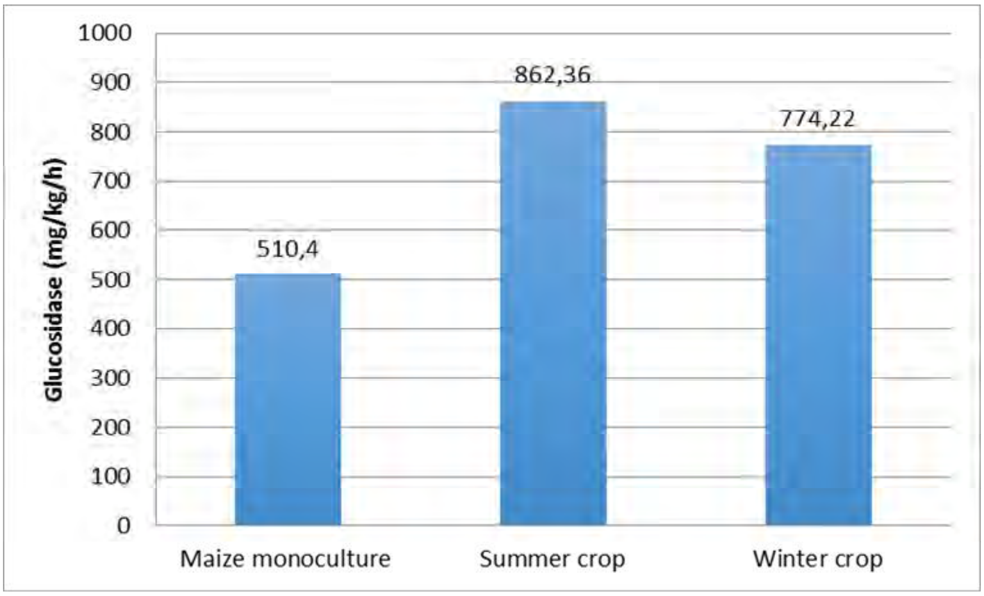
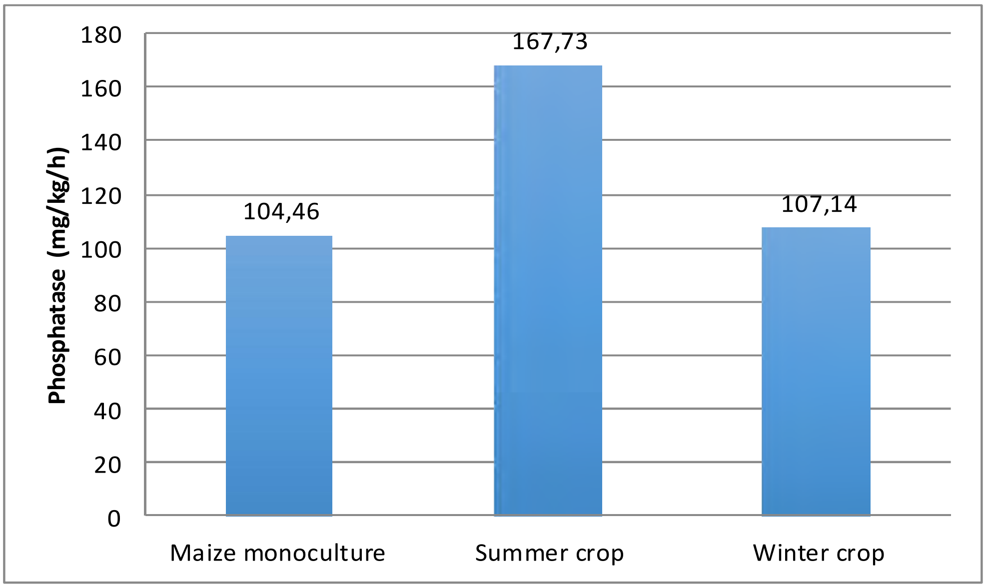


Figure 16: Cover crop effects on maize microbial groups.





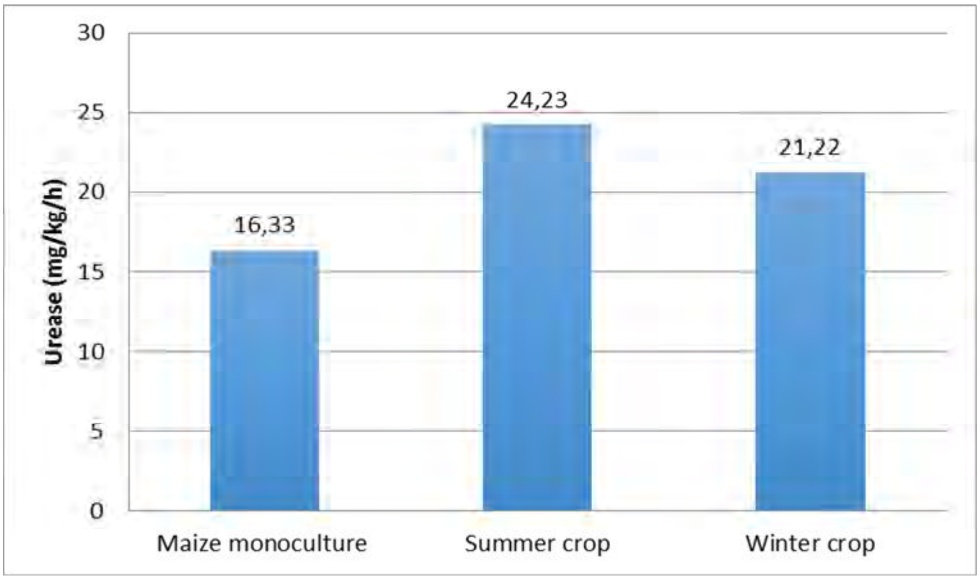


Figure 17: Cover crop effects on soil microbial enzyme activity.

4.2.9.3 Conclusion

Statistical differences ($p \leq 0.05$) could be detected among the treatments for microbial activities (enzymes and counts) on the cover crop trial. Higher values were observed for alkaline phosphatase and glucosidase activities. This is the first season of the trial and no conclusive findings can be drawn since this data serves as a baseline for further investigations.

4.3 Trials 2 and 3: Local CA, ROR and reduced tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat, as well as maize/soybean, compared to monoculture maize cultivation.

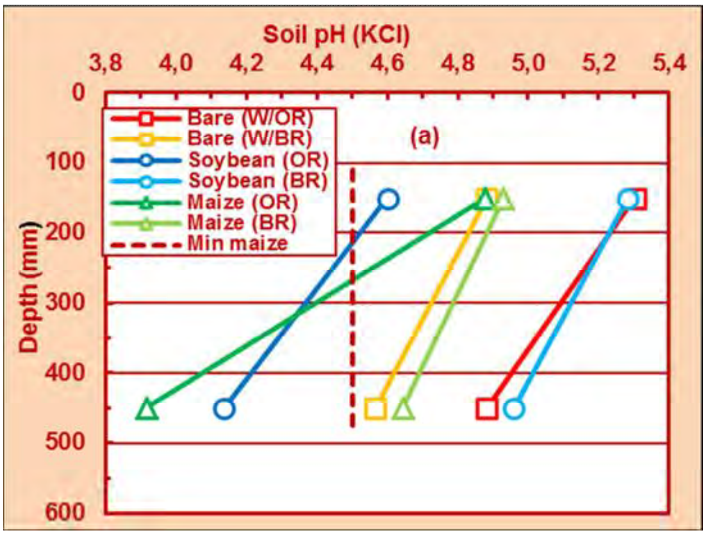
(Trial 2 at Christinasrus-Thabo van Zyl: Trial 3 at Klein Constantia-Lourens van der Linde)

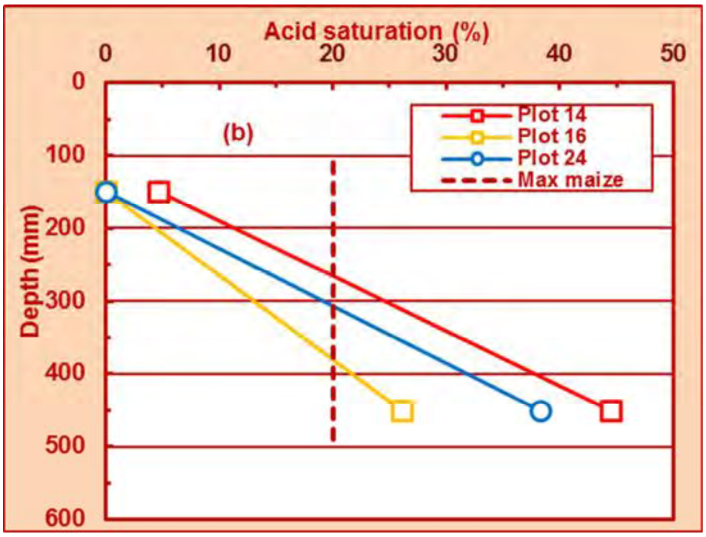
4.3.1 Soil sampling and analysis by OMNIA (Trial 2)

Some soil properties (e.g. pH (KCl)) and some soil nutrient values are displayed in Figures 18a-j. The interpretation of the values in terms of sufficient or minimum requirements for maize growth is based on norms from the FSSA (2007) and does not necessarily represent the viewpoints of OMNIA. Each data point in the graphs represents the mean of three replicates.

- Soil pH (KCl) (Fig 18a): In general all pH values are rather low with some subsoil values below the norm of 4.5. There is a general trend of lower pH values in the subsoil compared to the topsoil. Topsoil and subsoil pH values were below and above the critical norm of 4.5, respectively. It is advised that soil acidity should be ameliorated with dolomitic agricultural lime because of the sub-optimal topsoil Mg status (6^{th} bullet).
- Acid saturation (Fig 18b-c): Two scenarios are presented, using selected plots as examples. Figure 10b depicts low topsoil acid saturation, but with unacceptable high subsoil acid saturation ranging from 26%-44.5%. Except for one value, Figure 10c shows unacceptable high acid saturation values for both the top and subsoils.
- Inorganic N (NO_3 and NH_4) (Fig 18d-e): Very low NO_3-N values, ranging from 4.3-7 mg kg^{-1} in the 0-60 soil layer, were measured. Relatively high NH_4-N values, ranging from 38-49 mg kg^{-1} in the 0-60 soil layer, were measured. The use of urea or NH_4-fertilizers as N carrier on these sandy soils with their very poor acid buffer capacity should be discouraged.
- Phosphorus (P): Topsoil P values are above the minimum P requirement for maize, while, in general, subsoil residual P is inadequately provided (Figure 18f).
- Potassium (K): Figure 18g shows that both top and subsoil K are, in general, well-supplied. The below-norm values for on-the-row soil K for maize could be due to active uptake of K by the maize.
- Calcium (Ca) and magnesium (Mg): Both soil Ca and Mg are inadequately supplied in both the topsoil and subsoil (Figure 18h-i). The relatively low Mg values should prompt the use of dolomitic lime to ameliorate soil acidity.
- Soil organic C: Soil C is generally very low and ranged from 0.34-0.58% (Figure 18j). Noticeable are the relatively high on-the-row topsoil values of 0.58% and 0.54% for maize and soybean, respectively.

Mean effective cation exchange capacity (ECEC) for the trial area was very low (1.86 $cmol_c$ kg^{-1}) in the topsoil, but increased somewhat to 2.10 $cmol_c$ kg^{-1} in the subsoil. Mean sand, silt and clay contents were 88%, 4% and 8% in the topsoil, and 85%, 7% and 8% in the subsoil, respectively.





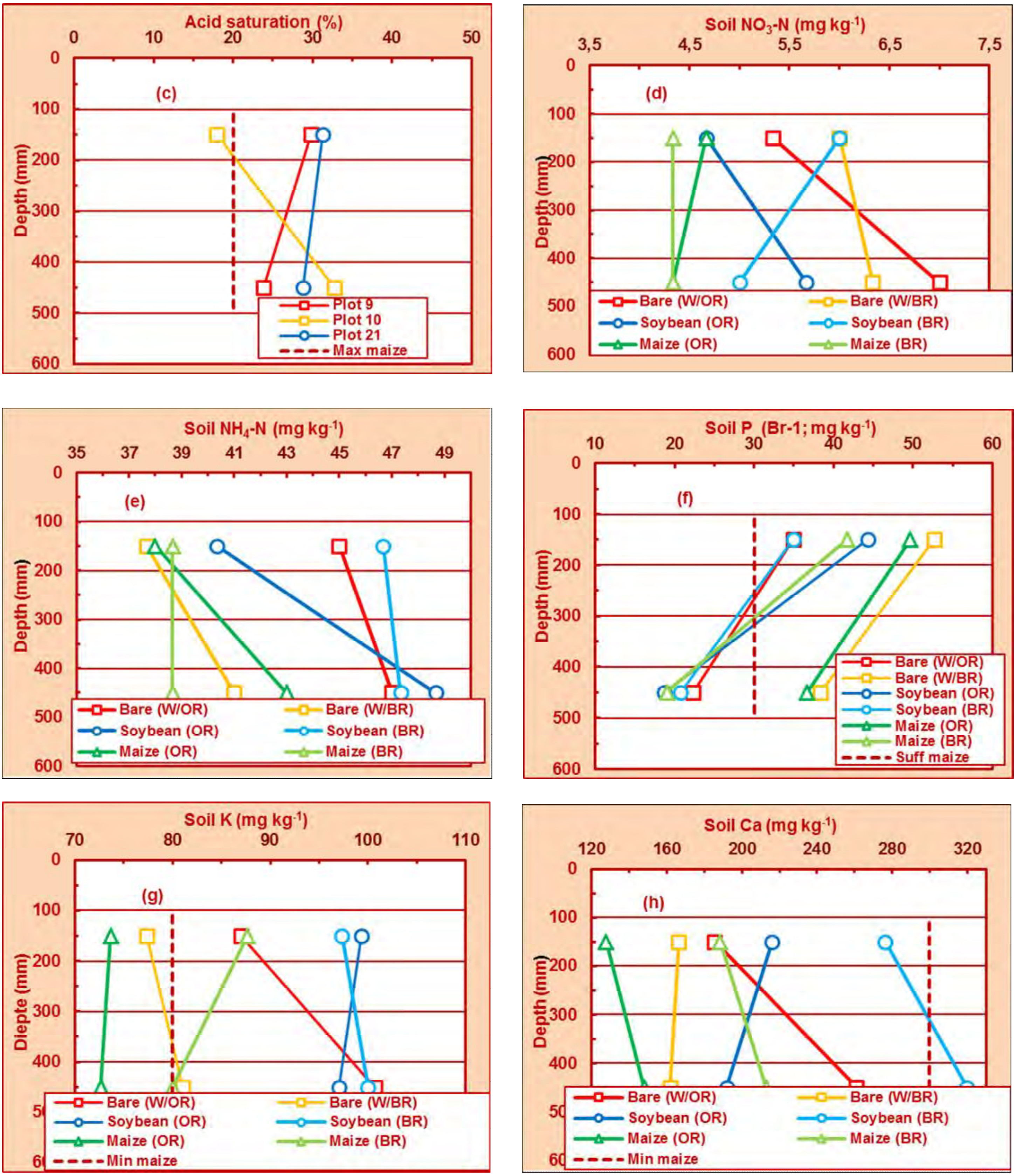
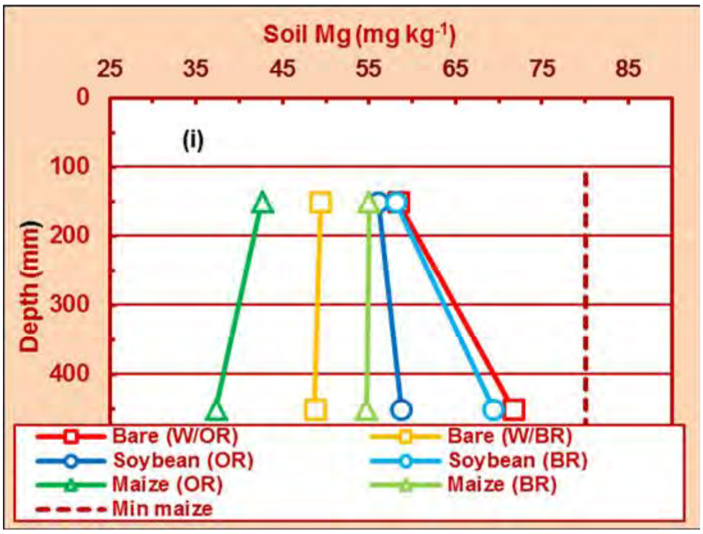


Figure 18a-h: Soil analysis values on Trial 2 (W/OR=wheat on row; W/BR= wheat between row).



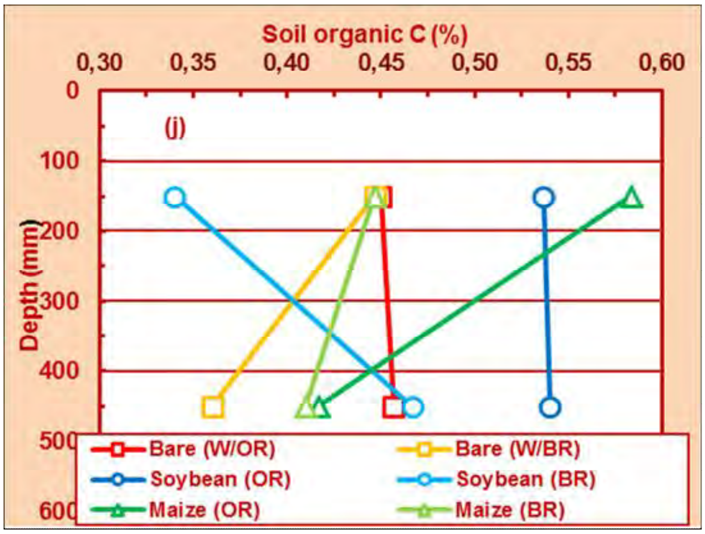


Figure 18i-j: Soil analysis values on Trial 2 ((W/OR=wheat on row; W/BR= wheat between row).

4.3.2 Root and crown rot severity study (Trial 2)

Reporting by: Dr M Craven, ARC-Grain Crops Institute, Potchefstroom

With the initial inspection of the field trial, an apparent physiological effect was observed which manifested as yellowing of the maize plants. As an example, Plate 11 provides a side view of plot 15. From this photo it can be observed that the yellowing occurred on the back half of plot 15 and continued to plot 24 (replicate 3). Due to the clear distinguishable line between lush green maize plants and yellow maize plants mid plot, the possibility should be investigated that a problem might have occurred regarding fertilizer application during planting. Other possibilities can, however, not be excluded. Whatever the reason for the yellowing, it should be kept in mind that this effect could have impacted on the parameters measured in this report.

Averages obtained for plant biomass, root mass and root and crown rot severity for the 30 plants sampled per plot are indicated in Table 8. Averaged biomass plant^{-1} ranged between 1.04 and 1.97 kg, whilst root mass varied between 0.13 and 0.22 kg plant^{-1} (Table 8). Root rot severity varied between 133.3 and 190 (index value), and crown rot severity between 7 and 86.67 (index value). Examples of crown and root rot severities observed are indicated in Plates 12 and 13.

Box plots generated over replicates indicated that replicate three (Figure 19), in general, had the lowest plant biomass and root mass, whilst having the highest average root and crown rot severity (Figure 19). The mentioned yellowing might accordingly have had an impact on the parameters evaluated, as any stress the plant experience could contribute to root, crown and stalk rot, as well as plant biomass.

Box plots generated over treatments (Figure 20) indicated larger variation and general skewness of data generated for the various parameters within treatments. This might be expected as the measurements represent baseline data. The impact of the physiological effect observed can, however, not be ruled out. It should also be noted that the root and crown rot severity were higher in the monoculture maize (MMM) treatments. The reason for this is not clear yet.

Plate 11: Physiological effect observed at Trial 2. Yellowing of plants visible in plot 15 which continued to the right onto replicate 3.

Table 8: Average plant biomass, root mass, as well as root and crown rot severity obtained from 30 randomly selected maize plants from 12 plots from Trial 2.

Plot	Treatment	Rep	Biomass plant^{-1} (kg)	Root mass plant^{-1}	Root rot severity[a]	Crown rot severity[b]
3	MMM	1	1.97	0.18	168.89	57.32
5	MKS1	1	1.78	0.17	123.33	17.67
6	MMK2	1	1.87	0.22	120.00	12.00
9	MMK1	1	1.88	0.17	130.74	27.04
12	MKS1	2	1.86	0.18	130.00	7.00
15	MMM	2	1.44	0.14	150.00	37.67
16	MMK1	2	1.24	0.14	140.00	9.33
18	MMK2	2	1.50	0.17	133.33	27.33
19	MMM	3	1.45	0.15	190.00	61.00
20	MMK2	3	1.51	0.15	175.56	55.33
24	MMK1	3	1.04	0.18	166.67	86.67
26	MKS1	3	1.21	0.13	190.00	34.00
		AVG	1.56	0.16	151.54	36.03

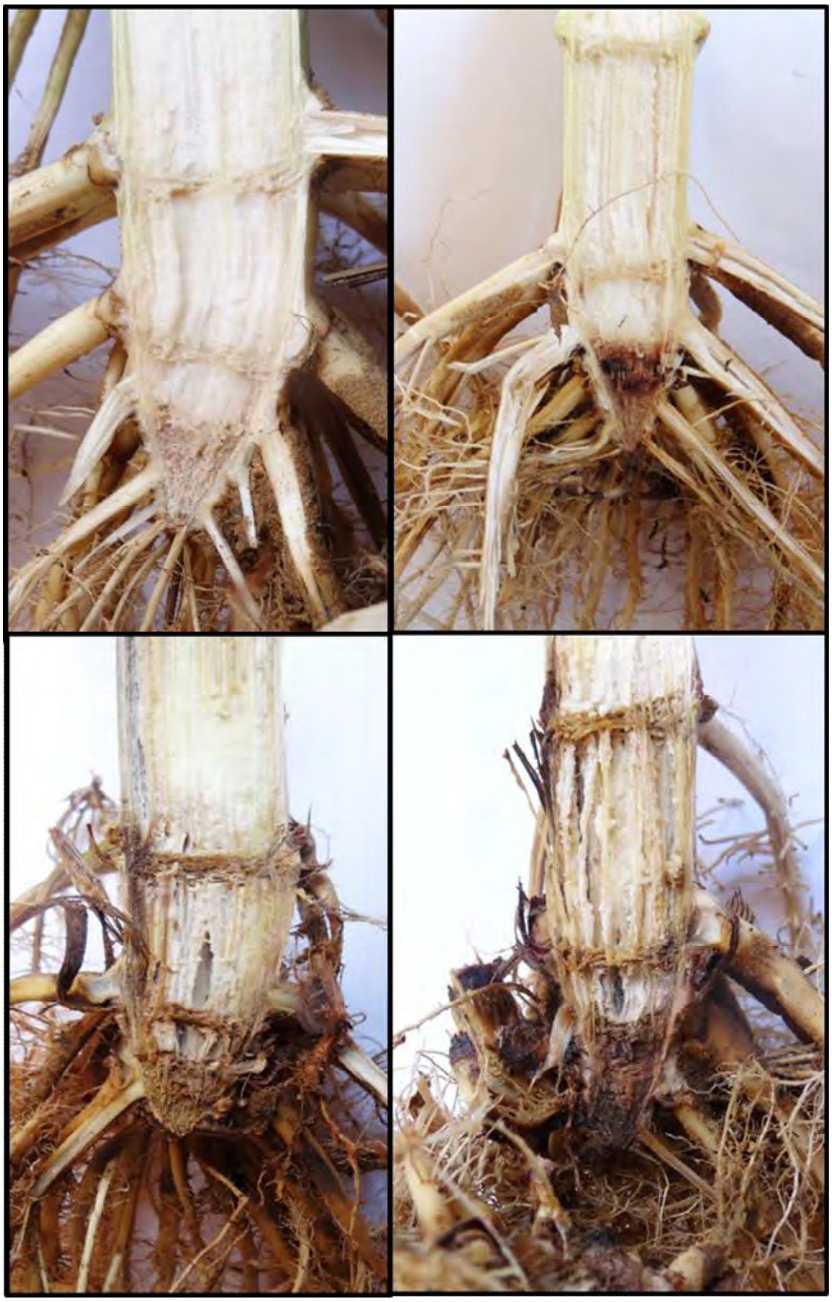


Plate 12: Various degrees of crown rot observed in sampled plant material from Trial 2.

Plate 13: Examples of root rot severities observed in maize plants sampled in Trial 2.

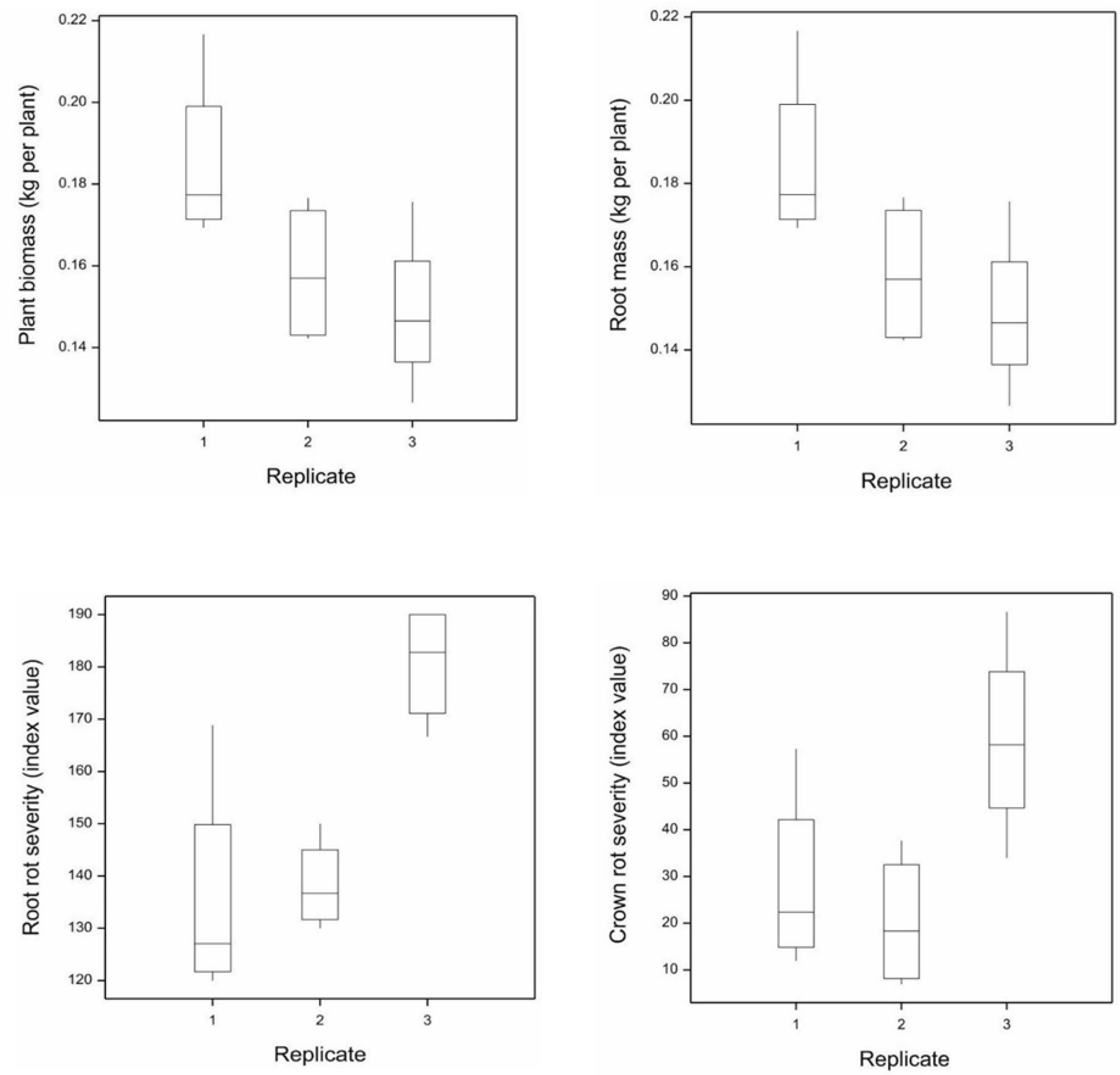


Figure 19: Box plots generated to indicate a possible gradient effect observed over replicates regarding the parameters evaluated (*i.e*. plant biomass, root mass as well as root and crown rot severity).

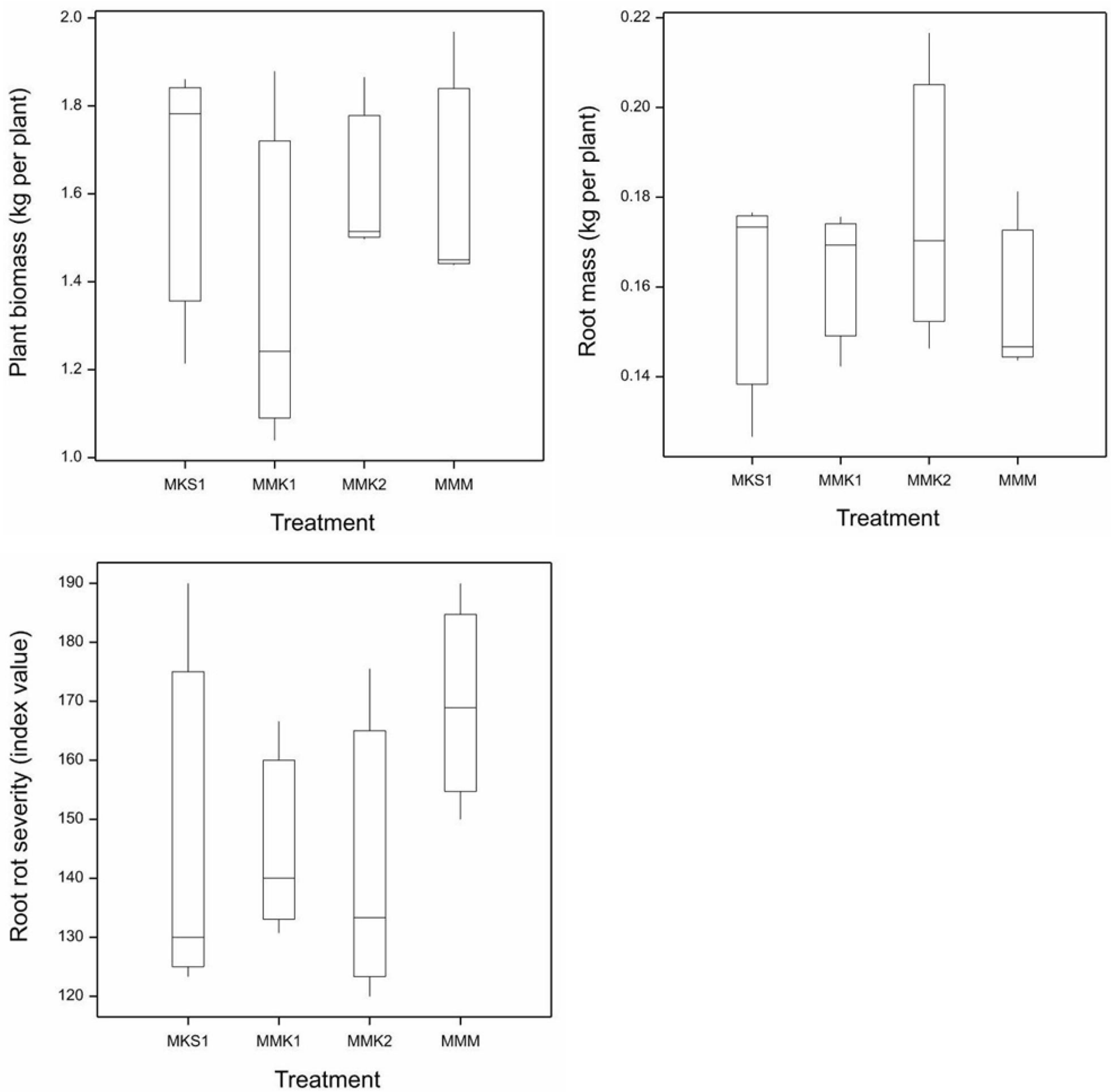


Figure 20: Box plots generated to indicate distribution of data points and skewness over treatments for parameters measured (*i.e*. plant biomass, root mass as well as root and crown rot severity).

4.3.3 Plant parasitic nematode study (Trial 2)

Reporting by: Dr S Steenkamp, ARC-Grain Crops Institute, Potchefstroom

4.3.3.1 Treatments sampled

Treatments for the Crop Rotation Trial (Trial 2) at Christinasrus consisted of:

1. Maize – Maize – Maize – Maize (MMM)
2. Maize – Maize – Wheat (MMK1)
3. Maize – Wheat – Maize (MMK2)
4. Wheat – Maize – Maize (MMK3)
5. Wheat – Maize – Maize – Wheat (MMK4)
6. Maize – Wheat – Soybean (MKS1)
7. Wheat – Soybean – Maize (MKS2)
8. Wheat – Soybean – Maize - Wheat (MKS3)
9. Soybean – Maize - Wheat (MKS4)

Nematode numbers maintained in soil samples collected from the Crop Rotation Trial are provided in Table 9. The treatments did not differ significantly from each other in terms of the nematode numbers of the different genera present in the soil samples (Table 9). *Pratylenchus* spp numbers ranged from 7 (treatment 4) to 105 (treatment 6) nematodes per 200 cm^3 soil, that of *Criconema* spp from 0 (treatments 4, 8 & 9) to 82 (treatment 6) nematodes and that of spiral nematodes from 0 (treatment 4) to 82 (treatment 1) nematodes per 200 cm^3 soil (Table 9). An average of 7 *Xiphinema* spp was found in soil samples from treatment 9 (Table 9).

Table 9: Nematode numbers in soil samples of the Crop Rotation Trial.

Treatment	Nematodes per 200 cm^3 soil			
	[1]*Pratylenchus* spp	[2]*Criconema* spp	[3]*Xiphinema* spp	Spiral nematodes
1	1.3 (64) a	0.8 (18) a	0 (0) a	1.1 (82) a
2	1.3 (70) a	1.1 (35) a	0 (0) a	0.7 (41) a
3	0.7 (35) a	1.3 (64) a	0 (0) a	1.4 (47) a
4	0.3 (7) a	0 (0) a	0 (0) a	0 (0) a
5	0.6 (18) a	0.5 (12) a	0 (0) a	0.3 (11) a
6	1.1 (105) a	1.3 (82) a	0 (0) a	1.0 (53) a
7	0.5 (12) a	0 (0) a	0 (0) a	0.3 (6) a
8	0.6 (18) a	0 (0) a	0 (0) a	0.5 (12) a
9	0.7 (56) a	0 (0) a	0.3 (7) a	0.3 (7) a

[1]Lesion nematodes [2]Ring nematodes [3]Dagger nematodes

*Actual nematode numbers provided in brackets after the log transformed numbers

** Numbers followed by the same letters do not differ significantly from each other

Nematode numbers in the root samples from the Crop Rotation Trial are provided in Table 10. Roots were not available in treatments 4, 5, 7 and 8, however. The number of *Meloidogyne* spp per 50g roots ranged from 140 (treatment 9) to 778 (treatment 3) and from 14 to 99 per 5g roots (Table 10). *Pratylenchus* spp numbers ranged from 0 (treatments 6 & 9) to 18 (treatment 3) nematodes per 5g roots.

Table 10: Nematode numbers in root samples of the Crop Rotation Trial.

Treatment	Nematodes per 50g roots	Nematodes per 5g roots	
	[1]*Meloidogyne* spp	*Meloidogyne* spp	[2]*Pratylenchus* spp
1	228	93	6
2	604	76	12
3	778	99	18
4	No roots available		
5			
6	298	41	0
7	No roots available		
8			
9	140	14	0

[1]Root-knot nematodes [2]Lesion nematodes

4.3.4 Free living nematodes (Trial 2)

The soil samples with the free-living nematodes of both localities are currently being analysed. Results will be available during November 2017.

4.3.5 Soil microbiological study (Trial 2)

Reporting by: Mr OHJ Rhode, ARC-Grain Crops Institute, Potchefstroom

4.3.5.1 Microbial groups

The monoculture maize, as well as the maize/soybean and maize/wheat rotations had significant effects (Table 12: F ratio = 26.55 (p = 0.00); 32.61 (p = 0.00); 4.2 (p = 0.02)) on all microbial counts. Bacteria and actinomycetes counts were higher under maize/soybean and maize/wheat rotations compared to monoculture maize (Table 11; Figure 21). Fungi counts were surprisingly higher under monoculture maize compared to the maize/soybean and maize/wheat rotations (Table 11; Figure 13). The bacteria could possibly play a role in N fixation.

4.3.5.2 Enzyme activity

The monoculture maize, as well as the maize/soybean and maize/wheat rotations had a significant effect (Table 12: F ratio = 4.24 (p = 0.02)) on phosphatase activity. Activities for glucosidase and phosphatase enzymes were the highest under monoculture maize (Table 12, Figure 22) Urease activity was the highest under a maize/soybean rotation (Table 12, Figure 14).

Table 11: Statistical parameters for microbial counts.

Source of variation	**F ratio (probability, *p*)**		
	Property		
	Bacteria	**Actinomycetes**	**Fungi**
Crop	26.55 (0.00)	32.61 (0.00)	4.2 (0.02)
Practice	**Treatment means**		
	(cfu g soil^{-1})	**(cfu g soil^{-1})**	**(cfu g soil^{-1})**
Monoculture maize	6.59a	6.32b	3.59a
Wheat	6.09b	5.75c	3.3b
Soybean	6.8a	6.74a	3.56ab
LSD(0.05)			

Table 12: Statistical parameters for enzymatic activity.

Source of variation	**F ratio (probability, *p*)**		
	Property		
	Glucosidase	**Phosphatase**	**Urease**
Crop	2.66 (0.08)	4.24 (0.02)	0.23 (0.79)
Practice	**Treatment means**		
	(mg kg $^{-1}$ hr^{-1})	**(mg kg $^{-1}$ hr^{-1})**	**(mg kg $^{-1}$ 2hr^{-1})**
Monoculture maize	1249.16a	2182.73a	19.06a
Wheat	839.008b	1074.63ab	17.52a
Soybean	1169.28ab	992,001b	25.25a
LSD(0.05)			

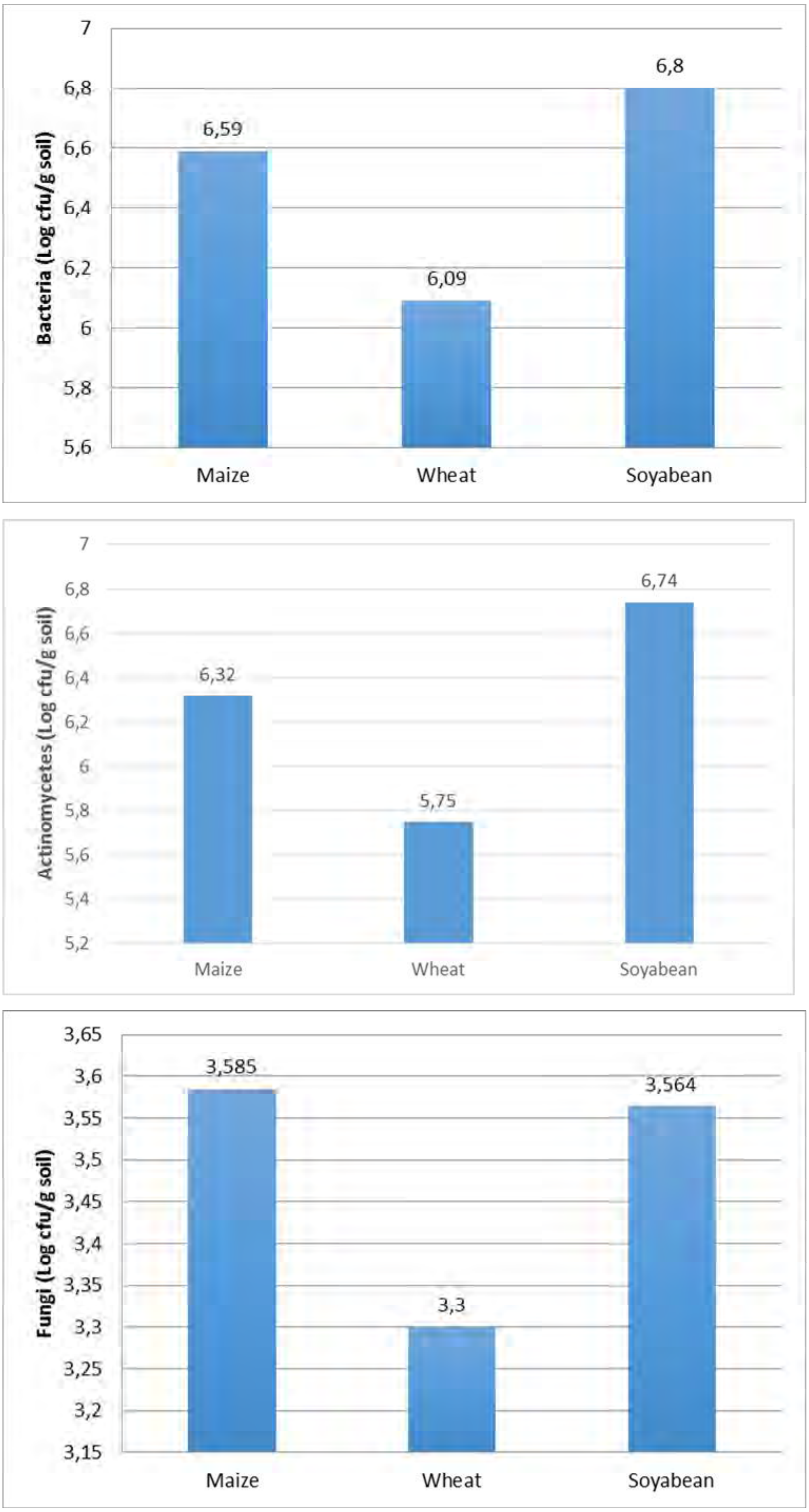


Figure 21: Cropping effects on maize microbial groups.

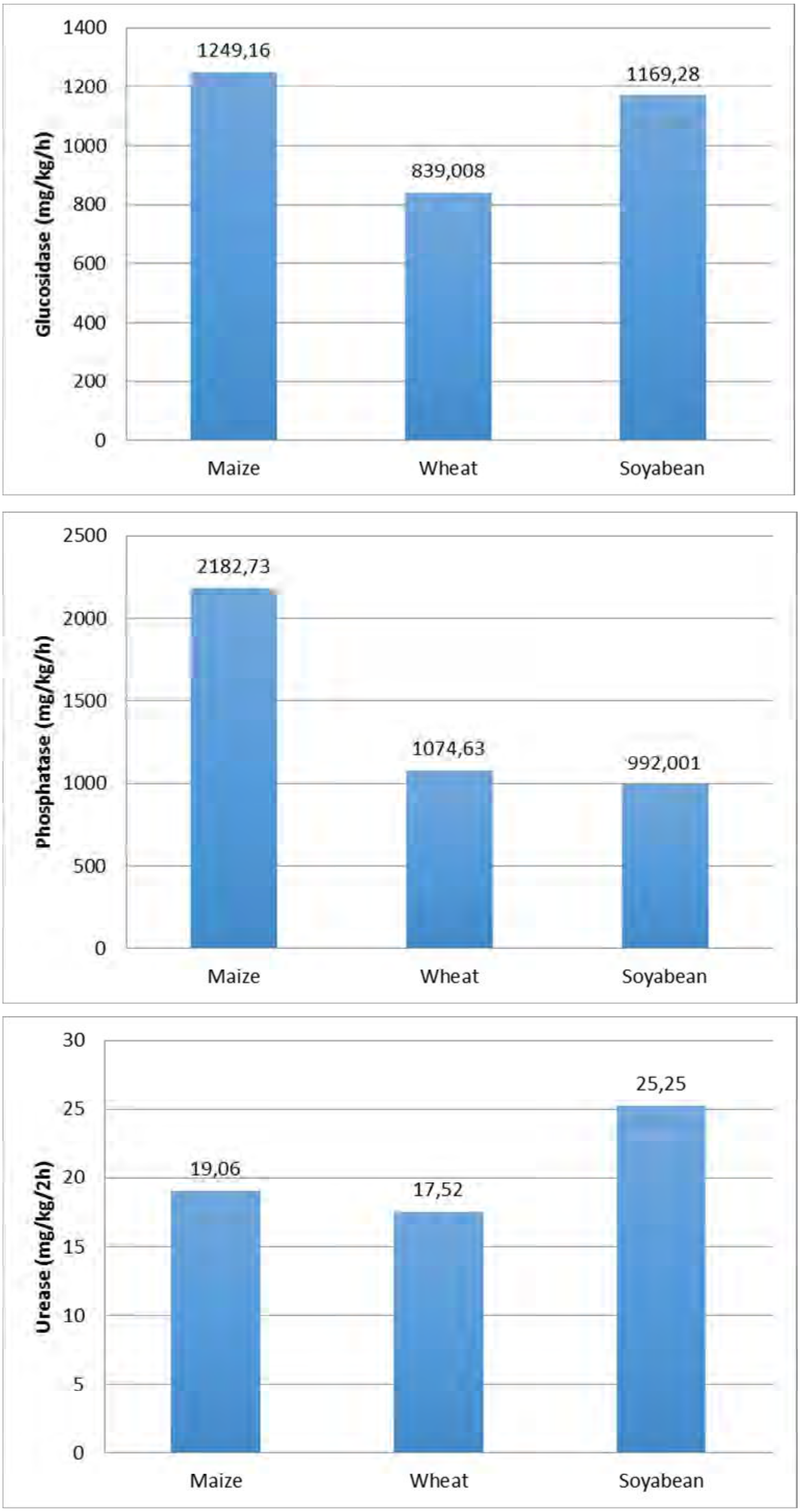


Figure 22: Cropping effects on soil microbial enzyme activity.

4.3.5.3 Conclusion

In the rotation trial the highest microbial activities (counts and enzyme activity) were generally detected in the maize/soybean system, except for urease activity that showed no significant difference among the rotations. This is the first season of the trial and no conclusive findings can be drawn since this data serves as a baseline for further investigations.

4.3.6 Agronomic observations and measurements (Trial 2)

(Dr AA Nel)

4.3.6.1 Maize in rotation with soybean and wheat

As 2016/2017 was the first season of this trial, no agronomic measurements were made apart from the yields of the different crops. Maize yield ranged from 2.89 to 9.68 t ha^{-1} with a mean yield of 7.71 t ha^{-1}. The large yield range is due to 3 plots where the application of fertilizer was most likely limited. Soybean yields ranged from 2.02 to 2.31 t ha^{-1} with a mean yield of 2.21 t ha^{-1}. Both maize and soybean yields were high and it can be assumed that a rotational effect was created which may affect the crops in the 2017/2018 season.

Due to a lack of rain during the period of March-June, the emergence and seedling growth of the wheat was very poor and was regarded as a failure.

4.3.7 Maize/soybean rotation system at Klein Constantia (Trial 3)

(Trial 3 at Klein Constantia-Lourens van der Linde)

Although there were four plots per tillage treatment, only the centre two plots were harvested and combined maize grain yields measured. Due to a lack of replicates, no statistical analysis could be done. For the 2016/17-season, the soybean plots were planted to maize as part of the maize/soybean rotation system. The tillage sequences in Figure 23 depict the tillage operations in 2014/15 and 2016/17 (e.g. ROR/ROR: ROR in 2014/15 and ROR in 2016/17). The trial was not tilled or planted in the 2015/16-season due to the extreme drought conditions.

The 2016/17-season was marked by severe wind damage in December 2016, followed by excessive rain events in January and February, totalling 511 mm (Figure 2). The latter led to water-logged conditions on the trial site. These events were not conducive to good growth and yields. Compared to the trial sites of the other farmer co-workers, relatively low maize grain yields, ranging between 1952 and 4049 kg ha^{-1}, were realized (Figure 23). No clear effects in terms of crop rotation or tillage on maize grain yield could be discerned.

Plate 14: Maize stand (Klein Constantia) on 11 Jan 2017.

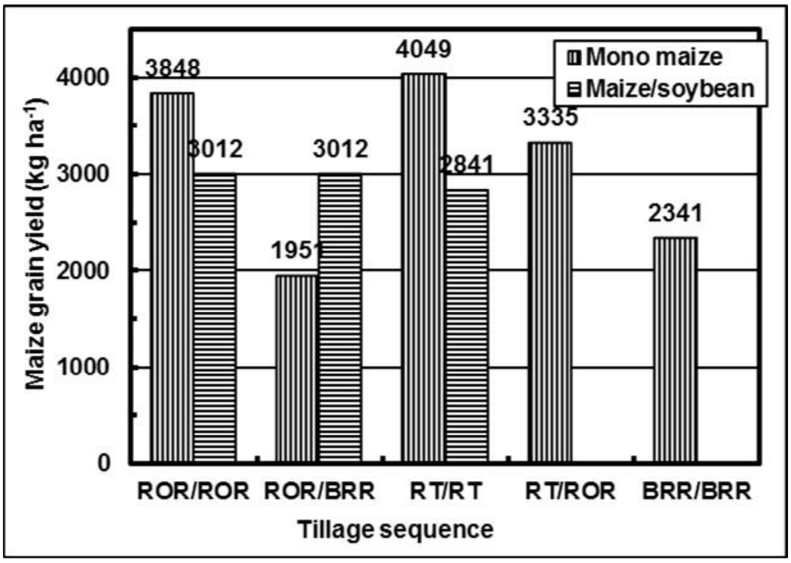


Figure 23: Maize grain yields as a function of rotation and tillage (ROR=Rip-on-row; BRR= Between-row-rip; RT=Reduced tillage).

4.4 Trials 4 and 5: Interactions of plant row width, population density and cultivar as component to the sustainable cultivation of monoculture maize on sandy soils.

(Trial 4 at Doornbult-Thabo van Zyl; Trial 5 at Vlakvlei-Danie Minnaar)

4.4.1 The effect of plant population and row width on yield of maize (Trial 4)

The plant population density as related to the seeding density is shown in Figure 24. The plant population deviates linearly from the seeding density with increasing seeding rates.

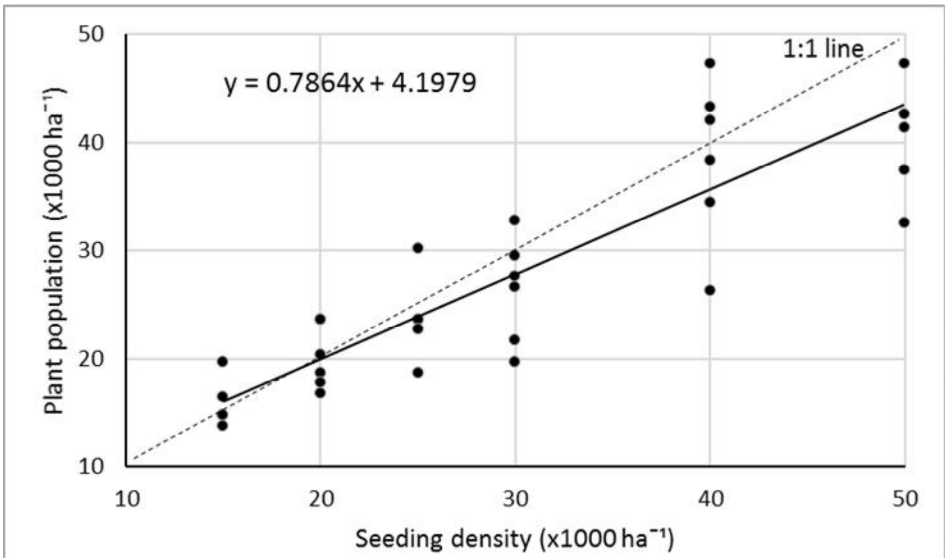


Figure 24: Plant population density as a function of seeding density at Doornbult.

Plant and seeding densities were similar at 20 000 ha^{-1} while the plant density was 11% lower than the seeding density at 40 000 ha^{-1}.

Plant density had no effect on the formation of tillers (Table 13). Row width, however, had a significant effect on tiller formation. Maize plants in 1.524 m rows had 2.5 times the number of tillers than maize plants in the 1.016 m spaced rows. This indicates that intra-row competition between plants had a strong effect on tiller development with higher competition resulting in less tillers.

Plate 15: Viewing the maize stands on the plant density trial on 10 Jan 2017.

Table 13: The effect of plant population density and row width on number of tillers ha^{-1}.

Row width	Plant population density (x 1000 ha-1)						Mean
(m)	16.0	19.9	23.9	27.8	35.7	43.5	
1.016	20	20	17	25	17	11	18
1.524	12	12	9	5	3	5	8
Mean	16	16	13	15	10	8	
Significance		F-ratio	Probability (*p*)				
Row width		24.2	<0.01				
Plant density		1.61	0.21				

Maize grain yield was affected by both plant population density and row width (Table 14). The mean yield of the 1.016 rows was 1.37 t ha^{-1} higher than that of the 1.524 m rows. However, it should be taken into account that the fertiliser application during planting was band-placed 1.016 m apart and that the 1.524 m rows received half of its fertiliser next to the plant row and the other half in-between the rows. This practice most likely played a role in the yield difference between row widths. The results are also graphically displayed in Figure 25 with regression curves fitted to the data.

Table 14: Maize grain yield (t ha^{-1}) as affected by plant population density and row width.

Row width	Plant population density (x 1000 ha-1)						Mean
(m)	16.0	19.9	23.9	27.8	35.7	43.5	
1.016	6.11	6.84	7.44	7.96	7.88	8.55	7.46
1.524	5.15	5.43	6.40	6.16	6.61	6.77	6.09
Mean	5.63	6.14	6.92	7.06	7.25	7.66	
Significance		F-ratio	Probability (p)		LSD		
Row width		205.7	<0.01		0.20		
Plant density		41.0	<0.01		0.35		

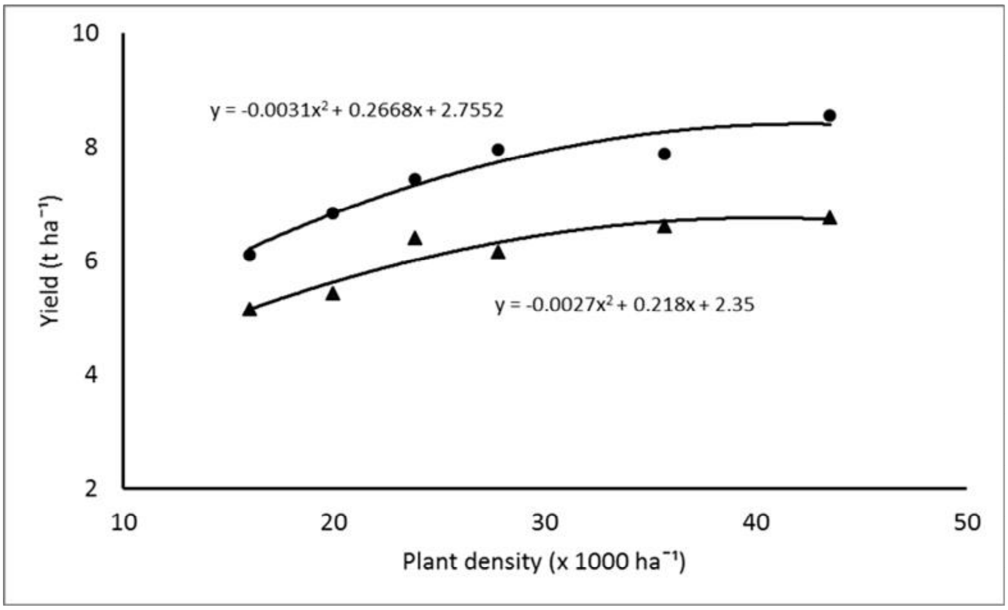


Figure 25: Grain yield as related to plant population density. The upper curve represents the 1.016 m and the lower curve the 1.524 m row spacing.

The two relationships are both curvi-linear and thus suitable for calculation of optimum planting densities. Assuming a seed price of R3 260 per 60 000 seeds and a grain price of R1 650 t^{-1}, the optimum plant densities are 37 800 and 34 300 ha^{-1} for the 1.016 and 1.524 row spacings, respectively.

Mean yield per plant as related to plant population and row width is shown in Figure 26. As in the case of yield ha^{-1}, two distinct curvi-linear relationships were found. It is surprising that these relationships are not linear as expected. Its curvi-linearity indicates that this cultivar displays tolerance to stress caused by increasing plant densities.

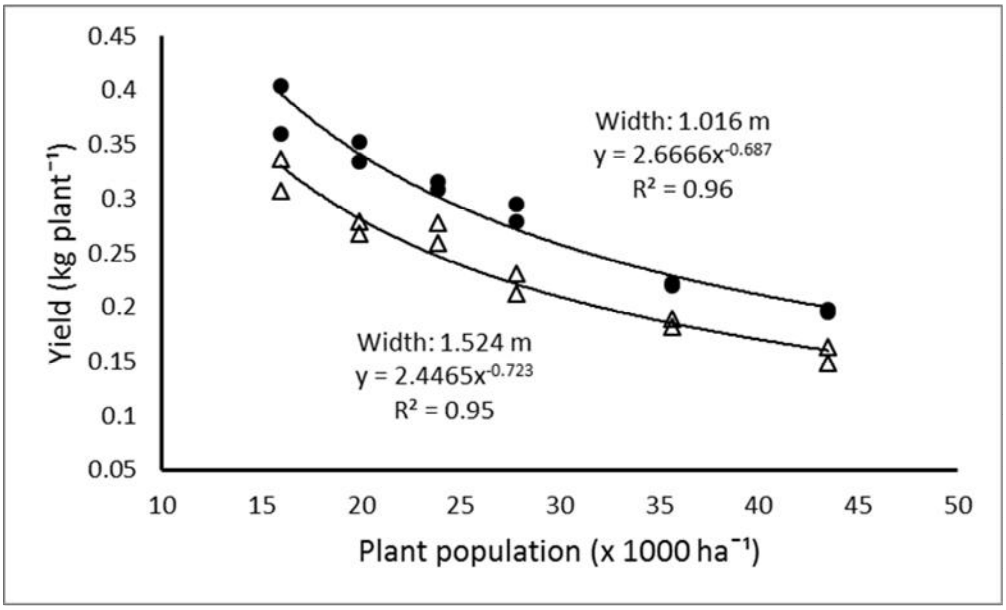


Figure 26: Yield per plant as related to plant population density at Doornbult.

4.4.2 The effect of plant population and cultivar on the yield of maize (Trial 5)

As in Trial 4 (Doornbult), the plant population density for Trial 5 (Vlakvlei) deviated from the seeding density in a linear way (Figure 27). Seeding and plant densities were similar at 12 000 per ha^{-1} while the plant density was 6% lower than the seeding density at 26 000 ha^{-1}.

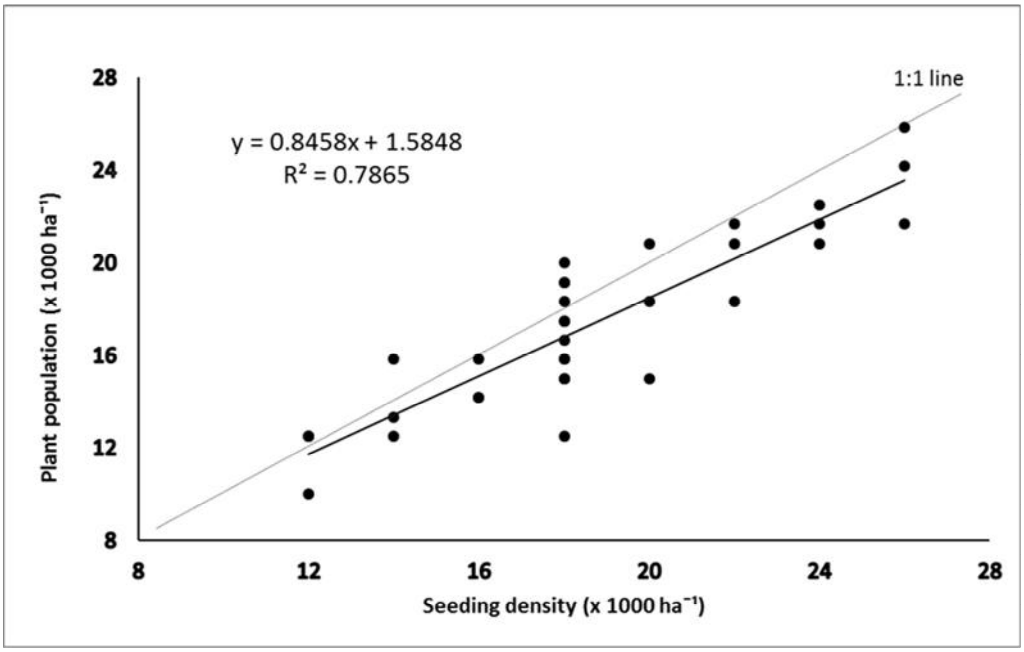


Figure 27: Plant population density as a function of seeding density at Vlakvlei.

Similar to the results at Doornbult, the number of tillers that developed had no significant relationship with plant population density. The number of tillers varied from 18 000 to 49 000 ha^{-1} with an overall mean 33 000 ha^{-1}.

Plate 16: Viewing the maize stand on the plant density trial at Vlakvlei on 10 Jan 2017.

The grain yield of each cultivar showed a distinct relationship with plant population density (Figure 28). At a density of 12 000 plant ha^{-1}, the yield difference between the two cultivars was 0.86 t ha^{-1}, while at 23 000 plants ha^{-1} the difference was only 0.35 t ha^{-1}. As the two relationships are not curvilinear, no optimum plant population densities could be derived. It is, however, obvious that the optimum density is higher than 23 000 plants ha^{-1}.

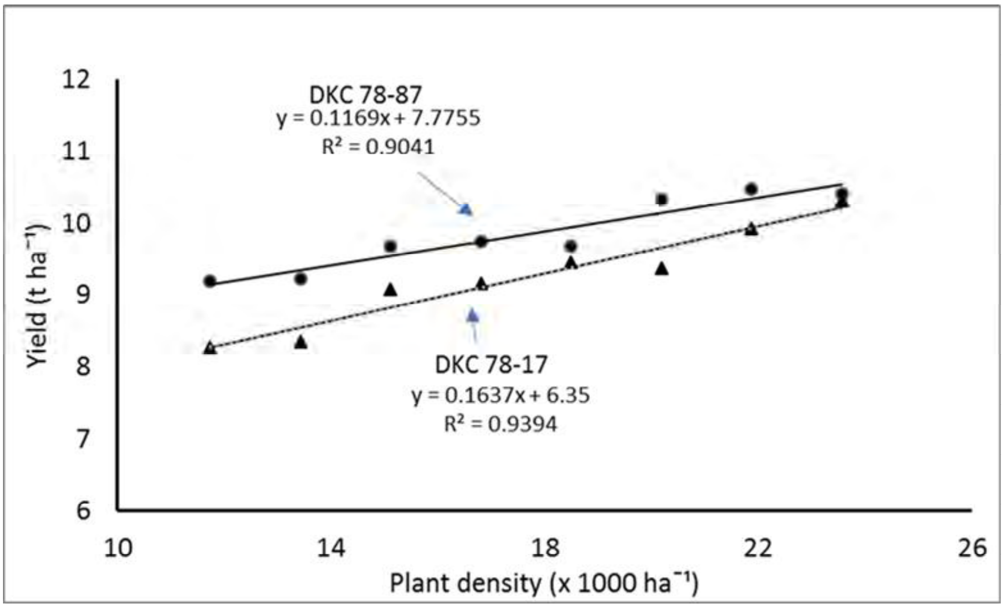


Figure 28: Grain yield of DKC 78-87 and DKC 78-17 as related to plant population density.

Tiller and main stem grain yields showed a linear but negative relationship (Figure 29). The maize grain yield of tillers declined as the yield of the main stem increased. This indicates that tillers do not have a significant contributing advantage to the grain yield ha^{-1}. Yield gained by tillers was simply lost from main stems.

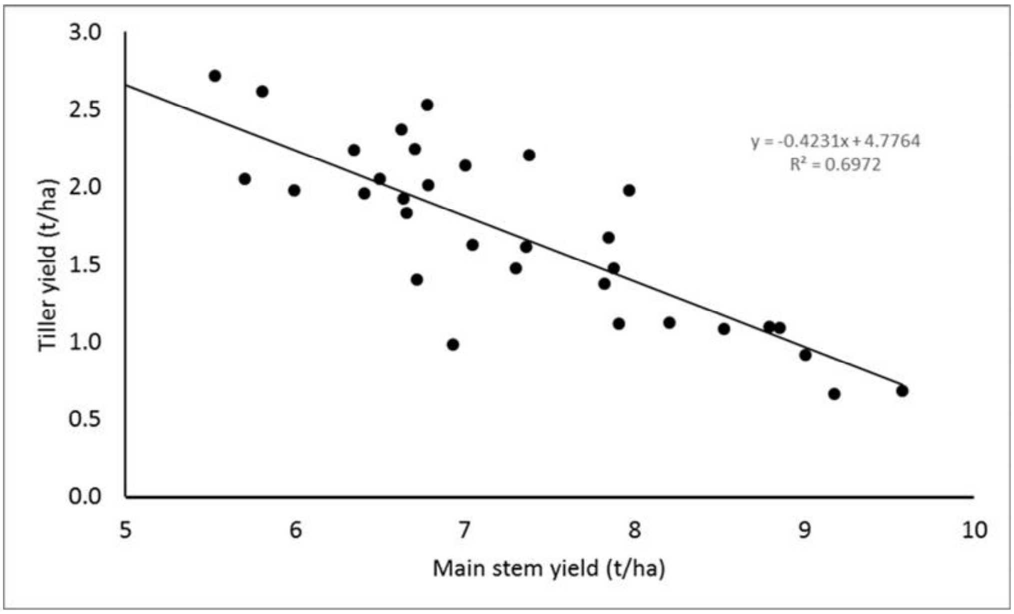


Figure 29: Tiller yield as related to main stem yield for DKC 78-87 and DKC 78-17.

Grain yield per plant, for both cultivars, had a curvilinear relation to plant population density (Figure 30). These two cultivars displayed tolerance to stress caused by increasing plant densities which is similar to what was found for the cultivar used at Doornbult.

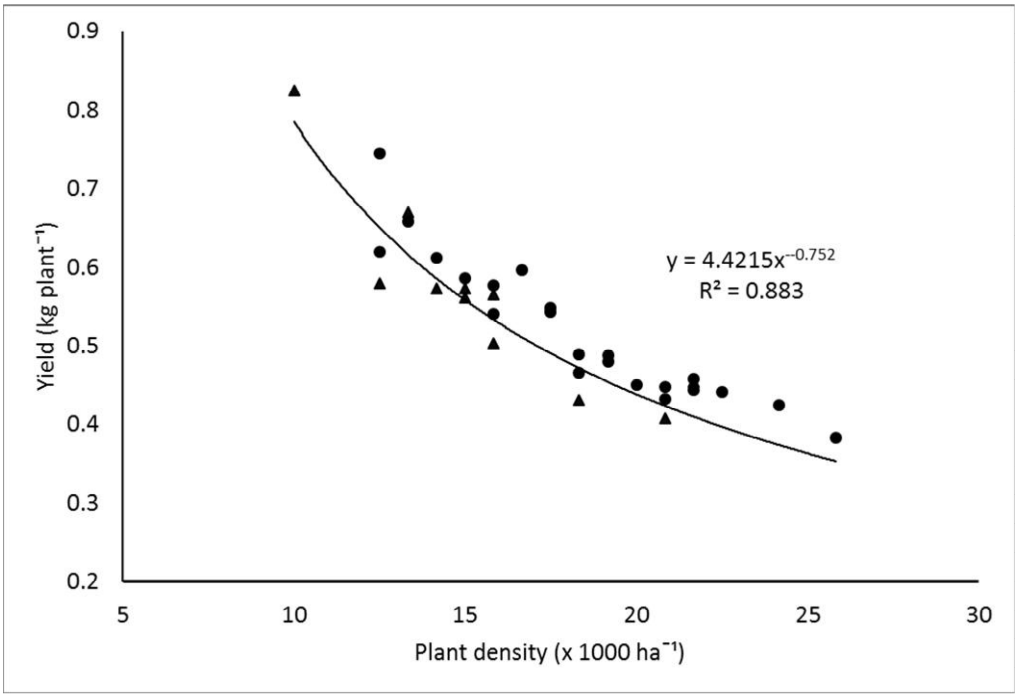


Figure 30: Yield per plant as related to plant population density for DKC 78-87 and DKC 78-17.

Analysis of variance was also performed (XLSTAT, Version 2011) on the harvester maize grain yields of cultivar DKC 78-87 to test for the Fisher variance ratio (F) at 1 and 5% levels of significance, as well as the least significant difference (LSD) for Student t values at 5% level of significance between plant population density combinations. According to the LSD ($p \leq 0.05$)=623. 6 kg ha^{-1} in Figure 31, there were no statistical differences in maize grain yield within the density ranges 12K-20K and 22K-26K, respectively, while yields for 22K-26K density grouping were statistically different from the 22K-26K density grouping.

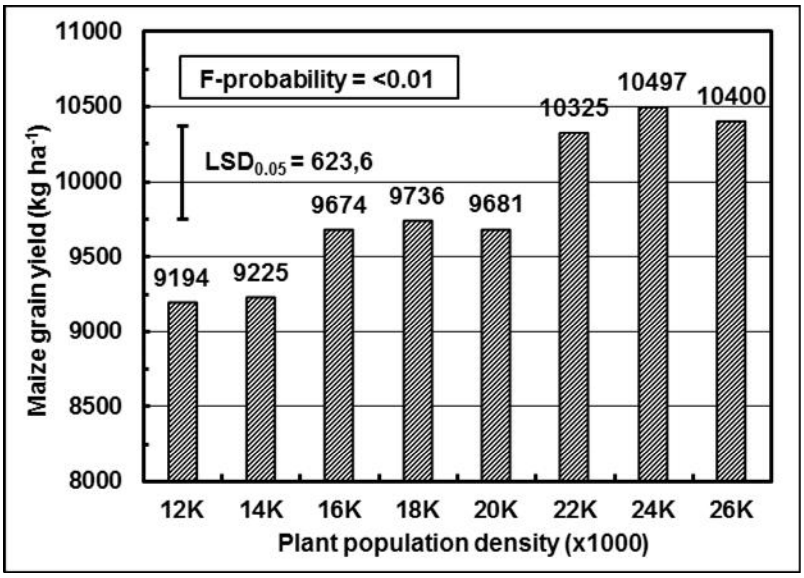


Figure 31: Grain yield of DKC 78-87 as related to plant population density.

4.5 Trial 6: The optimum depth of ripping for the sustainable cultivation of monoculture maize on sandy soils.

(Doornbult-Thabo van Zyl)

Diesel consumption increased curvi-linearly with increasing ripping depths (Figure 32). Increasing the ripping depth from 45 to 60 cm, increased diesel consumption by 2.13 L ha^{-1}, while increasing the ripping depth from 75 to 90 cm, led to an increased consumption of 7.26 L ha^{-1}.

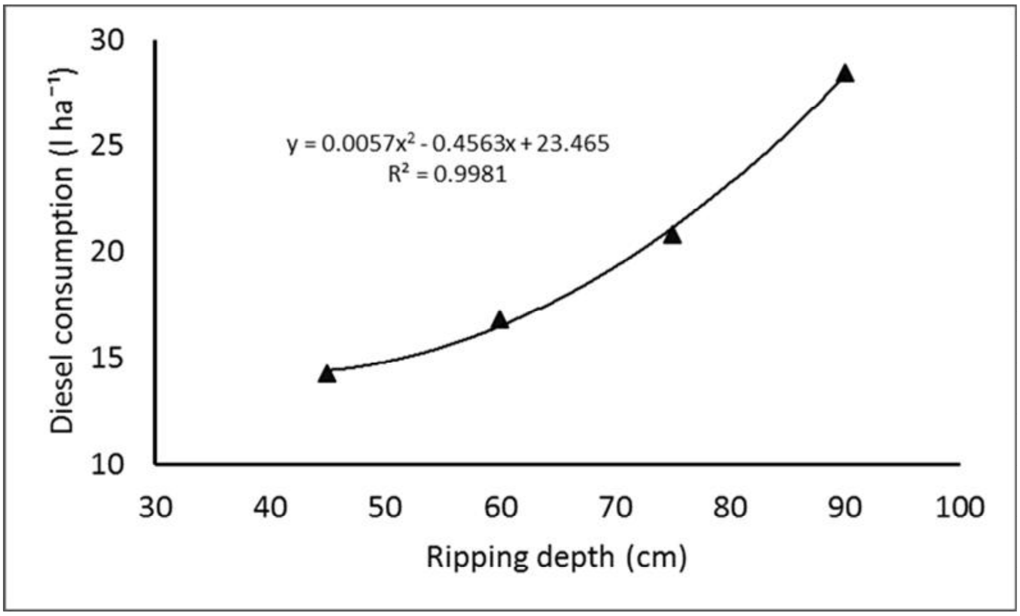


Figure 32: Diesel consumption as related to ripping depth at Doornbult.

Ripping depth had no significant effect on plant height (F-probability = 0.24; data not included). The height varied from 0.9 to 1.79 m with an overall mean of 1.425.

Ripping depth had a highly significant effect on grain yield (Table 15). The results are also graphically displayed in Figure 33.

Table 15: Maize yield (t ha^{-1}) as affected by ripping depth at Doornbult.

	Ripping depth (cm)				F-ratio	Probability	LSD
	45	60	75	90			
Yield	4.27	5.66	6.87	7.00	160	<0.01	1.00

Grain yield increased linearly with ripping depths from 45 to 75 cm at a rate of 0.87 t ha^{-1} per 10 cm increase in depth. Increasing the depth from 75 to 90 cm resulted in no significant increase in yield. Accordingly, there is no advantage to rip deeper than 75 cm.

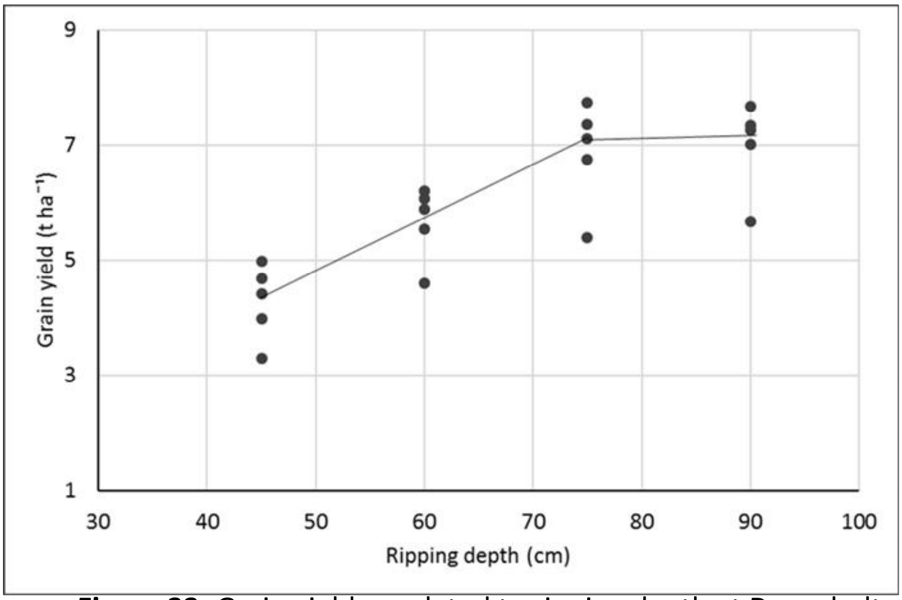


Figure 33: Grain yield as related to ripping depth at Doornbult.

4.6 Enterprise financial analyses

4.6.1 Maize/soybean rotation system at Klein Constantia (Trial 3)
(Klein Constantia-Lourens van der Linde)

For the monoculture maize a better margin (R1249 ha^{-1}) was realized where rip-on-row (ROR) tillage was done in 2014/15, followed by fallow in 2015/16, followed by ROR tillage in 2016/17, compared to a margin of R988 ha^{-1} under reduced tillage(RT) in 2014/15, followed by fallow in 2015/16, followed by RT tillage in 2016/17 (Appendix 1).

4.6.2 The effect of plant population and row width on yield of maize (Trial 4)
(Doornbult – Thabo van Zyl)

For this very good rainfall season, the best margins were realized with narrow rows (1.106 m) at high population densities, compared to wider (1.524 m) rows. For example, R5082 ha^{-1} and R5153 ha^{-1} were realized with narrow rows at a high population densities of 30000 and 50000 plants ha^{-1}, respectively. With wider rows (1.524 m), the highest margin (R3001 ha^{-1}) was obtained at a population density of 25000 plants ha^{-1}, compared to R1703 and R2356 ha^{-1} for 20000 and 50000 plants ha^{-1} stands, respectively (Appendix 2).

4.6.3 The effect of plant population and cultivar on the yield of maize (Trial 5)
(Vlakvlei - Danie Minnaar)

Cultivar 78-87Bt: For replicate 1 a plant population density of 24000 plants ha-1 gave a slightly higher (R12246 ha^{-1}) margin than 26000 plants ha^{-1} (R12187 ha^{-1}). Although the 26000 plants ha^{-1} stand gave a higher (20 kg ha^{-1}) yield, with the present low maize price it will not compensate for the additional seed cost. It will be necessary to get a farm gate price of R59 t^{-1} more (R1759 t^{-1}) for a 26000 stand ha^{-1} to break even with the 24000 stand ha^{-1} (Appendix 3).

Cultivar 78-87Bt: For replicate 2 a plant population density of 22000 plants ha^{-1} yielded a slightly better (R11561 ha^{-1}) margin than 24000 plants ha^{-1} (R11400 ha^{-1}). The 22000 plants ha^{-1} stand yielded 40 kg ha^{-1} more than the 24000 plants ha^{-1} stand equating to R161 ha^{-1} more for the former stand (Appendix 3).

Against the background of the present low farm gate price for maize, it would appear as if the economic optimum stand for cultivar 78-87Bt is 22000-24000 plants ha^{-1}.

Cultivar 78-17Bt: A plant population density of 26000 plants ha^{-1} yielded a higher (R11443 ha^{-1}) margin than 24000 plants ha^{-1} (R10891 ha^{-1}). The 26000 plants ha^{-1} stand yielded 380 kg ha^{-1} more than the 24000 plants ha^{-1} stand equating to R552 ha^{-1} more for the former stand (Appendix 3).

Comparing the margins of the two cultivars, it can be seen that cultivar 78-87Bt (replicate 1) with a stand of 24000 plants ha-1 yielded R803 ha^{-1} more than a 26000 plants ha^{-1} stand of cultivar 78-17Bt.

4.6.4 The optimum depth of ripping for the sustainable cultivation of monoculture maize on sandy soils (Trial 6)
(Doornbult – Thabo van Zyl)

The 900 mm deep ripping yielded a slightly higher margin (R3966-R3890 = R76 ha^{-1}) than the 750 mm ripping. However, the additional capital cost (not included in the present analysis) will eliminate this financial advantage. It can be concluded that a 900 mm deep ripping would not have a financial gain over the current farm practice of ripping to 750 mm depth. Furthermore, when evaluating the economic analyses of all ripping depths, it can be concluded that ripping shallower than 750 mm will not be economically viable (Appendix 4).

4.7 Soil water content measurements with capacitance probes

Reporting by Petrus van Staden, Senwes

4.7.1 Local CA, ROR tillage, stubble-mulch, cash crop rotations with maize/wheat/soybean and maize/maize/wheat (Trial 2)

(Christinasrus – Thabo van Zyl)

No results are available due to software and data issues.

Plate 17: Capacitance probe installation in soybean stand at Christinasrus (1 Feb 2017).

4.7.2 The effect of plant population and row width on yield of maize (Trial 4)

(Doornbult – Thabo van Zyl)

The changes in soil water content are presented in Figures 34 to 38. The 2016-17-season was characterised by good rainfall during February. In the water table sandy soils of the Wesselsbron area, this led to waterlogging in several crop lands. In Figures 34 to 38 the water content of at least the 100 – 120 cm layer indicates the presence of a water table.

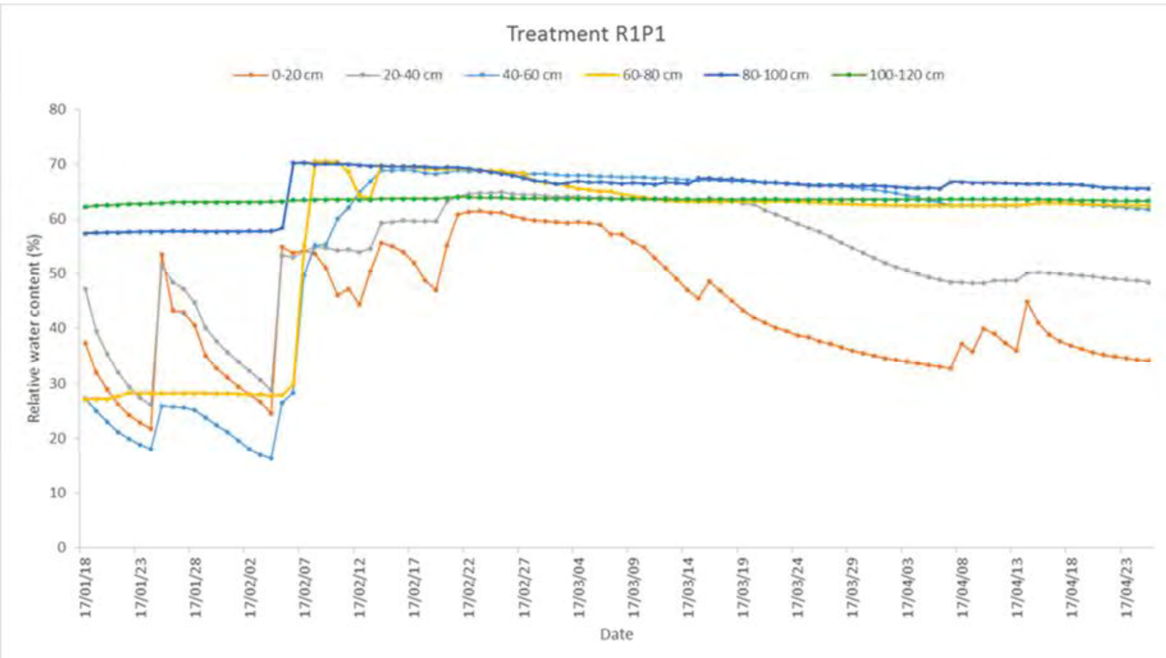


Figure 34: Change in soil water content in the R1 (1.016 m) P1 (15 000 plants ha^{-1}) plot.

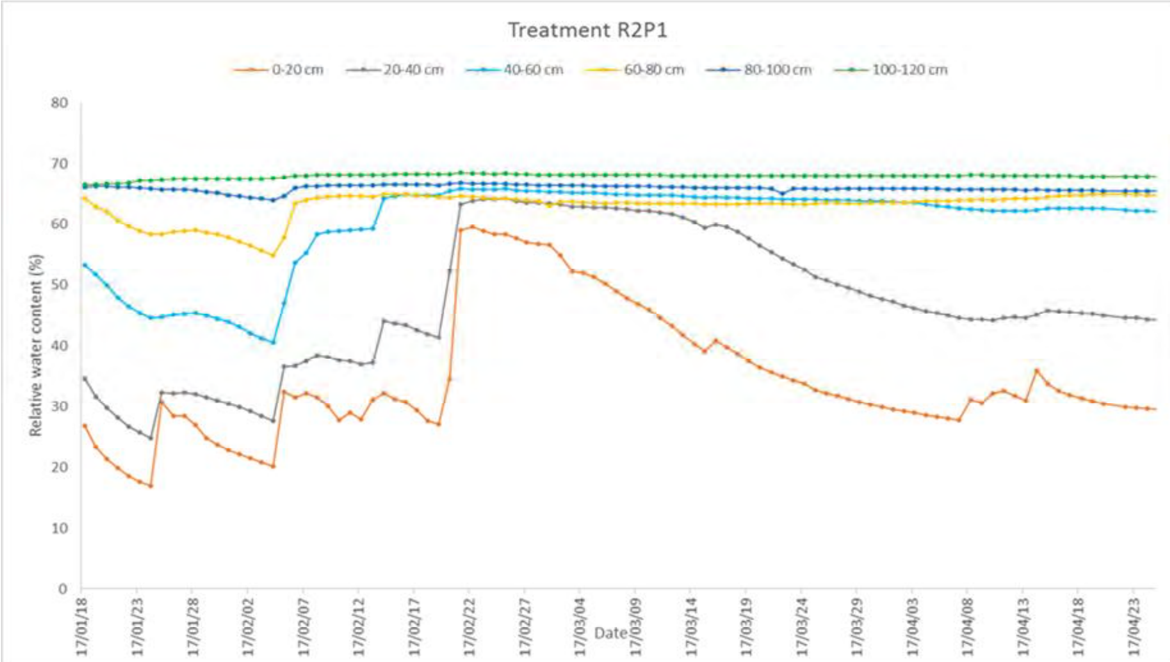


Figure 35: Change in soil water content in the R2 (1.524 m) P1 (15 000 plants ha^{-1}) plot.

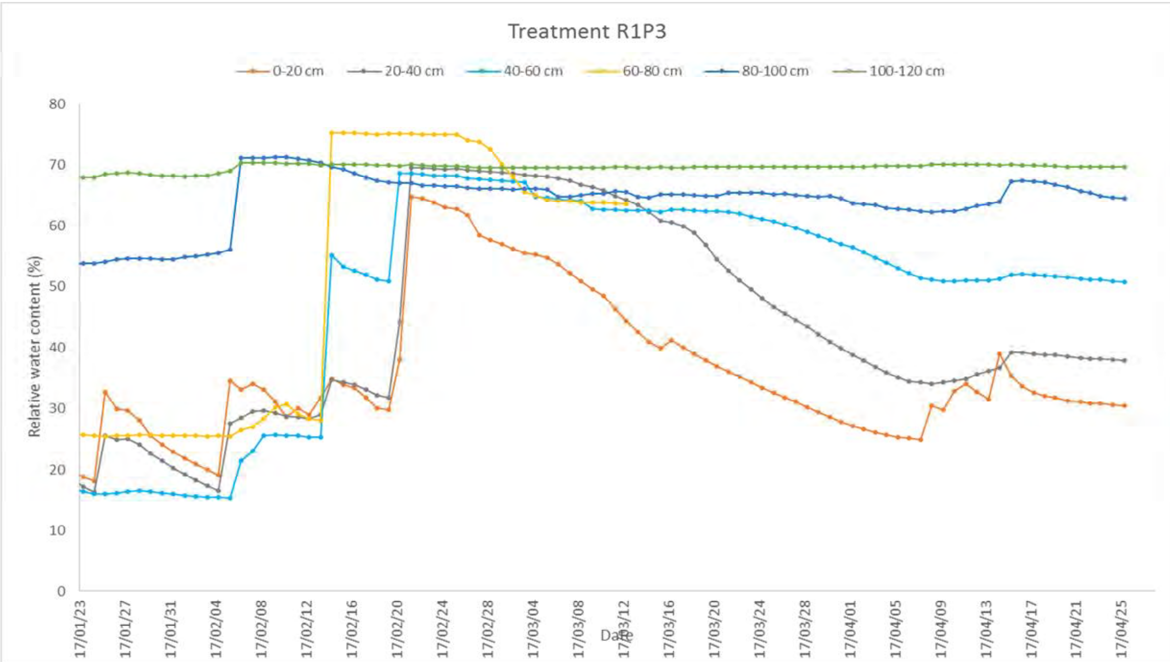


Figure 36: Change in soil water content in the R1 (1.016 m) P3 (25 000 plants ha^{-1}) plot.

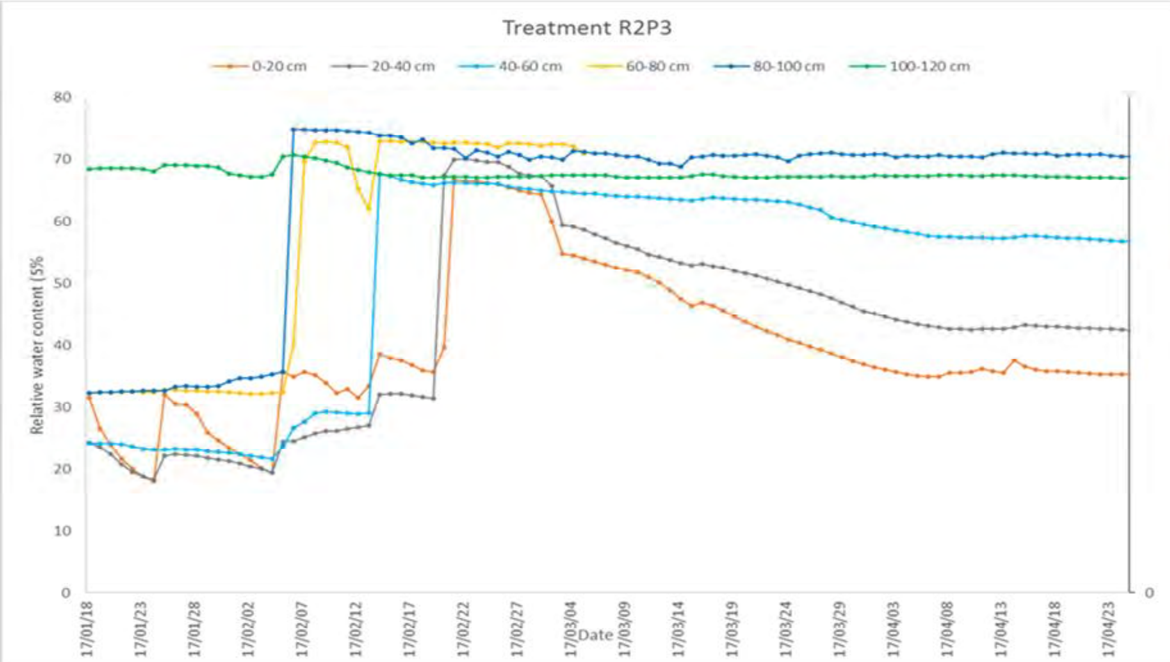


Figure 37: Changes in soil water content in the R2 (1.524 m) P3 (25 000 plants ha^{-1}) plot.

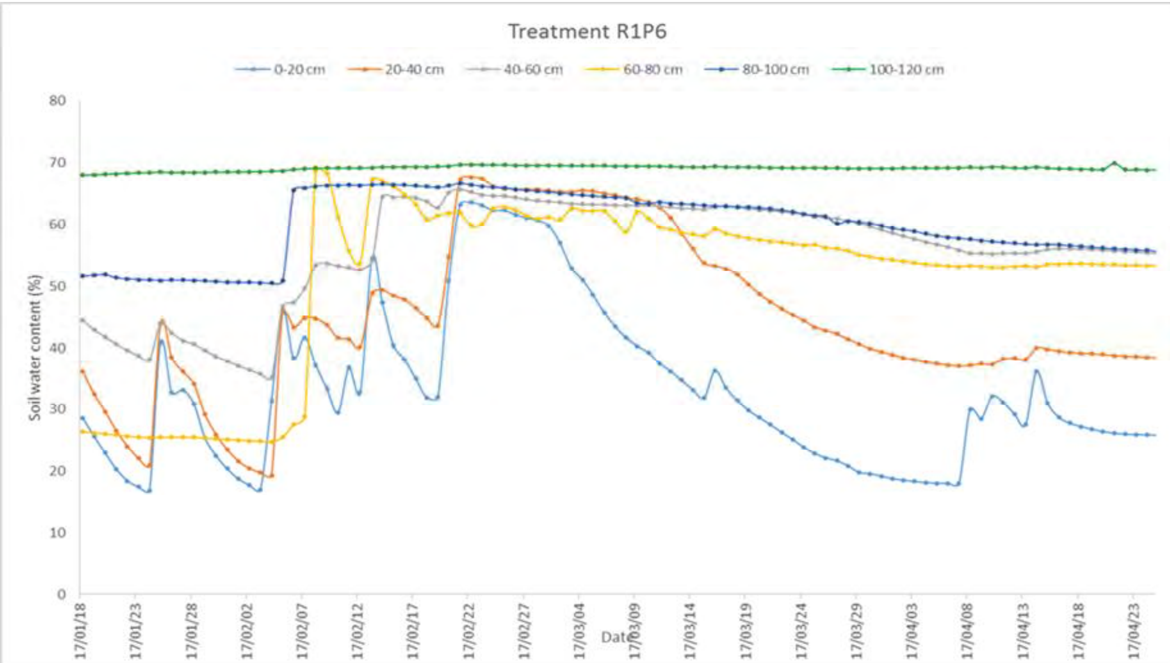


Figure 38: Changes in soil water content in the R1 (1.016 m) P6 (50 000 plants ha^{-1}) plot.

4.7.2.1 Conclusions on: The effect of plant population and row width on yield of maize (Trial 4) (Doornbult – Thabo van Zyl)

- The row-width vs. plant population trial clearly indicated that soil water extraction with 15 000 plant population ha^{-1} was only observed in the top two soil layers. The other four layers indicated very small to no change. No effect of row-width on soil water extraction could be measured.
- When the plant population was increased to 25 000 ha^{-1}, soil water extraction from three soil layers by the maize was definitely observed. From the other three layers, the sensor in the 60-80 cm layer of both row-width plots produced data with very high variance. The next two layers indicated very low soil water extraction.

- The 50 000 plant population plot indicated soil water extraction from five layers.

Plate 18: Probe and weather station installation at Doornbult (1 Feb 2017).

4.7.3 The optimum depth of ripping for the sustainable cultivation of monoculture maize on sandy soils (Trial 6)

(Doornbult – Thabo van Zyl)

The changes in soil water content as a function of ripping are presented in Figures 39 and 40.

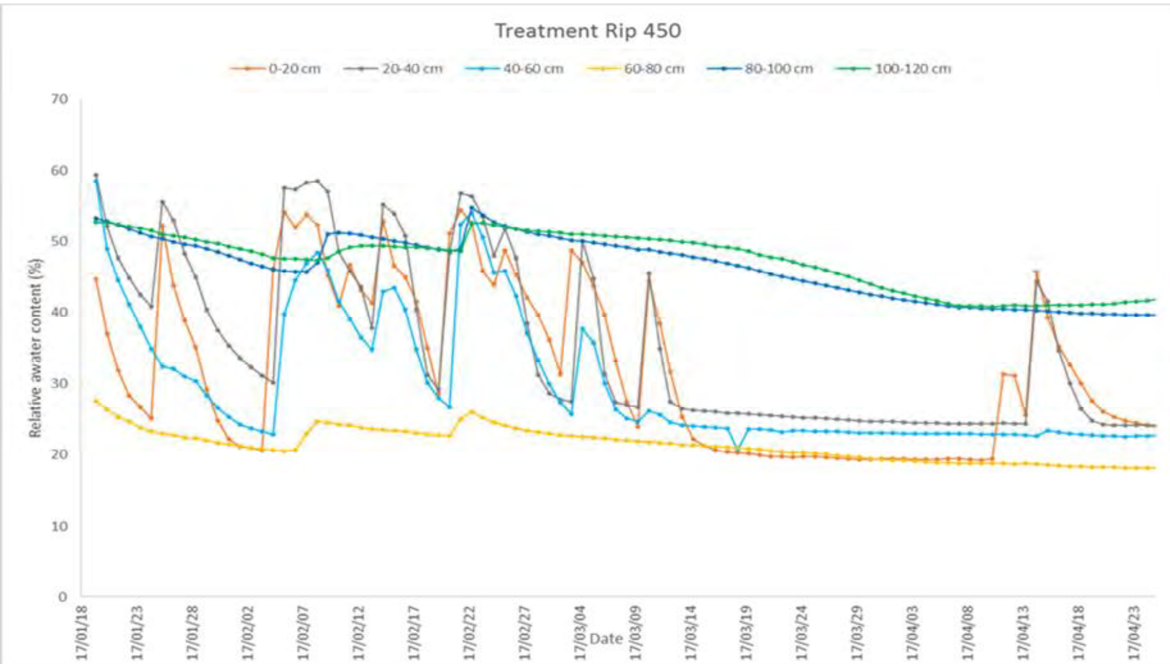


Figure 39: Change in soil water content in the 450 mm rip plot.

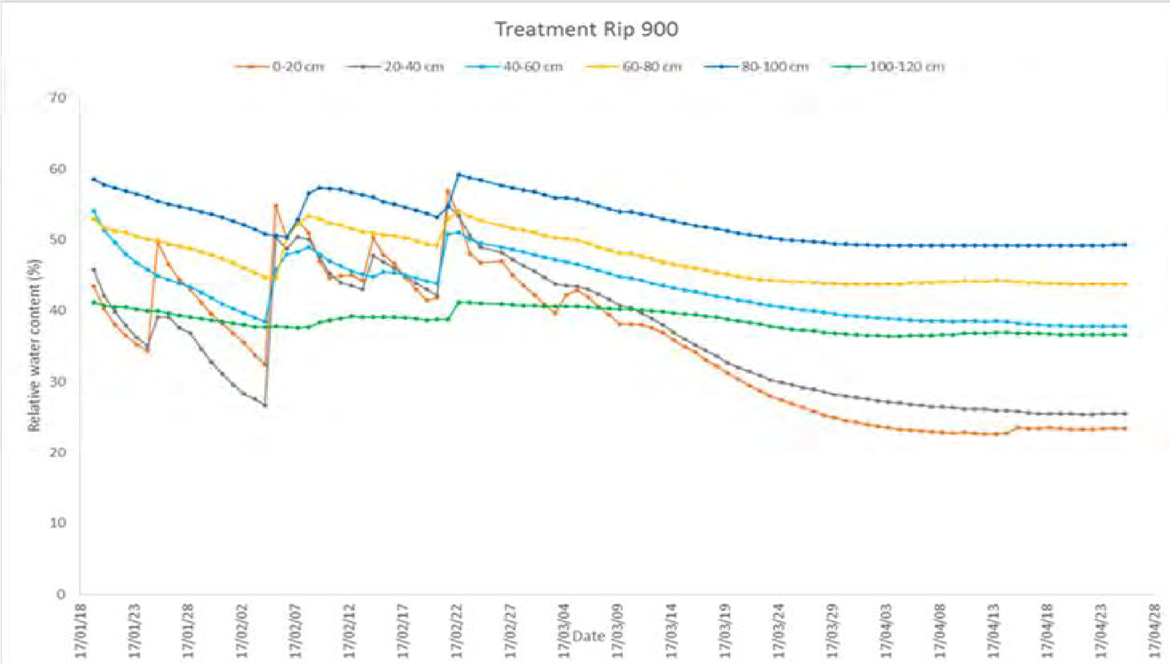


Figure 40: Change in the soil water content of the 900 mm rip plot.

4.7.3.1 Conclusions on: The optimum depth of ripping for the sustainable cultivation of monoculture maize on sandy soils (Trial 6).
(Doornbult – Thabo van Zyl)

- Ripping to 450 mm resulted in soil water extraction in the top three soil layers. In the 60 to 120 cm layers the changes in water content were very small compared to the 0 to 60 cm layers.
- Ripping to 900 mm resulted in water extraction to 1000 mm (100 cm) depth.

4.7.4 Recommendations

- The project was successful and needs to be replicated as per project plan in order to confirm results.
- Soil bulk density needs to be measured. During installation it was observed that due to ripping the soil was very unstable in the 40 to 80 cm layer. This could be seen in the data. This can possibly have an effect on root development.

5 ANY PROBLEMS THAT HAVE BEEN ENCOUNTERED WITH THE PROJECT

5.1 Cover crop trial at Deelpan

Although noted problems can be regarded as minor, they can have serious effects on these sandy soils, such as compaction, and therefore should be mentioned:

- Lack of experience using heavy equipment on sandy soils.
- Equipment that can compact soils (see Plate 19) was used to get the seed into the soil.
- Because of the unavailability of a small seed planter, a fertilizer spreader was used for planting – the latter could not be calibrated. This meant that the seeding rate was almost doubled for the small area.
- Documents that ARC need to register SOK on their financial system do not seem to exist. Payment for the services of Mr G Trytsman has therefore lagged far behind.

Plate 19: Implement used to get seed covered with soil.

6 MILESTONES THAT HAVE NOT BEEN ACHIEVED AND REASONS FOR THAT

The Finance Section of ARC-Animal Production Institute has still not received the required registration document. This must be completed and signed by the Finance Section before any claims from Mr G Trytsman will be paid.

7 AN ASSESSMENT OF THE ADEQUACY OF FUNDING TO COMPLETE THE EXECUTION OF THE PROJECT

Bank statements for period 2016-12-01 to 2017-09-23 are included in Appendices 5 to 11. On 2016-12-15 an amount of R488 932.80, comprising 60% of the approved amount for 2017/18, together with the remaining balance of the funding for 2016/17, following the approval of the final report dated 30 September 2016, was paid into the designated bank account of the Sandy Soils Development Committee. Following the approval of the March 2017 progress report, an amount of R135 743.80 was paid into the designated bank account. The balance on 2017-09-23 was R795 029-79.

It should be noted that on 2017-09-23 there were several claims to be submitted. These claims are outstanding due to administrative and logistical reasons. They will be submitted during October 2017.

8 THE ESTIMATED DURATION OF THE PROJECT UNTIL COMPLETION

Five (5) years. The evaluation of regenerative and locally adapted CA systems, with the emphasis on promoting CA principles and soil health to contribute to sustainable maize production systems on semi-arid sandy soils with water tables, need to be investigated over a number of years for various reasons. To name three:

- The beneficial effects of CA on certain soil properties, like soil microbiology and soil organic C, will only be manifested after three to five years, but might take longer on these semi-arid sandy soils.
- Soil compaction is a recurring phenomenon, even under deep ripping (e.g. ROR). The search must go on comparing mechanical or biological tillage practices that economically alleviates soil compaction over the long term.
- The effects of CA and soil health on nematode infestation and the occurrence of crown and root rot will only be manifested after three to five years.

A report back meeting, attended by all role players, on the 2016/17-season was held on 11 September 2017. A planning meeting was held on 20 September 2017 to discuss the anticipated project activities for the 2017/18-season. An application for financial assistance for the continuation of the present project in 2017/18 will be submitted to the Maize Trust on 30 September 2017.

9 MANNER IN WHICH RESULTS WILL BE PUBLISHED

9.1 Farmers Day at Doornbult

A Farmers Day was held on 29 March 2017 on the farm, Doornbult, of Thabo van Zyl to view and discuss the role of crop rotation, depth of tillage, row width and planting density in sustainable crop production on sandy soils (See Appendix 12: Programme). The Day was attended by 24 farmers, input supply personnel, persons from organized agriculture and research personnel. The field trials on Doornbult were visited to view, *inter alia*, root development as a function of depth of ripping (Plate 20). Several topics were presented at the Losdorings Study Group Hall, prompting lively interaction and discussion by the delegates (Plate 21). The Day was concluded with a pleasant lunch.

Plate 20: Viewing root development as function of depth of ripping.

Plate 21: Attending the Farmers Day presentations at Losdorings Hall.

9.2 Printed media and farmers days

It is foreseen that project results will be made available through articles in agricultural periodicals (e.g. Landbouweekblad, Farmers Weekly), publication in SA Grain Journal, oral presentations at farmers days and farmer study groups.

The present project follows and builds on a completed project funded by the Maize Trust. In the latter project a base was laid for the present project by testing the effects of tillage and crop rotation on soil chemical, physical and biological properties to contribute to sustainable maize production on the sandy soils with water tables in the north western Free State. Four articles from the previous project were accepted for publication in the SA Grain journal. Two articles already appeared in the August 2017 edition.

10 REFERENCES

Allison LE, 1965. Organic Carbon. In*:* CA Black (ed). *Methods of Soil Analysis. Part 2. Chemical and Microbiological Methods. Agronomy Series No.9*, Madison, Wisconsin, USA. pp 1367-1378.

Bennie ATP, Botha FJP, Ferreira AF. 1982. Die effek van verskillende metodes van diepbewerking op mieliegroei. *Crop Production* 11: 74-78.

Bennie ATP, Burger RDuT. 1988. Penetration resistance of fine sandy apedal soils as affected by relative bulk density, water content and texture. *South African Journal of Plant and Soil* 5: 5-10.

Bennie ATP, Hoffman JE, Coetzee JM. 1995. Sustainable crop production on aeolian sandy semi-arid soils in South Africa. African Crop Science Journal 3 (1): 67-72.

Bennie ATP, Hensley. 2001. Maximizing precipitation utilization in dryland agriculture in South Africa – a review. Journal of Hydrology 241: 124-139.

Beukes DJ, Craven M, Rhode OHJ, Trytsman G. 2016. Implementation of cultivation practices for the improvement of the physical, biological and chemical soil conditions necessary for sustainable dry land maize production systems on sandy soils. *Final Progress Report for the period: 1 Jan-30 Sept2016 of project funded by the Maize Trust.* pp 95.

Blake GR, Hartge KH. 1986. Bulk Density. In: A Klute (ed). *Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods.* Second Edition, Agronomy Series No.9, Madison, Wisconsin, USA. pp 363-375.

CAVENESS FE, JENSEN HE. 1955. Modification of the centrifugal-flotation technique for the isolation and concentration of nematodes and their eggs in soil. *Proceedings of the Helminthological Society of Washington* 22:87-89.

COBB NA. 1918. Estimating the mean population of the soil. *Agric. Tech. Circ. Bur. Pl. Ind. US. Dep. Agric. No1*. 48pp.

Danielson RE, Sutherland PL. 1986. Porosity. In A Klute (ed*). Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods.* Second Edition, Agronomy Series No.9, Madison, Wisconsin, USA. pp441-461.

DE WAELE E, DE WAELE D, WILKEN R. 1987. Effect of root mass on the efficacy of methods for extracting root-lesion nematodes from maize roots. *Phytophylactica* 19:473-474.

FSSA. 2007. Fertilizer Handbook. The Fertilizer Society of South Africa. Sixth revised edition. Pretoria, South Africa. 298pp.

Genstat for Windows. 2009. 12th Edition. VSN International, Hemel Hempstead, UK.

Gomez KA, Gomez AA. 1984. Regression and correlation analysis. In: Gomez KA Gomez AA (eds). *Statistical Procedures for Agricultural Research*. Second Edition, John Wiley & Sons, New York, USA. pp 357-423.

Hanks RJ, Ashcroft GL. 1980. Soil Heat Flow and Temperature. In: Hanks RJ, Ashcroft (eds). *Applied Soil Physics*. Springer-Verlag, New York, USA. pp125-144.

Harmse HJ Von M. 1963. The sedimentary petrology of the aeolian sands in the North-Western Orange Free State. MSc Verhandeling, Potchefstroom Universiteit vir Christelike Hoër Onderwys, Potchefstroom.

Henning JAG, Stoffberg DJ. 1990. Effek van bewerking op opbrengs en wortelontwikkeling van mielies in 'n Bleeksandserie met 'n watervlak. *Applied Plant Science* 4(1): 17-20.

Henning JAG. 1991. Die invloed van variërende vrywatervlakke in grond van die noordwestelike OVS op verbouing van gewasse (veral mielies). PhD Proefskrif, Potchefstroomse Universiteit vir Christelike Hoër Onderwys, Potchefstroom. 125pp.

Koch CD. 1974. Die invloed van sekere bewerkingsmetodes en bemestingplasing op die mielieopbrengs op Viljoenskroon en Bleeksandgrondseries. *Crop Production* 3: 57-59.

Koch CD, Badenhorst JH. 1977. Grondbewerkingspraktyke by mielieverbouing. *Mielies F. 1.1.* Pretoria: Departement van Landboutegniese Dienste.

Liebenberg AJ. 2012. Sojaboon Produksiehandleiding. LNR-Instituuut vir Granngewasse, Potchefstroom. 159pp.

Loubser HL, Nel AA. 2004. Productivity and stability of grain yield in maize and sorghum as affected by rotational cropping systems in the north western Free State. *S. Afr. Tydskr. Plant Grond* 21(2): 80-84.

Mallet JB, Koch CD, Visser PA, Botha AJ. 1985. Tillage-related soil compaction and its effect upon maize grain yields on a Viljoenskroon fine sand. *South African Journal of Plant and Soil* 2(1): 52-56.

Nel AA, 2005.Crop rotation in the summer rainfall area of South Africa. S. Afr. Tydskr. Plant Grond 22(4): 274-278.Payne RW, Murray DA, Harding SA, Baird DB, Soutar DM. 2011. An Introduction to GenStat for Windows. (14th edn). VSN International, Hemel Hempstead, UK.

RIEKERT HF. 1995. An adapted method for extraction of root-knot nematode eggs from maize root samples. *African Plant Protection* 1:41-43.

Soonthornpoct P, Trevathan LE, Gonzales MS, Tomaso-Peterson M. 2000. Fungal occurrence, disease incidence and severity, and yield of maize symptomatic for seedling disease in Mississippi. *Mycopathologia* 150: 39-46.

Tabatabai, MA. 1982. Soil enzymes In: A.L. Page, R.H. Miller & D.R. Keeney (eds.) *Methods of soil analysis, part 2 Chemical and Microbiological Properties* 2nd ed., Madison, Wisconsin USA.

Tabatabai, MA. 1994. Soil enzymes. In: Weaver RW, Angle JS, Bottomley PS (eds) *Methods of soil analysis, part 2. Microbiological and biochemical properties.* SSSA Book Series No. 5. Soil Sci. Soc. Am. Madison, Wis., pp. 775-833.

XLSTAT, Version 2011 (Addinsoft to Microsoft Excel 2010, New York, USA).

11 APPENDICES

Appendix 1: Economic analysis: Trial 3: Monoculture maize and crop rotation (Klein Constantia)

NOORD-VRYSTAAT, Spoorverkeer (DKC 78-87 Bt) Alles op oorle vanaf die droogte seisoen 2015_2016

Plaas Klein Constantia Wesselsbron

Mielies op mielies

Berekening van proef marges **DKC 78-87 (Bt)**

Produksiejaar 2017/2018	Produkprys		1600	Rand/ton					
2014_2015			ROR	No Till	ROR	No Till	ROR	TRR	TRR
2015_2016 oorle droogte jaar									
2016_2017			ROR	No Till	NO Till	ROR	ROR	TRR	ROR
Proef rywydtes			1,140	1,140	1,140	1,140	1,140	1,140	1,140
Opbrengs realiseer (ton/ha)			4,207	4,040	3,100	3,560	3,480	2,340	1,950
Bruto produksie waarde (R/ha)			6731	6464	4960	5696	5568	3744	3120
A:Gespesifiseerde koste									
Proef plantestand Saad (sade/ha)	R/pit	%	21000	21000	21000	21000	21000	21000	21000
C: Totale Koste (A + B) R/ha			5482	5476	5265	5281	5283	5419	5406
Koste per ton R/ton			1303	1356	1698	1483	1518	2316	2772
D: Marge (Surplus/Tekort) R/ha			1249	988	-305	415	285	-1675	-2286
Marge (Surplus/Tekort) R/ton			297	244	-98	117	82	-716	-1172
Gelykbreek opbrengs ton/ha			3,43	3,42	3,29	3,30	3,30	3,39	3,38

Met die proef waar mielies op mielies geplant word op die spesifieke tipe gronde met die 2015/2016 seisoen wat a.g.v. die droogte oorgelê het is die beste marges realiseer met die Rip op die ry in 2014/2015, oorle droogte jaar 2015/2016, en weer Rip op die ry 2016/2017 met 'n marge van R 1249/ha teenoor die No till 2014/2015, oorle 2015/2016 en No till 2016/2017 se marge van R 988/ha.

1

NOORD-VRYSTAAT, Spoorverkeer (DKC 78-87 Bt) Alles op oorle vanaf die droogte seisoen 2015_2016

Plaas Klein Constantia Wesselsbron

Mielies op Soja's

Berekening van proef marges **DKC 78-87 (Bt)**

Produksiejaar 2017/2018	Produkprys		1600	Rand/ton		
2014_2015			ROR	TRR	No Till	ROR
2015_2016 oorle droogte jaar						
2016_2017			TRR	ROR	NO Till	TRR
Proef rywydtes			1,140	1,140	1,140	1,140
Opbrengs realiseer (ton/ha)			3,520	3,010	2,841	2,500
Bruto produksie waarde (R/ha)			5632	4816	4546	4000
A:Gespesifiseerde koste						
Proef plantestand Saad (sade/ha)	R/pit	%	21000	21000	21000	21000
C: Totale Koste (A + B) R/ha			5459	5442	5436	5245
Koste per ton R/ton			1551	1808	1913	2098
D: Marge (Surplus/Tekort) R/ha			173	-626	-890	-1245
Marge (Surplus/Tekort) R/ton			49	-208	-313	-498
Gelykbreek opbrengs ton/ha			3,41	3,40	3,40	3,28

Appendix 2 Economic analysis: Trial 4: Row width and maize plant population: Doornbult.

NOORD-VRYSTAAT, Spoorverkeer (DKC 78-87 Bt)
Plaas Doornbult Bothaville agter

Berekening van proef marges — **DKC 78-87 (Bt)**

Produksiejaar 2017/2018	Produkprys		1600	Rand/ton									
Proef rywydtes			1,016	1,016	1,016	1,016	1,016	1,016		Reënval Doornbult agter			
Opbrengs realiseer (ton/ha)			6,107	6,841	7,437	7,964	7,878	8,553	Grondvog	Okt.	Nov.	Des	Jan
Bruto produksie waarde (R/ha)			2748	3079	3347	3584	3545	3849	???	39 mm	104 mm	48 mm	102 mm
A:Gespesifiseerde koste Proef plantestand Saad (sade/ha)	R/pit	%	15000	20000	25000	30000	40000	50000					
C: Totale Koste (A + B) R/ha			6948	7190	7427	7660	8081	8533					
Koste per ton R/ton			1138	1051	999	962	1026	998					
D: Marge (Surplus/Tekort) R/ha			2824	3756	4473	5082	4525	5153					
Marge (Surplus/Tekort) R/ton			462	549	601	638	574	602					
Gelykbreek opbrengs ton/ha			4,34	4,49	4,64	4,79	5,05	5,33					

1

NOORD-VRYSTAAT, Spoorverkeer (DKC 78-87 Bt)
Plaas Doornbult Bothaville

DKC 78-87 (Bt)

Berekening van proef marges

Produksiejaar 2016/2017	Produkprys		1600	Rand/ton				
Proef rywydtes			1,524	1,524	1,524	1,524	1,524	1,524
Opbrengs realiseer (ton/ha)			5,146	5,434	6,403	6,157	6,615	6,767
Bruto produksie waarde (R/ha)			2316	2445	2881	2771	2977	3045
A:Gespesifiseerde koste Proef plantestand Saad (sade/ha)	R/pit	%	15000	20000	25000	30000	40000	50000
C: Totale Koste (A + B) R/ha			6767	6991	7243	7445	7888	8472
Koste per ton R/ton			1315	1287	1131	1209	0	1252
D: Marge (Surplus/Tekort) R/ha			1466	1703	3001	2406	2695	2356
Marge (Surplus/Tekort) R/ton			285	313	469	391	407	348
Gelykbreek opbrengs ton/ha			4,23	4,37	4,53	4,65	4,93	5,29

Die beste marge vir die 2016/2017 seisoen wat relatief nat was op die spesifieke grond, word realiseer met die nouer ry wydte (1.106m rye) teen 'n hoër plantestand. Die beste marge is by die nou rye met 'n plantestand van 30 000 en 50 000 plante /ha waar laasgenoemde se marge R 71/ha beter is. By die wye ry proewe (1,524m rye) het die beste marges realiseer by 'n plantestand van 25 000/ha.

Appendix 3: Economic analysis: Trial 5: Maize plant population and cultivar: Vlakvlei.

NOORD-VRYSTAAT, Spoorverkeer
Plaas Vlakvlei Kroonstad

Berekening van proef marges
Kultivar 1 (Herhaling 1) — **78-87 Bt**

Produksiejaar 2016/2017	Produkprys		1700	Rand/ton						
Proef rywydtes			1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Opbrengs realiseer (ton/ha)			9,14	9,47	9,48	9,78	9,97	10,36	10,74	10,76
Bruto produksie waarde (R/ha)			15538	16099	16116	16626	16949	17612	18258	18292
A:Gespesifiseerde koste Proef plantestand Saad (sade/ha)	R/pit	%	12000	14000	16000	18000	20000	22000	24000	26000
C: Totale Koste (A + B) R/ha			5375	5487	5586	5697	5803	5918	6012	6105
Koste per ton R/ton			588	579	589	583	582	571	560	567
D: Marge (Surplus/Tekort) R/ha			10163	10612	10530	10929	11146	11694	12246	12187
Marge (Surplus/Tekort) R/ton			1112	1121	1111	1117	1118	1129	1140	1133
Gelykbreek opbrengs ton/ha			3,16	3,23	3,29	3,35	3,41	3,48	3,54	3,59

As gekyk word na die kultivar 78-87Bt in herhaling 1 is die marge realiseer met 'n plantestand van 24 000 plante/ha beter as die marge realiseer met 'n plantestand van 26 000 plante/ha. Die plantestand van 26 000 het wel 'n 20kg/ha beter opbrengs gelewer maar teen die huidige swak prys vergoed dit nie vir die ekstra koste verbonde aan die saad nie. Die marge verskil is R 59 positief vir die 24 000 plantestand. Dit sal dus nodig wees om 'n plaashek prys van R 59 per ton beter te kry (R 1 759/ton) met 'n stand van 26 000 plante om die selfde marge te realiseer as met die 24 000 plantestand.

Appendix 3 (Continue): Economic analysis: Trial 5: Maize plant population and cultivar: Vlakvlei.

NOORD-VRYSTAAT, Spoorverkeer
Plaas Vlakvlei Kroonstad

Berekening van proef marges
Kultivar 1 (Herhaling 2) **78-87 Bt**

Produksiejaar 2016/2017	Produkprys		1700 Rand/ton							
Proef rywydtes			1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Opbrengs realiseer (ton/ha)			9,25	8,98	9,86	9,90	9,39	10,28	10,24	10,03
Bruto produksie waarde (R/ha)			15725	15266	16762	16830	15963	17476	17408	17051
A:Gespesifiseerde koste										
Proef plantestand Saad (sade/ha)	R/pit	%	12000	14000	16000	18000	20000	22000	24000	26000
C: Totale Koste (A + B) R/ha			5379	5467	5601	5702	5780	5915	6008	6102
Koste per ton R/ton			582	609	568	576	616	575	587	608
D: Marge (Surplus/Tekort) R/ha			10346	9799	11161	11128	10183	11561	11400	10949
Marge (Surplus/Tekort) R/ton			1118	1091	1132	1124	1084	1125	1113	1092
Gelykbreek opbrengs ton/ha			3,16	3,22	3,29	3,35	3,40	3,48	3,53	3,59

As gekyk word na die Kultivar 78-87Bt in herhaling 2 is die marge realiseer met 'n plantestand van 22 000 plante/ha beter as die marge realiseer met 'n plantestand van 24 000 plante/ha. Die plantestand van 22 000 het 'n 40kg/ha beter opbrengs gelewer. Die marge verskil is R 161 positief vir die 22 000 plantestand. Dit is dan ook duidelik uit herhaling 1 en 2 dat die optimale plantestand vir die huidige seisoen met plaashek pryse wat relatief laag is in die orde van 22 000 tot 24 000 plante per ha is. Met herhaling 1 se stand van 24 000 plante wat die beste marge per ha lewer.

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NOORD-VRYSTAAT, Spoorverkeer
Plaas Vlakvlei Kroonstad

Berekening van proef marges
Kultivar 2 (Herhaling 1) **78-17 Bt**

Produksiejaar 2016/2017	Produkprys		1700 Rand/ton							
Proef rywydtes			1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Opbrengs realiseer (ton/ha)			8,27	8,36	9,08	9,29	9,46	9,40	9,92	10,30
Bruto produksie waarde (R/ha)			14059	14212	15436	15793	16082	15980	16864	17510
A:Gespesifiseerde koste										
Proef plantestand Saad (sade/ha)	R/pit	%	12000	14000	16000	18000	20000	22000	24000	26000
C: Totale Koste (A + B) R/ha			5339	5442	5570	5677	5783	5879	5973	6067
Koste per ton R/ton			646	651	613	611	611	625	602	589
D: Marge (Surplus/Tekort) R/ha			8720	8770	9866	10116	10299	10101	10891	11443
Marge (Surplus/Tekort) R/ton			1054	1049	1087	1089	1089	1075	1098	1111
Gelykbreek opbrengs ton/ha			3,14	3,20	3,28	3,34	3,40	3,46	3,51	3,57

As gekyk word na die Kultivar 78-17Bt is die marge realiseer met 'n plantestand van 26 000 plante/ha beter as die marge realiseer met 'n plantestand van 24 000 plante/ha. Die plantestand van 26 000 het 'n 380kg/ha beter opbrengs gelewer. Die marge verskil is R 552 positief vir die 26 000 plantestand. Dit is dan ook duidelik dat die verskil tussen die 2 kultivars redelik groot is in die seisoen, met die kultivar 78-87 Bt in herhaling 1 met plantestand van 24 000 plante se marge R 803/ha beter is as kultivar 78-17 Bt met plantestand 26 000.

Appendix 4: Economic analysis: Trial 6: Depth of ripping for monoculture maize.

NOORD-VRYSTAAT, Spoorverkeer (DKC 78-87 Bt)
Plaas Doornbult Bothaville **voor**

DKC 78-87 (Bt)

Berekening van proef marges prys

Tandem skeurploeg breë platskare 400mm en 200mm

Produksiejaar 2016/2017	Produkprys		1600 Rand/ton			
Proef rip dieptes			450,00	600,00	750,00	900,00
Opbrengs realiseer (ton/ha)			4,27	5,66	6,81	6,93
Bruto produksie waarde (R/ha)			1922	2547	3065	3119
A:Gespesifiseerde koste						
Proef plantestand Saad (sade/ha)	R/pit	%	27000	27000	27000	27000
C: Totale Koste (A + B) R/ha			6761	6881	7007	7123
Koste per ton R/ton			1583	1216	1029	1028
D: Marge (Surplus/Tekort) R/ha			74	2174	3890	3966
Marge (Surplus/Tekort) R/ton			17	384	571	572
Gelykbreek opbrengs ton/ha			4,23	4,30	4,38	4,45

Die beste marge vir die 2016/2017 seisoen word realiseer met die 900mm diep rip op die spesifieke tipe gronde met 'n voordeel van R 76/ha. Dit moet egter beklemtoon word dat die ekstra koste van kapitaal om dieper te rip binne 'n spesifieke vensterperiode nie hier in berekening gebring is nie, wat die voordeel verkry kan elimineer. As bogenoemde in ag geneem sou word kan daar met die resultate soos verkry op die spesifieke grond nie 'n beduidende voordeel verkry word om 900mm diep te rip bo die praktyk om 750mm diep te rip nie. Volgens marges realiseer blyk optimale rip dieptes vir die spesifieke gronde te wees in die orde van nie vlakker as 750mm nie.

Appendix 5: Bank account statement for period 2016-12-01 – 2017-02-01

ABSA

Transaksie Geskiedenis (2017-03-08 06:00:08)

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

ABSA
4076174899
SANDGROND OK

Huidige balans	R 960,056.84
Beskikbare saldo soos op	R 960,056.84
Overrekende tjeks	R 0.00

Staat vir Periode 2016-12-01 - 2017-03-08

Datum	Transaksie Beskrywing	Bedrag	Balans
Saldo oorgebring			**577,997.91**
2016-12-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-59.50	577,938.41
2016-12-01	ADMIN KOSTE HOOFKNTOOR	-20.00	577,918.41
2016-12-01	KREDIETRENTE HOOFKNTOOR	47.51	577,965.92
2016-12-12	JOERNAALDEBIET HOOFKNTOOR MAANDELIKSE FOOI - SEP 2016	-59.50	577,906.42
2016-12-15	IBANK BETALING VAN VEREFFEN ABSA BANK Maize Trust Funding	488,932.80	1,066,839.22
2017-01-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-59.50	1,066,779.72
2017-01-01	ADMIN KOSTE HOOFKNTOOR	-20.00	1,066,759.72
2017-01-01	KREDIETRENTE HOOFKNTOOR	71.86	1,066,831.58
2017-01-16	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-23,324.56	1,043,507.02
2017-01-22	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-27,249.08	1,016,257.94
2017-02-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	1,016,192.94
2017-02-01	ADMIN KOSTE HOOFKNTOOR	-25.00	1,016,167.94
2017-02-01	KREDIETRENTE HOOFKNTOOR	40.92	1,016,208.86

10/03/2017 11:54

2017-03-08 06:00:08 bladsy 1 van 2

Appendix 6: Bank account statement for period 2017-02-11 – 2017-03-01

ABSA

Datum	Transaksie Beskrywing	Bedrag	Balans
2017-02-11	IBANK BETALING NA VEREFFEN ABSA BANK Barenbrug	-3,021.00	1,013,187.86
2017-02-19	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-32,455.87	980,731.99
2017-02-19	IBANK BETALING NA VEREFFEN ABSA BANK G Trytsman	-971.00	979,760.99
2017-02-24	IBANK BETALING NA VEREFFEN ABSA BANK Agri Consult Trust	-19,614.15	960,146.84
2017-03-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	960,081.84
2017-03-01	ADMIN KOSTE HOOFKNTOOR	-25.00	960,056.84
Saldo oorgedra			**960,056.84**

2017-03-08 06:00:08 bladsy 2 van 2

10/03/2017 11:55

Appendix 7: Bank account statement for period 2017-03-01 – 2017-03-18

Transaksie Geskiedenis (2017-03-21 06:26:04)

SANDGROND ONTWIKKELINGS KOMMITEE	**ABSA**
POSBUS 7042	4076174899
KROONPARK	SANDGROND OK
9502	

Huidige balans	R 916,486.84
Beskikbare saldo soos op	R 916,486.84
Overrekende tjeks	R 0.00

Staat vir Periode 2017-03-01 - 2017-03-21

Datum	Transaksie Beskrywing	Bedrag	Balans
Saldo oorgebring			**960,146.84**
2017-03-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	960,081.84
2017-03-01	ADMIN KOSTE HOOFKNTOOR	-25.00	960,056.84
2017-03-18	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-43,570.00	916,486.84
Saldo oorgedra			**916,486.84**

2017-03-21 06:26:04 bladsy 1 van 1

Appendix 8: Bank account statement for period 2017-03-27 – 2017-04-26

Stuur terug na:
Privaatsak X18, Johannesburg, 2000

Tjekrekeningnommer: 40-7617-4899

Sandgrond Ontwikkelings Kommitee

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

008140
003645
Bb Northern Free State (00)
1Ste Vloer Absa Gebou
1Ste Vloer Absa Gebou
Crossstraat
Kroonstad
9499

056 216 7312

Tjekrekeningstaat

27 Mrt 2017 tot 26 Apr 2017

Rekeningtipe:	Klassieke Besig Rek	**Uitgereik op:**	26 Apr 2017
Staatnr:	0083		
Kliënt BTW-reg-no:			

Rekeningopsomming:

Saldo oorgedra	916 486,84
Diverse Debiete	88 048,19 -
Koste	90,00 -
Saldo	**828 348,65**
Oortrekkingslimiet	**0,00**

U transaksies

Datum	*Transaksiebeskrywing*		*Koste*		*Debietbedrag*	*Kredietbedrag*	*Saldo*
27/03/2017	Saldo Oorgedra						916 486.84
27/03/2017	Bankstaat	Hoofkntoor	25.00	A			916 486.84
29/03/2017	Ibank Betaling Na Absa Bank Arc-Api	Vereffenin			46 658.67		869 828.17
31/03/2017	Ibank Betaling Na Absa Bank Tjm Minnaar	Vereffenin			1 350.00		868 478.17
31/03/2017	Ibank Betaling Na Absa Bank Thuso Graan Edms Bpk	Vereffenin			1 614.79		866 863.38
1/04/2017	Mndeliks Rek-Fooi	Hoofkntoor		*	65.00		866 798.38
1/04/2017	Admin Koste	Hoofkntoor		*	25.00		866 773.38
20/04/2017	Ibank Betaling Na Absa Bank Dr Dj Beukes	Vereffenin			38 424.73		828 348.65

DIENSGELD : 75.00/0.00/75.00 MNDLKS REK-FOOI : R65.00

KREDIETRENTE SOOS OP 27/03/2017 STANDAARD - VERWYS NA TAK

WANNEER HET U LAAS U BESIGHEIDSKONTAKNOMMER EN E-POSADRES OPGEDATEER?DIT IS

Appendix 9: Bank account statement for period 2017-04-27 – 2017-05-26

Stuur terug na:
Privaatsak X18, Johannesburg, 2000

Tjekrekeningnommer: **40-7617-4899**

008140
003645
Bb Northern Free State (00)
1Ste Moer Absa Gebou
1Ste Moer Absa Gebou
Crossstraat
Kroonstad
9499

056 216 7312

Sandgrond Ontwikkelings Kommitee

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

Tjekrekeningstaat

27 Apr 2017 tot 26 Mei 2017

Rekeningtipe:	Klassieke Besig Rek	**Uitgereik op:**	26 Mei 2017
Staatnr:	0084		
Kliënt BTW-reg-no:			

Rekeningopsomming:

Saldo oorgedra	828 348,65
Koste	90,00 -
Saldo	**828 258,65**
Oortrekkingslimiet	**0,00**

U transaksies

Datum	*Transaksiebeskrywing*		*Koste*		*Debietbedrag*	*Kredietbedrag*	*Saldo*
27/04/2017	Saldo Oorgedra						828 348.65
27/04/2017	Bankstaat	Hoofkntoor	25.00	A			828 348.65
1/05/2017	Mndeliks Rek-Fooi	Hoofkntoor		*	65.00		828 283.65
1/05/2017	Admin Koste	Hoofkntoor		*	25.00		828 258.65

DIENSGELD : 75.00/0.00/75.00 MNDLKS REK-FOOI : R65.00

KREDIETRENTE SCOS OP 27/04/2017 STANDAARD - VERWYS NA TAK

WANNEER HET U LAAS U BESIGHEIDSKONTAKNOMMER EN E-POSADRES OPGEDATEER?DIT IS VIR ONS BELANGRIK OM MET U, AS 'N GEWAARDEERDE BESIGHEIDSBANKDIENSTE-KLIENT TE KAN KOMMUNIKEER. AS U U KONTAKBESONDERHEDE DEURENTYD OPDATEER, HELP DIT ONS OM U OP HOOGTE TE HOU. KONTAK ASSEBLIEF ONS KONTAKSENTRUM BY 0860 040 302 OF U BANKIER OM U TE HELP.

* = BTW R11.05- INGESLUIT

KOSTE : A = ADMINISTRASIE D = DIENSGELD G = GEMENGDE K = KONTANTDEPOSITO T = TRANSAKSIE

Belangrik State word as korrek aanvaar tensy navraag binne 30 dae gedoen word. Tjeks wat op hierdie staat verskyn en nie aangeheg / gefotografeer is nie, sal by u volgende staat ingesluit word.

Appendix 10: Bank account statement for period 2017-05-01 – 2017-09-01

Transaksie Geskiedenis (2017-09-02 16:13:51)

SANDGROND ONTWIKKELINGS KOMMITEE	**ABSA**
POSBUS 7042	4076174899
KROONPARK	SANDGROND OK
9502	

Huidige balans	R 830,328.35
Beskikbare saldo soos op	R 830,328.35
Overrekende tjeks	R 0.00

Staat vir Periode 2017-04-01 - 2017-09-02

Datum	Transaksie Beskrywing	Bedrag	Balans
Saldo oorgebring			**828,348.65**
2017-05-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	828,283.65
2017-05-01	ADMIN KOSTE HOOFKNTOOR	-25.00	828,258.65
2017-05-30	IBANK BETALING VAN VEREFFEN ABSA BANK Maize Trust Funding	135,743.80	964,002.45
2017-06-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	963,937.45
2017-06-01	ADMIN KOSTE HOOFKNTOOR	-25.00	963,912.45
2017-06-06	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-42,732.90	921,179.55
2017-06-11	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-44,491.96	876,687.59
2017-07-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	876,622.59
2017-07-01	ADMIN KOSTE HOOFKNTOOR	-25.00	876,597.59
2017-07-28	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-46,089.24	830,508.35
2017-08-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	830,443.35
2017-08-01	ADMIN KOSTE HOOFKNTOOR	-25.00	830,418.35
2017-09-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	830,353.35
2017-09-01	ADMIN KOSTE HOOFKNTOOR	-25.00	830,328.35
Saldo oorgedra			**830,328.35**

2017-09-02 04:13:51 bladsy 1 van 1

Appendix 11: Bank account statement for period 2017-06-01 – 2017-09-23

ABSA

Transaksie Geskiedenis (2017-09-28 08:28:50)

SANDGROND ONTWIKKELINGS KOMMITEE	ABSA
POSBUS 7042	4076174899
KROONPARK	SANDGROND OK
9502	

Huidige balans	R 795,029.79
Beskikbare saldo soos op	R 795,029.79
Overrekende tjeks	R 0.00

Staat vir Periode 2017-06-01 - 2017-09-28

Datum	Transaksie Beskrywing	Bedrag	Balans
Saldo oorgebring			**964,002.45**
2017-06-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	963,937.45
2017-06-01	ADMIN KOSTE HOOFKNTOOR	-25.00	963,912.45
2017-06-06	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-42,732.90	921,179.55
2017-06-11	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-44,491.96	876,687.59
2017-07-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	876,622.59
2017-07-01	ADMIN KOSTE HOOFKNTOOR	-25.00	876,597.59
2017-07-28	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-46,089.24	830,508.35
2017-08-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	830,443.35
2017-08-01	ADMIN KOSTE HOOFKNTOOR	-25.00	830,418.35
2017-09-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	830,353.35
2017-09-01	ADMIN KOSTE HOOFKNTOOR	-25.00	830,328.35
2017-09-13	JOERNAALDEBIET CORP ADMIN ARCHIVE STATEMENTS	-165.00	830,163.35
2017-09-20	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-34,318.56	795,844.79
2017-09-23	IBANK BETALING NA VEREFFEN ABSA BANK BAP Nel	-815.00	795,029.79
Saldo oorgedra			**795,029.79**

2017-09-28 08:28:50 bladsy 1 van 1

BOEREDAG

AANGEBIED DEUR: SANDGRONDONTWIKKELINGSKOMITEE

DATUM: 08H45 VIR 09H00 WOENSDAG 29 MAART 2017
DISTRIK: BOTHAVILLE
PLAAS: DOORNBULT (THABO VAN ZYL)

GRAIN SA
GRAAN SA

TEMA

BEWARINGSLANDBOU: DIE ROL WISSELBOU, DIEPTE VAN BEWERKING, RYWYDTE EN PLANTDIGTHEID IN VOLHOUBARE GEWASPRODUKSIE OP SANDGRONDE

PROGRAM

08H45-09H00 ONTMOET OP PLAAS DOORNBULT: GPS 27.498025°S 26.438584°E

- Thabo van Zyl

09H00-12H00 BESOEK AAN VELDPROEWE (Thabo, Petrus van Staden):

- Mielie-rywydte en –plantdigtheid (Doornbult)
- Ripdiepte met monokultuur mielies (Doornbult)
- Mielies in wisselbou met koring en sojabone (Christinasrus)

12H20-13H00 AANBIEDINGE (Losdorings Studiegroep Saal):

- Bewerking en wisselbouproewe: Lourens van der Linde
- Bekendstelling van ander SOK-proewe: Danie Minnaar, Danie Crous, Gerrie Trytsman
- Die rol van wisselboustelsels in bewaringslandbou: André Nel

13H00-13H05 SAMEVATTING:

- Hendrik Smith (Bewaringslandbou, Graan SA)

13H05-14H00 LIGTE MIDDAGETE

14H00 VERTREK

Antwoord teen 09h00 27 Maart 2017: E-pos: danie.beukes122@gmail.com
Sel: 082 442 0484

Appendix 13: Programme for report back and planning meeting.

TERUGVOER EN BEPLANNINGSVERGADERING

SOK-PROJEK: Investigating the impacts of conservation agriculture practices on soil health as key to sustainable dry land maize production systems on semi-arid sandy soils with water tables in the north western Free State

AANGEBIED DEUR: SANDGRONDONTWIKKELINGSKOMITEE

DATUM: 11 SEPT 2017, 10H00 – 13H00
PLEK: SPRINGBOKLAAGTE (DANIE MINNAAR)

FOKUS

TERUGVOER OOR RESULTATE VAN 2016/17-SEISOEN EN BEPLANNING VIR 2017/18-SEISOEN

PROGRAM (Voorsitter: Danie Minnaar)

10H00-10H10 VERWELKOMING EN OPENING:
- Jaco Minnaar, Voorsitter, Graan SA
- Danie Crous (Skriflesing)

10h10-11H45 TERUGVOER OOR RESULTATE VAN 2016/17-SEISOEN:
- Boeremedewerkers: Danie, Lourens, Thabo, Danie Crous
- Tegniese medewerkers:
  LNR-IGG (Maryke, Sonia, Owen): Mikrobiologie en patogene
  LNR-Irene (Gerrie): Dekgewasproef
  Andre & Danie: Groei en opbrengs, Grondeienskappe
  Senwes (Petrus & Boet): Grondwater; Ekonomiese ontledings
  Omnia (Kobus): Grondontledings

11H45-11H55 BIOLOGIESE BREEK

11H55-12H30 BEPLANNING VIR 2017/18-SEISOEN:
- Boeremedewerkers: Danie, Lourens, Thabo, Danie Crous
- Tegniese medewerkers: LNR-IGG, LNR-Irene, Senwes (Petrus & Boet), Andre & Danie, Kobus (Omnia)

12H30-12H35 VORDERINGSVERSLAG EN AANSOEK AAN MIELIETRUST:
- Insette en sperdatums (Danie)

12H35-12H45 ENIGE ANDER SAKE:
- …………………
- …………………
- …………………

12H45-12H50 SAMEVATTING EN AFSLUITING:
- Jaco Minnaar, Voorsitter, Graan SA

13H00-13H45 LIGTE MIDDAGETE
14H00 VERTREK

Kontakbesonderhede: Danie: 0824420484; danie.beukes122@gmail.com
Andre Nel: 0836549430; nelaa1954@gmail.com

Appendix 14: Programme for planning meeting for 2017/18-season.

BEPLANNINGSVERGADERING

SOK-PROJEK: Investigating the impacts of conservation agriculture practices on soil health as key to sustainable dry land maize production systems on semi-arid sandy soils with water tables in the north western Free State

AANGEBIED DEUR: SANDGRONDONTWIKKELINGSKOMITEE

DATUM: 20 SEPT 2017, 10H00 – 13H00
PLEK: SENWES RAADSAAL, KROONSTAD

The Maize Trust

GRAIN SA
GRAAN SA

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FOKUS

BEPLANNING VIR 2017/18-SEISOEN

PROGRAM (Voorsitter: Danie Minnaar)

10H00-10H10 VERWELKOMING EN OPENING:

- Jaco Minnaar, Voorsitter, Graan SA
- Danie Crous (Skriflesing)

10H55-12H30 BEPLANNING EN AKTIWITEITE VIR 2017/18-SEISOEN:

- Bestaande proewe:
  - Boeremedewerkers: Danie, Lourens, Thabo, Danie Crous
  - Tegniese medewerkers:
    LNR-IGG (Maryke, Sonia, Owen)
    LNR-Irene (Gerrie)
    Senwes (Petrus & Boet)
    Proefmetings (Andre & Danie)
    Omnia (Kobus)
- Nuwe inisiatiewe
- Boeredag en ander uitreike

11H45-11H55 BIOLOGIESE BREEK

12H30-12H35 VORDERINGSVERSLAG EN AANSOEK AAN MIELIETRUST:

- Insette en sperdatums (Danie)

12H35-12H45 ENIGE ANDER SAKE:

- …………………
- …………………

12H45-12H50 SAMEVATTING EN AFSLUITING:

- Jaco Minnaar, Voorsitter, Graan SA

13H00-13H45 LIGTE MIDDAGETE
14H00 VERTREK

Kontakbesonderhede: Danie: 0824420484; danie.beukes122@gmail.com
Andre Nel: 0836549430; nelaa1954@gmail.com