INTERIM PROGRESS REPORT

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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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1 IDENTIFICATION OF THE PROJECT AND THE PROJECT LEADER

1.1 Background

The current project builds on previously 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 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.

1.2 Problem description and literature overview

The sandy soils of the North Western Free State are known for their inherent compaction problem, low organic matter content and low nutrient and water retention capability. Research results since the 1970's 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. The presence of fluctuating water tables on these soils could eliminate the positive effect of 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. One of the immediate negative consequences of soil compaction is the inhibition of proper root development, causing poor nutrient and water uptake, leading to poor crop growth and yield.

Against this background, and during the evaluation and planning sessions of September 2016, it has become clear that a more comprehensive investigative initiative should be launched on these semi-arid water table sandy soils, based on CA principles and practices with the emphasis, 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, and (vii) 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 water table sandy soils of the North Western Free State.

1.3 Project objectives

- 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-aims:
  - 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 leaders

Danie Beukes and André Nel

2 ACTIONS THAT HAVE BEEN TAKEN WITH REGARD TO THE PROJECT

The following actions are of note:

- September 2017: Two feedback and planning sessions were held with stakeholders to refine the 2016/17 proposal to the Maize Trust 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.
- September 2017: Application for financial assistance for the project proposal submitted to The Maize Trust.
- November-December 2017: Telephone and e-mail contacts with farmer co-workers on final trial lay-outs and planting conditions.
- 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).
    - Trials 2 & 3: Local CA, reduced tillage, stubble-mulch, cash crop rotations with maize/ forage sorghum/soybean, as well as crop rotation of maize/soybean, compared to mono culture maize (Farmer co-workers: Thabo van Zyl, Christinasrus; Lourens van Zyl, Klein Constantia).
    - Trials 4 & 5: Interactions of plant row width, population density and planting date components to the sustainable cultivation of mono culture maize on sandy soils (Farmer co-workers: Thabo van Zyl, Doornbult; Danie Minnaar, Springboklaagte).
    - Trial 6: The optimum depth of ripping for the sustainable cultivation of mono culture maize on sandy soils (Farmer co-workers: Thabo van Zyl, Doornbult).
    - Trial 7: Effects of N fertilizer application on soybean growth and yield (Farmer co-worker: Thabo van Zyl, Sanniesrus).
- December 2017: Preliminary approval of the project proposal.
- December 2017: The project team notified of the approval.

- December 2017-March 2018: Maintenance of trials in terms of N top-dressing, weeds and pests.
- January-March 2018: Four visits were paid to the trials to view and discuss the seasonal progress with the farmer co-workers.
- January-June 2018: Installation of instruments and measurements of soil and crop parameters on selected trials by the technical team.
- January-February 2018: Planning and holding of Farmers Day and Information Session of Region 22 of Grain SA at Springboklaagte.
- February 2018: Meeting with ARC-GCI researchers to plan and coordinate their sampling and studies.
- March 2018: ARC-Grain Crops Institute: Sampling of root and plant material of Trials 1 and 2 at Deelpan and Christinasrus for microbiological, pathological en nematological studies.
- March 2018: Annual soil sampling of Trials 1 and 2 at Deelpan and Christinasrus by OMNIA and Drr DJ Beukes and AA Nel.
- February-March 2018: Collation of inputs, data processing, compilation of interim progress report.

3 THE PROGRESS THAT HAS BEEN MADE WITH THE PROJECT

3.1 Background and objectives on the established trials

Trial 1: Regenerative CA crop-livestock integrated system with rotations of maize-summer-winter diverse ley crops (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 was left on the soil surface for the creation of a mulch. The yield and economy of maize produced in a conventional monocrop system will be compared with the cover crop - maize system.

Trial 2: Local CA, reduced tillage, stubble-mulch, cash crop rotations with maize/ fodder sorghum/soybean, compared to mono culture maize (Christinasrus):

The trial was formerly known as the "Maize in rotation with soybean and wheat". The objective of this trial was to compare the sustainability and profitability of monocropped maize with two rotation systems namely, a maize – wheat - soybean rotation and a maize – maize – wheat rotation system. The expectation is that the soil health will improve due to crop rotation which will then improve the sustainability and profitability of maize. However, due to low profitability, it was decided that fodder sorghum should replace wheat from 2017/18 onwards. A four crop rotation system will be used namely: 1. Maize – fodder sorghum – soybean; 2. Maize - maize – soybean; 3. Maize – maize - maize; 4. Soybean – maize$_{-40}$ where the maize will be fertilised with 40 kg ha^{-1} less nitrogen than the other maize in the trial.

Trial 3: Local CA, reduced tillage, stubble-mulch, cash crop rotation of maize/soybean (Klein Constantia):

This trial was changed for the 2017/18-season to a monoculture maize trial where rip-on-row tillage (ROR) will be compared with no-till. Tillage and planting rows were moved laterally by about 500 mm.

Trial 4: Interactions of plant row width and population density as components to the sustainable cultivation of mono culture maize on sandy soils (Doornbult):

The objective of the trial is to find the optimal combination of row width and plant population of maize on the sandy soil for a second season. Yields from two row widths (1.016 and 1.524 m) with plant populations varying from 15 000 to 50 000 plants ha^{-1} are compared to determine optimal values. The same plots as in 2016/17 are used to accommodate any long-term effect of plant populations and row widths.

Trial 5: Interactions of population density and planting date as components to the sustainable cultivation of mono culture maize on sandy soils (Springboklaagte):
The objective of the trial is to find the optimal combination of plant population and planting date on the sandy soil. Due to the late onset of the summer rain, the second planting date could not be implemented. Plant populations varying from 15 000 to 40 000 plants ha^{-1} are compared to determine optimal values.

Trial 6: The optimum depth of ripping for the sustainable cultivation of mono culture maize on sandy soils (Doornbult):
The objective is to find the optimal ripping depth for maize production on the sandy soil of the north-west Free State for a second season. Ripping depths varying from 450 to 900 m are compared in terms of the yield of maize. The same plots/treatments used in 2016/17 are used in 2017/18 to accommodate possible long-term effects of ripping.

Trial 7: Effects of N fertilizer application on soybean growth and yield (Sanniesrus):
The objective of this trial is to determine if the grain yield increases with additional nitrogen fertilisation. Nitrogen fertilisation rates vary from zero to 150 kg ha^{-1}, replicated six times.

Agronomical aspects such as plant population density and number of tillers are determined during the growing season on relevant trials. Grain yields are determined by combine harvester at the end of the season on all trials.

3.2 General farm operations and trial establishment

Pre-plant 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. All trials were planted according to the agreed technical specifications. Maintenance operations (e.g. herbicide and pesticide) are being carried out according to on-farm specifications.

Planting dates were as follows:
Trial 1: Danie Crous: Maize: 11 Dec 2017; Summer cover crop mixture: 9 January 2018; Winter cover crop mixture: 21 February 2018.
Trial 2: Thabo: Maize and forage sorghum: 3 December 2017; Soybean: 5 Dec 2017.
Trial 3: Lourens: Maize: 6 December 2017.
Trial 4: Thabo: Maize: 18 December 2017.
Trial 5: Danie Minnaar: Maize: 14 & 28 December 2017.
Trial 6: Thabo: Maize: 18 December 2017.
Trial 7: Thabo: Soybean: 7 December 2017.

During November-December 2017 telephone and e-mail contacts were made with the farmer co-workers on final trial lay-outs and planting conditions. Four visits to the trials were made from January to March 2018 to view and discuss the seasonal progress with the farmer co-workers.

3.3 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, ARC-API, personnel from OMNIA, Mrr B van Zyl and P van Staden from Senwes, and 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.	In progress.
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.	On-going process.
4. Trials 1, 2, 4 & 6: Regular gravimetric soil water sampling, determining soil bulk density and laboratory work to calibrate capacitance sensors.	Calibration equations.	On-going process.
5. Trials 1, 2, 4 & 6: Cleaning of data, processing and finalising of results.	Soil water and temperature graphs as function of trial treatments.	On-going process.
6. Trial 1: Calculation of soil water balances.	Data on water use and water productivity of crops as function of trial treatments.	On-going process.
7. Trials 1 & 2: Soil sampling and analysis by OMNIA.	Soil fertility and soil carbon data.	Scheduled.
8. Trial 1: Regular sampling and analysis of water table water.	Data on temporal chemical composition of water table.	On-going process.
9. Trials 1, 4 & 5: Agronomic measurements in March 2018.	Data on sprouting and planting density.	In progress.
10. Trials 1 & 2: Sampling in March 2018 of plant biomass and root rhizosphere for root pathogens, microbiology and nematology.	Plant biomass data and soil samples.	Scheduled.
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, and characterization and occurrence of nematodes.	To commence in April 2018.
12. Enterprise financial analyses of selected trials and crops.	Report on enterprise financial analyses.	To be done after harvesting.

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

3.3.1.1 Agronomic observations and measurements (Mr G Trytsman)

3.3.1.1.1 Partners Involved

Farmers, ARC, Grain SA, Maize Trust

3.3.1.1.2 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 and administration.
- Awareness events.

3.3.1.1.3 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 soil health, but increases biodiversity both above and below the soil surface, while increasing both water holding capacity and sequestering carbon at greater depths.

3.3.1.1.4 The progress that has been made with the project

According to the initial planning of the trial, this year only maize would have been planted. The summer and winter cover crop mixtures under no-till were to be rotated with maize under no-till. The summer and winter cover crop mixtures under conventional tillage (ROR) were rotated with maize under ROR. Plates 1 and 2 depict maize stands under ROR tillage for both treatments. The objective has been to evaluate the impact of ROR tillage and no-till on the rotation of maize and cover crop mixtures.

After fruitless attempts to get a no-till planter to the site, we eventually accepted defeat and decided to again plant summer and winter cover crop mixtures on the same plots as in the 2016/17 season.

Plate 1: Conventional (ROR) maize on summer cover crop mixture of the 2016/17-season.

Plate 2: Conventional (ROR) maize on winter cover crop mixture of the 2016/17-season.

Both summer (10 kg babala; 12 kg sorghum; 6 kg saia; 10 kg cowpea and 10 kg lablab) and winter cover crop mixtures (15 kg rye, 15kg black oats, 10kg hairy vetch and 250g of tillage radish) were planted. The summer and winter crop mixtures were planted on 1.2 and 0.75 ha, respectively. Fertilizer (LAN) was broadcast at 56 kg N ha^{-1} on each of the areas. Barenbrug provided the seed in both instances and the summer cover crop mixture was sponsored for which we are very grateful. The summer cover crop mixture was planted on the 9th of January while the winter cover crop mixture was planted on the 21st of February. Plates 3 and 4 represent images of the mixtures used.

Plate 3: Summer cover crop seed being mixed.

Plate 4: Winter cover crop mixture.

Due to a lack of asses to a fine seed planter both treatments were planted using a fertilizer spreader to broadcast the seed. The residues on the surface from the previous crops made it impossible to use implements such as spike tooth harrows to cover the seed with soil so a stalk chopper was used instead.

Probes for the measuring of soil water and temperature, respectively, were installed on the different treatments to monitor these two important variables. Micro-organism and disease measurement will be the responsibility of our co-workers of ARC-GCI and will be determined 100 days from the planting date.

3.3.1 2 Soil water and temperature measurements (Drr DJ Beukes & AA Nel)

Ten Aquacheck probes were installed on the eastern and western sides on each of the mono culture maize, summer cover crop (no-till), 2 x maize (ROR) and winter cover crop (no-till) plots, respectively. These probes have capacitance sensors and thermistors on 10, 200, 300, 400, 600 and 800 mm depth, respectively. Installation dates were 4 and 24 Jan 2018. Field downloading of data to a handheld logger was performed on 24 Jan, 21 Feb Feb and 22 March 2018, followed by downloading to a laptop computer.

Soil sampling for the determination of gravimetric soil water will be done for the purpose of calibrating the capacitance sensors. Graphical displays of temporal soil water and temperature data were consequently done.

3.3.1.3 Water table sampling (Drr DJ Beukes & AA Nel)

A hole was augered on 5 Jan 2018 to a depth of 2000 mm on each of the eastern and western sides of the experimental block in a commercial maize stand adjacent to the winter cover crop land. From observations of the previous season it was concluded that two distinct water tables are present, each with its own chemical composition. On 5 Jan a water table was present only on the western side and was sampled. Samples were obtained from both water tables on 24 Jan (Plate 5) and 21 Feb 2018. Before sampling, the holes were augered again to the original depths and left for a while for the water tables to equilibrate. Chemical analyses were done by the Analytical Laboratory of ARC-ISCW.

3.3.1.4 Root diseases, soil microbiology and nematology (Dr A Abrahams, Mr O Rhode & Dr S Steenkamp, ARC-GCI)

3.3.1.4.1 Root diseases and soil microbiology

The sampling of the cover crop trial was scheduled for 22 March 2018. Due to incessant rain on the 22nd, the sampling has been moved to early April. For the second (2017/18) growing season, 30 randomly selected maize plants, as well as roots with rhizosphere soil, per designated plot will be sampled at 100 days after planting. The plants, roots and rhizosphere soil will be put in bags and stored at 4^{o}C for later use. The aboveground biomass will be determined for the plants sampled within each plot and expressed as kg plant^{-1}. The roots for each of these plants will then be washed under running water and visually rated (visual discolouration) for disease symptoms on both roots and crowns. A root disease index (RDI) will be used to record disease ratings based on an adjusted scale of 0 – 4 (0 – no symptoms, 1 = >1-25% rot, 2 = 25-49% rot, 3 = 50-75% rot and 4 = 75-100% rot). Disease severity will accordingly be calculated as the product of disease incidence x RDI.

The soil surrounding the roots of the above samples, as well as rhizosphere samples taken on the summer and winter cover crop lands, will be subjected to various microbiological tests that include the determination of bacterial and fungal counts on nutrient agar and malt-extract agar media, respectively, as well as the enumeration of actinomycetes. Microbial enzyme activities will also be determined by means of extracting soil enzymes such as ß-glucosidase, phosphatase and urease. Microbial biomass carbon from collected soil samples will also be determined.

3.3.1.4.2 Parasitic and free living nematodes

Sampling: Each plot will be divided into two sub-plots to provide at least 6 replicates necessary for the statistical analysis of nematodes. Five plants per sub-plot will be 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 will be placed into a marked plastic bag. Samples were stored at 4°C until extraction.

Extraction of the nematodes: Soil samples: Nematodes will be extracted from 200 cm^3 soil samples using the sugar-flotation method (Cobb, 1918) followed by the sugar flotation method (Caveness & Jensen, 1955) and expressed as nematodes per 200 cm^3 soil.

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

Statistical analysis: ANOVA will be done on GenStat for plant-parasitic nematodes on the soil and root samples collected for each of the trials. All nematode data are log transformed before being subjected to statistical analysis. Means are separated using the Tukey HSD test at $P \leq 0.05$. Data will be analysed during the following seasons as follows:

Prominence values will be used to determine both the occurrence frequency and population density of the plant-parasitic nematodes.

Analyses of variance (ANOVA) will be used to determine if significant differences exists 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 subfactor. Means will be separated using the Tukey HSD test at $P \leq 0.05$.

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.

3.3.1.5 Soil sampling and analysis by OMNIA

Transect soil sampling of Trial 1 by OMNIA, Drr Beukes and Nel was scheduled for 22 March 2018. Due to incessant rain on the 22nd, the sampling has been moved to early April. The maize stand will be sampled on the row and between the rows, while random samples will be taken on the summer and winter cover crop lands. For soil fertility analysis, samples will be taken at 0-200 and 200-500 mm depth intervals, respectively. For soil organic C (SOC) analysis, samples will be taken at 0-50, 50-100, 100-200 and 200-400 mm depth intervals, respectively, on the experimental lands, as well as on an adjacent undisturbed grass stand. Standard soil fertility analyses (e.g. pH, P, cations, NH_4- and NO_3-N) will be performed, as well as Walkley-Black analyses for SOC.

Plate 5: Syphoning a water table sample on 24 Jan 2018 at Deelpan.

3.3.2 Trial 2: Local CA, reduced tillage, stubble-mulch, cash crop rotations with maize/forage sorghum/soybean, compared to maize mono culture.

3.3.2.1 Root diseases, soil microbiology and nematology (Dr A Abrahams, Mr O Rhode & Dr S Steenkamp, ARC-GCI

Root diseases and soil microbiology: The sampling of Trial 2 is scheduled for 27 March 2018. For the maize root diseases, 30 maize plants will be sampled for above-ground plant parts, as well as roots containing rhizosphere soil and put in bags and stored at 4^{o}C for later use. For the soil microbiology and nematology studies, apart from the maize plant samples, the rhizosphere soil of the soybean and forge sorghum plots will also be sampled. The same analysis procedures as listed in Section 3.2.1.4 will be used for the root diseases, soil microbiology and nematology studies.

Parasitic and free living nematodes: The same procedures as in Section 3.2.1.4 on sampling, extraction and statistical analysis will be followed.

3.3.2.2 Soil sampling and analysis by OMNIA

Soil sampling of Trial 2 by OMNIA, Drr Beukes and Nel is scheduled for 27 March 2018. On-the–row and between-the-row sampling of the three crops will be done for selected plots on all replicates. For soil fertility analysis, samples will be taken at 0-200 and 200-500 mm depth intervals, respectively. For soil organic C (SOC) analysis, samples will be taken at 0-50, 50-100, 100-200 and 200-400 mm depth intervals, respectively, on the experimental lands, as well as on an adjacent undisturbed grass stand. Standard soil fertility analyses (e.g. pH, P, cations, NH_4- and NO_3-N) will be performed, as well as Walkley-Black analyses for SOC.

3.3.3 Soil water and rainfall studies

(Mr P van Staden, Senwes).

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

The measurement of soil water content is done with continuous logging probes from DFM Software Solutions. The layout does not allow statistical analysis of data. Two types of probes are being used. The first type is 1200 mm in length and connected to an automatic rain gauge. Data is downloaded manually. The other type is a 1200 mm GPRS probe where data is stored on the cloud of DFM software Solutions.

One probe each was installed on 25 January 2018 in one replication of the following treatments:

- The maize, fodder sorghum and soybean plots of the maize-fodder sorghum-soybean rotation trial (Trial 2);
- Narrow and wide row width plots for the 50 000; 25 000 and 15 000 plants ha^{-1} (Trial 4);
- The 450 mm and 900 mm depth plots of the rip trial (Trial 6).

4 THE RESULTS THAT HAVE BEEN ACHIEVED

4.1 Seasonal rainfall

Figure 1 shows seasonal rainfall (Sept-Mar) for the 2017/18 growing season at Deelpan and Springboklaagte. The following are of note:

- Very late onset of the summer rain that let to delays in planting of crops. Excellent rainfall in December and good follow-up rains until March were received.
- At Deelpan and Springboklaagte the total amounts of rain for the period Sept-Mar 2018 are, respectively, 100 and 160 mm lower than for the same period in 2016/17. However, by the end of March all crops were looking excellent in terms of growth and vigour.

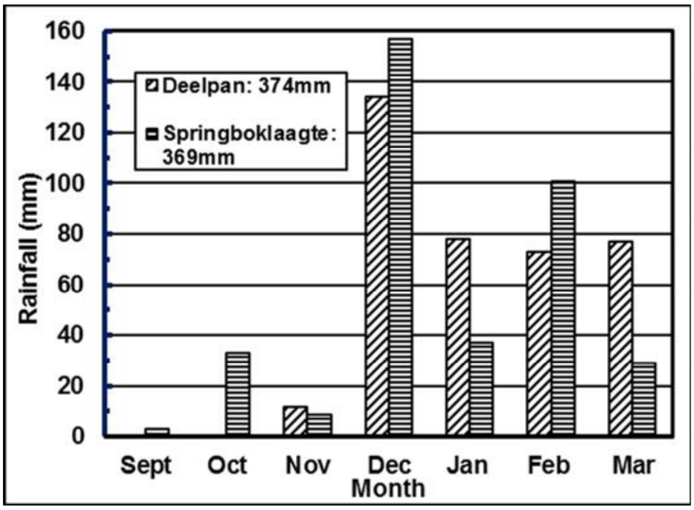


Figure 1: Seasonal rainfall at Deelpan and Springboklaagte.

Plate 6: Promising rain clouds over the study area on 24 Jan2018.

4.2 Observations during trial visits (Drr AA Nel and DJ Beukes)

During the regular trial visits the following observations were made:

- 3-5 Jan 2018: General appearance of the maize at Klein Constantia and Springboklaagte looked good. The maize stand at Doornbult (row width/plant density trial) in need of follow-up rain (Plates 7 and 8).
- 24-25 Jan 2018: Very good vigour and growth due to good rainfall during December and January 2018 (Plates 9-12).
- 21-23 Feb 2018: General appearance of the trial crops was still good due to fair rainfall during February (Plate 13-14).

Plate 7: Trial maize stands on 4 Jan 2018: Klein Constantia (left) and Doornbult (right).

Plate 8: Trial maize stand on 5 Jan 2018 (Springboklaagte).

Plate 9: Maize stand on 24 Jan 2018 following winter cover crop mixture (Deelpan).

Plate 10: Mono culture maize (left) and rotational soybean (right) on 25 Jan 2018 (Christinasrus).

Plate 11: Forage sorghum on 25 Jan 2018 (Christinasrus).

Plate 12: Maize stands at Springboklaagte (left) and Doornbult (right) at 30 000 and 25 000 plants ha^{-1} on 24 and 25 Jan 2018.

Plate 13: Maize plant density trial at Springboklaagte on 22 Feb 2018.

Plate 14: Maize stands on cover crop trial at Deelpan on 23 Feb 2018.

4.3 Research and technical activities

4.3.1 Regenerative CA crop-livestock integrated system (Mr G Trytsman, Drr AA Nel, DJ Beukes)

The summer cover crop mixture established successfully as can be seen in Plate 15 (left). The agitator in the spreader due to the fast rotation and forces that were created had a devastative effect on the cowpea seed. A lot of the seed split in half as can be seen in Plate 15 (right). Continuous soil water and temperature measurements are being made and will be reported on by Dr Beukes.

Plate 15: Summer cover crop mixture (left) and damaged cowpea seeds (right).

4.3.2 Soil water, soil temperature and water table measurements

4.3.2.1 Measurements on Trial 1 (Drr DJ Beukes and AA Nel)

Results on soil water content, soil temperature and water table measurements will be reported on in the next progress report.

4.3.2.2 Measurements on Trials 2, 4 and 6 (Mr P van Staden, Senwes)

Downloaded sensor and thermistor data will be processed, interpreted and included in the next progress report.

4.3.3 Root diseases, soil microbiology and nematology (Dr A Abrahams, Mr O Rhode & Dr S Steenkamp, ARC-GCI)

Results on root diseases, soil microbiology and nematology on the cover crop (Deelpan) and crop rotation (Christinasrus) trials will be reported on in the next progress report.

5 COMMUNICATION OF PROJECT RESULTS

5.1 Farmers Day on 22 February 2018

The annual Farmers Day was held on 22 February 2018 on the farm Springboklaagte, Kroonstad, of Mr Danie Minnaar and was attended by 78 people consisting of farmers, representatives from organized agriculture and input suppliers. Trials were visited, as well as oral presentations of project results were made by the farmer co-workers. Region 22 of Grain SA also held an Information Session with presentations by Mr Jannie de Villiers, Chief Executive Officer, and Dr Dirk Strydom, both from Grain SA.

5.2 Publications

An article on the Farmers Day was submitted to SA Grain for publication, while an article by Me Marleen Smith on the project results from the 2016/17-season will appear in Landbouweekblad.

6 ANY PROBLEMS THAT HAVE BEEN ENCOUNTERED WITH THE PROJECT

On the cover crop trial (Trial 1), the unavailability of suitable planters hampered normal planting operations:

- No small seed planter was available and, consequently, planting was done using a fertilizer spreader, which is basically impossible to calibrate. This meant that the seeding rate was almost double for the area planted.

- Although a no-till maize planter was promised through goodwill, the eventual unavailability meant a specific treatment could not be implemented.

Mr Petrus van Staden reports on his studies that, in contrast to the previous season, several problems were encountered: Besides a porcupine that gnawed off a probe cable, a faulty motherboard and batteries of other probes will cause gaps in the recorded data.

7 MILESTONES THAT HAVE NOT BEEN ACHIEVED AND THE REASONS FOR THAT

On the cover crop trial (Trial 1), the unavailability of a no-till maize planter meant that the specific treatment (planting of no-till maize) could not be implemented. To compensate for this misfortune, the same treatments (planting of no-till summer and winter cover crop mixtures) as those of the previous season were implemented.

8 ASSESSMENT OF ADEQUACY OF FUNDING TO COMPLETE PROJECT

See the appended copies of bank statements for the periods 27 Sept 2017 to 26 Oct 2018, 27 Oct 2017 to 26 Nov 2017, 27 Nov 2017 to 26 Dec 2018 and 1 Oct 2017 to 22 March 2018, respectively. The balance on 2018-03-14 was R1 174 042.41.

At this stage, Mr G Trytsman has made no claims for time and kilometres spent. However, expenditure on accommodation and diverse items, amounting to R4060, were claimed and consequently paid by the project. Claims for March 2018 by Drr Beukes and Nel, as well as ARC-GCI, will be submitted in April 2018.

9 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, 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 biology 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.

10 LITERATURE CITED

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. 48 pp.

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.

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

11 APPENDICES

11.1 Bank Account Statement No 1

Stuur terug na:
Privaatsak X18, Johannesburg, 2000

Tjekrekeningnommer: **40-7617-4899**

Sandgrond Ontwikkelings Kommitee

008140
003645

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

Bb Northern Free State (00)
1ste Vloer Absa Gebou
1ste Vloer Absa Gebou
Crossstraat
Kroonstad
9499

056 216 7312

Tjekrekeningstaat

27 Sep 2017 tot 26 Okt 2017

Rekeningtipe:	Klassieke Besig Rek	**Uitgereik op:**	26 Okt 2017
Staatnr:	0089		
Kliënt BTW-reg-no:			

Rekeningopsomming:

Saldo oorgedra	795 029,79
Diverse Debiete	158 728,92-
Koste	115,00-
Saldo	**636 185,87**
Oortrekkingslimiet	**0,00**

U transaksies

Datum	*Transaksiebeskrywing*		*Koste*		*Debietbedrag*	*Kredietbedrag*	*Saldo*
27/09/2017	Saldo Oorgedra						795 029.79
27/09/2017	Bankstaat	Hoofkntoor	25.00	A			795 029.79
1/10/2017	Mndeliks Rek-fooi	Hoofkntoor		*	65.00		794 964.79
1/10/2017	Admin Koste	Hoofkntoor		*	50.00		794 914.79
5/10/2017	Ibank Betaling Na Absa Bank Arc-api	Vereffenin			85 415.85		709 498.94
5/10/2017	Ibank Betaling Na Absa Bank Bap Nel	Vereffenin			1 200.00		708 298.94
5/10/2017	Ibank Betaling Na Absa Bank Dr Dj Beukes	Vereffenin			72 113.07		636 185.87

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

KREDIETRENTE SOOS OP 27/09/2017 STANDAARD - VERWYS NA TAK

VAN NOU AF MOET JY JOU BESIGHEIDSREKENINGNOMMER IN PLAAS VAN JOU BESIGHEIDSREGISTRASIENOMMER GEBRUIK OM JOU E-STATE OOP TE MAAK EN AF TE LAAI ONS DINK JY SAL VIND DAT DIE PROSES BAIE VINNIGER, MAKLIKER EN GERIEFLIKER IS.

* = BTW R14.12- 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.

Bladsy 1 van 1 | Absa Bank Beperk
Gemagtigde Finansiëledienstverskaffer - Geregistreerde Kredietverskaffer, Reg-no NCRCP7
Registrasienommer (1986/004794/06) | **Belastingfaktuur**
BTW-registrasienommer 4940112230
CSP002CQ (05/2017) SOKOMMI002

SOKOMMI002 4076174899 0089 26/10/2017

11.2 Bank Account Statement No 2

Stuur terug na:
Privaatsak X18, Johannesburg, 2000

Tjekrekeningnommer: **40-7617-4899**

008140
003645

Sandgrond Ontwikkelings Kommitee

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

Bb Northern Free State (00)
1ste Vloer Absa Gebou
1ste Vloer Absa Gebou
Crossstraat
Kroonstad
9499

056 216 7312

Tjekrekeningstaat

27 Okt 2017 tot 26 Nov 2017

Rekeningtipe: Klassieke Besig Rek
Staatnr: 0090
Kliënt BTW-reg-no:

Uitgereik op: 26 Nov 2017

Rekeningopsomming:

Saldo oorgedra	636 185,87
Koste	90,00-
Saldo	**636 095,87**
Oortrekkingslimiet	**0,00**

U transaksies

Datum	*Transaksiebeskrywing*		*Koste*		*Debietbedrag*	*Kredietbedrag*	*Saldo*
27/10/2017	Saldo Oorgedra						636 185.87
27/10/2017	Bankstaat	Hoofkntoor	25.00	A			636 185.87
1/11/2017	Mndelike Rek fooi	Hoofkntoor		*	65.00		636 120.87
1/11/2017	Admin Koste	Hoofkntoor		*	25.00		636 095.87

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

KREDIETRENTE SOOS OP 27/10/2017 STANDAARD - VERWYS NA TAK

ABSA BESIGHEIDSBANKDIENSTE HERSIEN SY FOOIE EN KOSTE VANAF 1 JANUARIE 2018
KONTAK ASSEBLIEF U VERHOUDINGSKAKEL VIR MEER GEDETAILLEERDE INLIGTING OF
BESOEK ABSA.CO.ZA

* = 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.

Bladsy 1 van 1

Absa Bank Beperk
Gemagtigde Finansiëledienstverskaffer - Geregistreerde Kredietverskaffer, Reg-no NCRCP7
Registrasienommer (1986/004794/06)

Belastingfaktuur
BTW-registrasienommer 4940112230
SOKOMM002

CSP002CQ (05/2017)
SOKOMM002 4076174899 0090 26/11/2017

11.3 Bank Account Statement No 3

Stuur terug na:
Privaatsak X18, Johannesburg, 2000

Tjekrekeningnommer: **40-7617-4899**

Sandgrond Ontwikkelings Kommitee

008140
003645

SANDGROND ONTWIKKELINGS KOMMITEE
POSBUS 7042
KROONPARK
9502

Bb Northern Free State (00)
1ste Vloer Absa Gebou
1ste Vloer Absa Gebou
Crossstraat
Kroonstad
9499

056 216 7312

Tjekrekeningstaat

27 Nov 2017 tot 26 Des 2017

Rekeningtipe:	Klassieke Besig Rek	**Uitgereik op:**	26 Des 2017
Staatnr:	0091		
Kliënt BTW-reg-no:			

Rekeningopsomming:

Saldo oorgedra	636 095,87
Diverse Debiete	22 074,93-
Koste	90,00-
Saldo	**613 930,94**
Oortrekkingslimiet	**0,00**

U transaksies

Datum	*Transaksiebeskrywing*		*Koste*		*Debietbedrag*	*Kredietbedrag*	*Saldo*
27/11/2017	Saldo Oorgedra						636 095.87
27/11/2017	Bankstaat	Hoofkntoor	25.00	A			636 095.87
1/12/2017	Mndeliks Rek-fooi	Hoofkntoor		*	65.00		636 030.87
1/12/2017	Admin Koste	Hoofkntoor		*	25.00		636 005.87
17/12/2017	Ibank Betaling Na Absa Bank Agri Consult Trust	Vereffenin			22 074.93		613 930.94

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

KREDIETRENTE SOOS OP 27/11/2017 STANDAARD - VERWYS NA TAK

ABSA BESIGHEIDSBANKDIENSTE HERSIEN SY FOOIE EN KOSTE VANAF 1 JANUARIE 2018
KONTAK ASSEBLIEF U VERHOUDINGSKAKEL VIR MEER GEDETAILLEERDE INLIGTING OF
BESOEK ABSA.CO.ZA

* = 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.

Bladsy 1 van 1

CSP002CQ (05/2017)

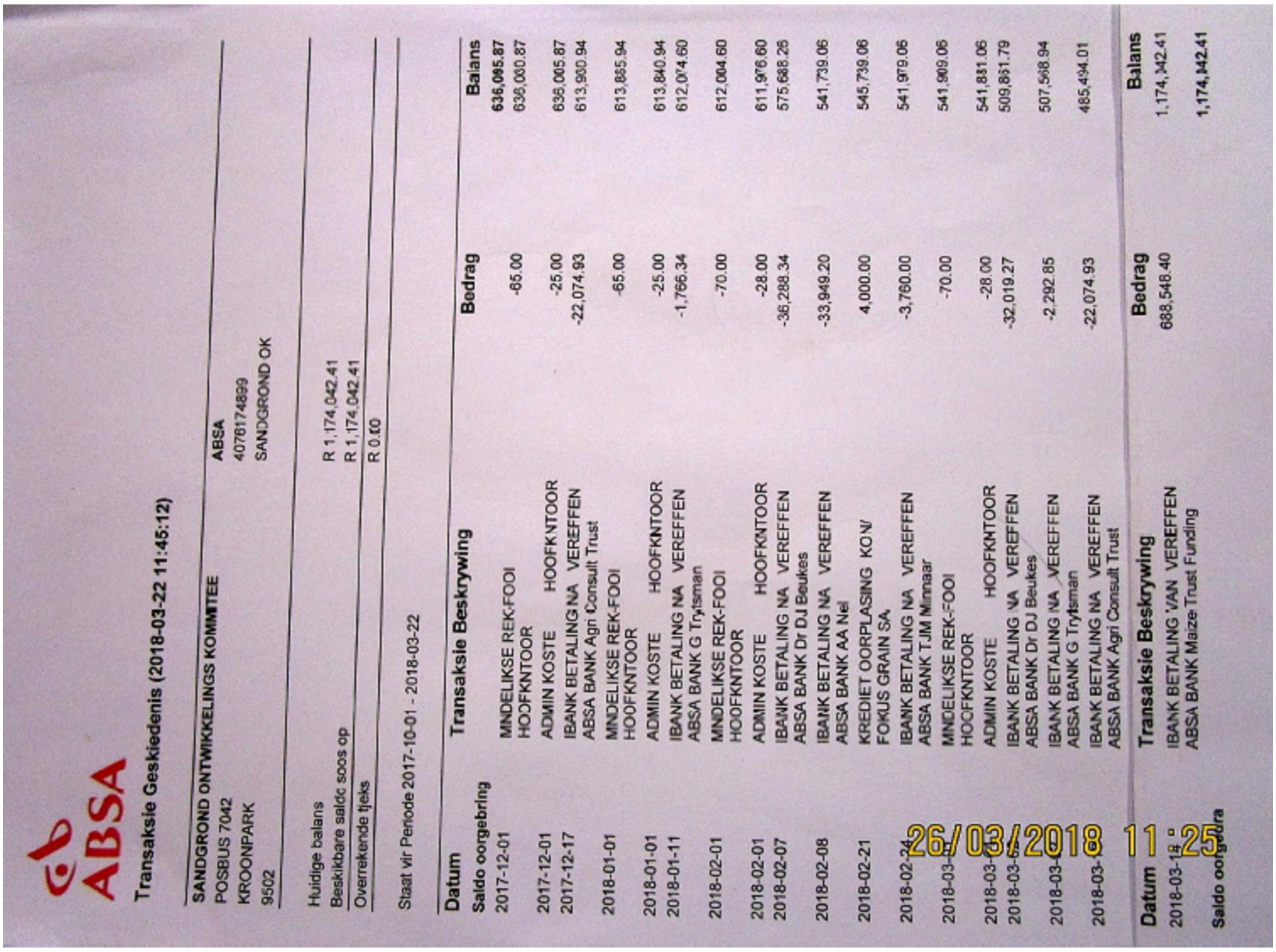
Absa Bank Beperk
Gemagtigde Finansiëledienstverskaffer - Geregistreerde Kredietverskaffer, Reg-no NCRCP7
Registrasienommer (1986/004794/06)

Belastingfaktuur

BTW-registrasienommer 4940112230
SOKOMMI002

SOKOMMI002 4076174899 0091 26/12/2017

11.4 Bank Account Statement No 4



ABSA

Transaksie Geskiedenis (2018-03-22 11:45:12)

SANDGROND ONTWIKKELINGS KOMMITEE	ABSA
POSBUS 7042	4076174899
KROONPARK	SANDGROND OK
9502	

Huidige balans	R 1,174,042.41
Beskikbare saldo soos op	R 1,174,042.41
Overrekende tjeks	R 0.00

Staat vir Periode 2017-10-01 - 2018-03-22

Datum	Transaksie Beskrywing	Bedrag	Balans
Saldo oorgebring			636,095.87
2017-12-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	636,030.87
2017-12-01	ADMIN KOSTE HOOFKNTOOR	-25.00	636,005.87
2017-12-17	IBANK BETALING NA VEREFFEN ABSA BANK Agri Consult Trust	-22,074.93	613,930.94
2018-01-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-65.00	613,865.94
2018-01-01	ADMIN KOSTE HOOFKNTOOR	-25.00	613,840.94
2018-01-11	IBANK BETALING NA VEREFFEN ABSA BANK G Trytsman	-1,766.34	612,074.60
2018-02-01	MNDELIKSE REK-FOOI HOOFKNTOOR	-70.00	612,004.60
2018-02-01	ADMIN KOSTE HOOFKNTOOR	-28.00	611,976.60
2018-02-07	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-36,288.34	575,688.26
2018-02-08	IBANK BETALING NA VEREFFEN ABSA BANK AA Nel	-33,949.20	541,739.06
2018-02-21	KREDIET OORPLASING KON/ FOKUS GRAIN SA	4,000.00	545,739.06
2018-02-24	IBANK BETALING NA VEREFFEN ABSA BANK TJM Minnaar	-3,760.00	541,979.06
2018-03-[illegible]	MNDELIKSE REK-FOOI HOOFKNTOOR	-70.00	541,909.06
2018-03-[illegible]	ADMIN KOSTE HOOFKNTOOR	-28.00	541,881.06
2018-03-[illegible]	IBANK BETALING NA VEREFFEN ABSA BANK Dr DJ Beukes	-32,019.27	509,861.79
2018-03-[illegible]	IBANK BETALING NA VEREFFEN ABSA BANK G Trytsman	-2,292.85	507,568.94
2018-03-[illegible]	IBANK BETALING NA VEREFFEN ABSA BANK Agri Consult Trust	-22,074.93	485,494.01

Datum	Transaksie Beskrywing	Bedrag	Balans
2018-03-1[illegible]	IBANK BETALING VAN VEREFFEN ABSA BANK Maize Trust Funding	688,548.40	1,174,042.41
Saldo oorgedra			1,174,042.41

26/03/2018 11:25