APPENDIX 4:

PROGRESS REPORT

THE PROMOTION OF CONSERVATION AGRICULTURE IN THE NORTH-EASTERN FREE STATE – PHASE 1 (TWO STUDY AREAS)

For period:

October 2015 to September 2016

Compiled by:

HJ Smith, Grain SA

In collaboration with:

Riemland (Reitz) and Ascent (Vrede) study groups

GRAIN SA
GRAAN SA

The Maize Trust

September 2016

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1. Introduction

This progress report covers the first year of the implementation of a project funded by The Maize Trust (MT)**,** which will assist with the scaling out of Conservation Agriculture (CA) to grain farmers in the north-eastern Free State Province. The north-eastern and eastern parts of the Free State are seen as key grain producing areas and have very suitable conditions (soil and climate) to practice CA; however, the area still has a very low adoption percentage of farmers practising CA. Consequently, this area has been identified by Grain SA's CA Farmer Innovation Programme (CA-FIP) as a target area to promote CA among farmers in order to improve their sustainability and profitability. The Grain SA CA-FIP uses innovative, well organised and interested farmers and/or their structures (e.g. study groups, clubs, associations, etc.) as platform to launch projects and scale out CA to the surrounding farming communities. In this respect two active study groups, namely Ascent (Vrede district) and Riemland (Reitz district) have agreed to serve as platforms to launch projects in these two study areas. The study groups have consequently been engaged in various planning and implementation activities for the 2015/16 season, which have all been included in various work packages that serve as the framework for this proposal.

Central to the CA-FIP philosophy and approach, farmers' resource-base, experiences, practices, problems, fears, perceptions and needs form the basis of any proposed or intended (project) intervention to promote CA in a specific area. The 'learning process starts from what they know and where they are'. As a first step a 'diagnosis' of the situation was needed. The **aim of the diagnostic phase** was to assist stakeholders to analyse, describe and understand the current [farming] system or situation in need of change (to 'build a picture or model' of and to 'get a handle' on their situation in order to formulate effective solutions). There after a participatory planning session took place aiming to identify solutions or treatments to the problems, work packages and an immediate action plan. **Figure 1** below indicates the participatory diagnosis and planning process followed with the Riemland study group (on 18 August 2014 at the Mooigelegen farm, Reitz district) and the Ascent study group (on 19 August 2014 at the Ascent grain silo, Vrede district). These events were facilitated by Dr Hendrik Smith (CA Facilitator at Grain SA), assisted by Dr Sybrand Engelbrecht (CA research coordinator, The Maize Trust). Mr Willem Killian and Ms Lientjie Visser from the ARC-SGI at Bethlehem also participated in both events.

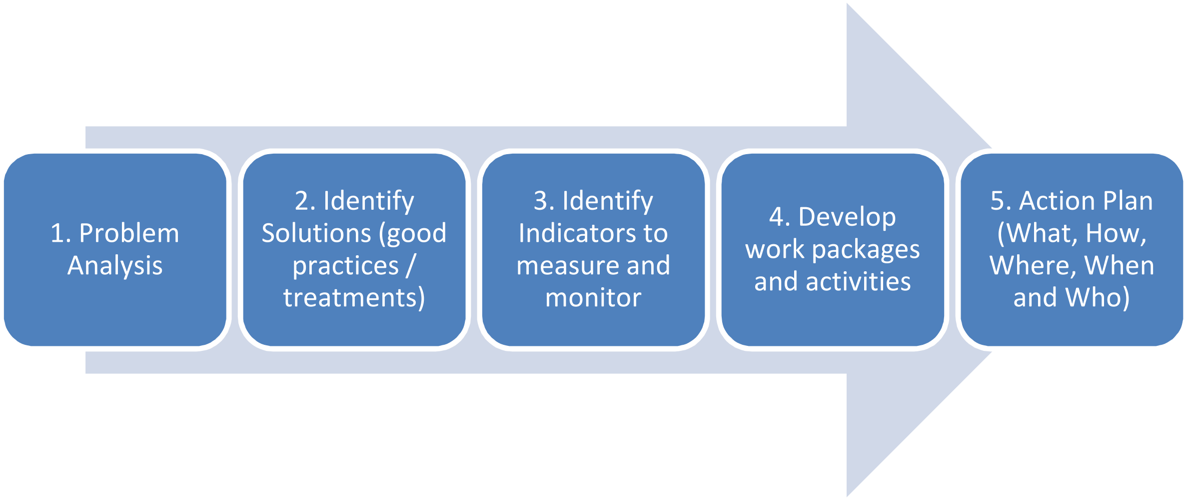


Figure 1: The participatory diagnosis and planning process followed with the Riemland and Ascent study groups

2. Description of the targeted study area(s)

The two study areas identified (listed below) were described in detail (Grain SA, March 2015).

The Frankfort-Vrede Plain occupies most of the northern half of the study area, south of the Vaal River. The underlying geology is mainly mudstone and sandstone of the Adelaide Formation, Beaufort Group with, in the north-east, shale of the Volksrust formation, Ecca Group. Dolerite intrusions occur frequently. The soils are mainly dark, swelling clays of the Arcadia form along with duplex soils (sandy, often bleached topsoil abruptly overlying gleyed clay) of the Estcourt and Kroonstad forms, especially in the north-west.

The Bethlehem-Reitz Basin, in the west of the area, is underlain mainly by mudstone and sandstone of the Tarkastad Formation, Beaufort Group. The soils here are mainly grey and yellow, sandy loam to sandy clay loam soils with grey, mottled plinthic subsoils, belonging to the Avalon, Westleigh and Longlands forms. Duplex soils, as well as shallow, rocky soils of the Mispah form, are also present.

3. Targeted beneficiaries or key project participants

Two separate farmer-centred Innovation Platforms (IP's) have been established around the Ascent and Riemland farmer study groups, which will target farming communities in the following Grain SA regions (and districts): Region 15 (Heilbron, Frankfort and Vrede) and Region 18 (Reitz and Lindley). Each of these two regions constitute fairly homogeneous agro-ecological conditions, which will facilitate the scaling out of CA practices from the representative project sites and trials on selected (or volunteering) farmers' fields (in the Vrede and Reitz districts).

It is envisaged that the IP's will be able to create a general awareness and innovation capacity among the farming communities in these regions and even beyond their borders. The official number of Grain SA members (grain producers) in these regions are 583 (region 15) and 371 (region 18), which have direct communication channels through the Grain SA structures and processes. Added to this is approximately the same number of non-member producers in these regions who are also seen as potential primary beneficiaries. Very few of these grain producers (<5%) follow CA practices, although a substantial (but unknown) percentage do follow some form of reduced tillage practice. The reasons for the poor adoption of CA is not well-understood, but are most probably and primarily due to a lack of information and awareness of the long term benefits of CA on farming and the environment. It is of utmost importance to break this cycle of ignorance and empower farmers with a truly sustainable farming system.

4. Project aim

The aim of the project is:
To promote conservation agriculture in key grain producing areas of the North-eastern Free State through a farmer-centred innovation process.

4.1. Objectives

The following short-term objectives will assist the project in achieving its aim:

a) To establish and facilitate on-farm trials around two local farmer structures (i.e. the Ascent and Riemland study groups)
b) To monitor and analyse a series of on-farm, farmer-led trials on selected farmers' fields
c) To create wider awareness and innovation capacity in local farming communities on the practices and benefits of locally adapted CA systems.
d) To support farmer facilitation, administration and reporting processes.

In order to effectively implement the above short-term objectives, a number of cross-cutting **work packages** were designed with each having a designated person or institution to implement and manage the specific activities and budget (see Section 11 below for detailed discussion of work packages). **Table 1** shows the different work packages and responsible champions in each project:

Table 1: Work packages and lead partners in Riemland and Ascent projects

Work Package	Lead partner - Riemland	Lead partner - Ascent
1. Coordination and management	Danie Slabbert (Riemland study group)	Paul Zietsman (Ascent study group)
2. Assessment of soil quality under CA systems	GP Schoeman (AgriSol or AS); Willie Pretorius (Soil Health Solutions or SHS)	Paula Lourens (Vermi Solutions or VS), Willie Pretorius (Soil Health Solutions or SHS)
3. Assessment of cover crop adaptability and suitability	Gerrie Trytsman (ARC-API)	Gerrie Trytsman (ARC-API)
4. Agronomic field trial planning, analyses and reporting	Willem Killian (ARC-SGI)	Willem Killian (ARC-SGI)
5. Coordination and facilitation of project activities among farmer participants	Pieter de Wet (VKB)	Robert Steynberg (VKB)

5. Project approach and rationale

In the original Grain SA proposal submitted in March 2015, the development and implementation of *Innovation Systems (IS)* to adapt CA principles to local (farmer) conditions has been well motivated and approved. Accordingly, and at the very least, the emphasis has to be on on-farm research and the inescapable experiential learning that this generates; both of which critically place the farmer in the central role.

Since the commencement of the implementation process in 2015, several 'actors' that influence the 'working' of the innovation process around the two project study areas, *have been 'formally' and effectively integrated with the IP's in the form of work packages and related responsibilities*. The CA FIP is confident that these two local IP's have their focus on **farmer empowerment**, i.e. ensuring that farmers are recognised, accepted, rewarded and used as independent innovators (or researchers). Proper facilitation and coordination of this farmer-led innovation process and its various activities is crucial and in the light of this IS philosophy, local resources (people) took up these responsibilities quite effectively. The CA facilitator at Grain SA (Dr Hendrik Smith), who manages and implements the CA-FIP, fulfils an overarching role in this respect. Another prominent local stakeholder, namely VKB, is playing a vital role at both sites as project or farmer facilitators, as well as implementing and monitoring field trials and other activities.

The key elements of the CA-FIP project approach are as follows:

5.1. Farmer-centred Innovation Systems Research

CA is defined by three key principles that have to be applied simultaneously and adapted to each farm ecosystem, namely minimal mechanical soil disturbance, permanent organic soil cover and crop diversity. The inescapable consequence of this is that farmers have to function as applied ecologists who have to fine-tune (adapt) universal principles to their own social, economic and ecological circumstances. As mentioned above, farmers are the adopters, the adapters and often the innovators of new farming techniques through an **on-farm, farmer-led research** process.

A series of selected on-farm, farmer-led trials, where farmers are lead or equal partners (in identifying research needs, designing, implementing and evaluating experiments), will give farmers independence, ownership and control. Experiments were well designed with appropriate treatments and sufficient replications spread over the entire agro-ecological zone and/or on a sufficient number of farms (see trial designs and layouts attached). Data from properly designed experiments will provide a much stronger starting point for discussion and investigation of a farmer's claims or problems. Hence, scientifically valid data are being generated and strengthened through the involvement of agricultural scientists in group problem solving and on-farm research (through the different work packages).

5.2. Participatory monitoring, evaluation and adaptive management

There are several purposes in the use of PM&E within the CA FIP, for example to enhance shared understandings (i.e. to offer a forum that allows different stakeholders to articulate their perspectives); to increase participants' engagement, sense of ownership, and self-determination; to strengthen organizations and promote institutional learning; to encourage institutional reform towards more participatory structures; etc. In this context PM&E is regarded less as an instrument of reporting and auditing, and more as a means of *enabling organizations and groups to keep track of their progress, build on their successes, and enhance their capacities for self-reflection, learning, and social responsiveness (or adaptability)*. Thus, PM&E is used in a more transformative / empowerment way to support learning and adaptive management among those involved.

The following indicators were identified and are being measured and monitored by and through the different work packages:

INDICATOR	YES / NO	MEASUREMENT	WHO (Ascent)	WHO (Riemland)
Compaction	Y	Root evaluation; bulk density; penetration resistance	Facilitator	Facilitator
Wind erosion	Y	Ground cover after plant (per	Farmers &	Farmers &

		Monitoring form)	Facilitator	Facilitator
Soil fertility	Y	Macro and micro nutrients – on row and in-between	VS	AS
Soil biology / Soil structure	Y	%C / SOM / MO/ C02 soil respiration – different depths every 3-4 yrs	VS & SHS	AS & SHS
Rainfall	Y	Per event / 24 hour	Rain gauge	Rain gauge
Pests	Y	Monitoring form	Farmers & Facilitator	Farmers & Facilitator
Diseases (soil-borne)	N	Monitoring form	NA	NA
Nematodes	N	Nematode counts	NA	NA
Production	Y	Yield; kg/mm; kg/kg NPK; biomass	Farmers & Facilitator	Farmers & Facilitator
Weeds	Y	Weed counts; keep plots clear of weeds; weed control / herbicide programme	Farmers & Facilitator	Farmers & Facilitator
Mico-toxins	N			
Economy	Y	Gross margin / savings of treatments / systems economy	Farmers & Facilitator	Farmers & Facilitator
Grain quality	Y	Grading	VKB	VKB
Record keeping	Y	Description of all physical and chemical practices on treatments	Farmers	Farmers
Water content	Y	Soil moisture probes	Facilitator	Facilitator

5.3. Reference Group

A Reference Group will be appointed for the project by the CA-FIP at Grain SA. The Reference Group (comprising key, concerned and capable persons) is tasked to provide the project team with guidance and to assist the CA-FIP in monitoring progress and evaluating deliverables. The Reference Group is only required to act in an advisory capacity.

It should be noted that, in exceptional cases, projects are not assigned a Reference Group.

Reference Group meetings are scheduled annually (or more frequently, if required) with the Project Leader in attendance and the CA-FIP facilitator fulfilling the role of Chairperson. Progress reports for the preceding period and work programmes for the following cycle are tabled at these meetings.

5.4. Awareness and marketing

General awareness (or sensitisation) has been experienced as particularly important to stimulate farmers getting involved with further learning activities, such as experimentation. The whole CA farmer innovation process usually needs an 'impulse' or an injection of energy (knowledge) to start or to speed-up the momentum and mostly it is a specific awareness event or sensitisation that achieves that. The CA-FIP sees three distinct awareness raising activities as key events during the entire CA innovation process:

- Organise cross-visits or Look & Learn visits to other successful CA communities or farmers
- Develop/distribute posters, pamphlets, videos/dvd's and other material to support the awareness raising events/campaign.
- Organise/support major or annual information days, workshops or conferences.

6. Work packages

As discussed above, a number of key stakeholders, who could play a role in the implementation of the project, were identified and involved at the start of the project. These stakeholders were invited to a planning workshop where they took part in a participatory brainstorm, identifying and prioritizing problems and solutions, consequently leading to the design of a number of Work Packages (WPs) to be implemented by selected stakeholders who were identified through these meetings. The project budget was consequently developed around these WPs, linked to various activities and deliverables. The implementation of these WPs is collectively monitored and managed through the project team, especially during site visits and monthly meetings. The on-farm trials form the basis of all the other activities in the project and will run through a number of seasons. Emphasis will be placed on data collection, interpretation, reporting and awareness.

7. Implementation of work plan – A summary of progress to date (October 2015 to September 2016)

KEY ACTIVITY	TIMELINE	INDICATOR OF SUCCESS	PROGRESS TO DATE (for period Oct'15-Sep'16)
Objective 1: To establish and facilitate on-farm trials around two local farmer structures (i.e. study groups)			
a) Prepare, establish and manage on-farm trials on selected sites (farms)	Continuous	Statistically designed trials established and managed on selected trial sites	Statistically designed trials were designed, established and managed on selected trial sites. ARC-SGI helped the Riemland group to measure, prepare and harvest the trial sites. Assistance was also given with the planting and harvesting of the row width trial. – see trial layouts attached
Objective 2: To monitor and analyse a series of on-farm, farmer-led trials on selected (volunteering) farmers' fields			
a) Participatory	January to	Collection of a	Collection of a range of

monitoring / data collection	September 2016	range of selected indicators from trials, especially soil samples	selected indicators from trials, especially soil samples. ARC-SGI sampled soil at all the trials to measure moisture at planting time.
b) Farmer participatory M&E and discovery learning	January to September 2016	Completion of Field monitoring form with farmers	Completion of Field monitoring form with farmers. ARC-SGI helped farmers to identify a fungus which was observed on maize stubble.
c) Data Analysis and Evaluation	June to September 2016	Analysis of data collected from on-farm trials and field forms	Analysis of data collected from on-farm trials and field forms.
Objective 3: To create wider awareness and innovation capacity in local farming communities on the practices and benefits of locally adapted CA systems.			
a) Annual farmers day or conference	February to March	A well organised and -attended awareness event	A farmers' day was successfully held at Ascent on 18 February, which was attended by 77 participants. A farmers day (green tour) was successfully held in Reitz on 17 March, which was attended by 100 participants.
b) Exposing on-farm trials to interested farmers and other	Continuous	Trial visits by interested people	A number of interested people (mostly farmers) have been visiting the on-farm trials through the season and had discussions with participating farmers.
Objective 4: To support social learning, farmer facilitation, administration and reporting processes.			
a) Project meetings	Bi-monthly meetings	At least six project meetings per year	A number of project meetings were held at each of the project sites to monitor and manage planned activities.
b) Farmer facilitation	Continuous	Effective deployment of a local farmer facilitation to assist	Two farmer facilitators were identified to facilitate and coordinate activities with and between the farmer co-workers, namely Pieter de Wet

		implementation and M&E with farmers	(VKB, with Riemland) and Robert Steynberg (VKB, with Ascent).
c) Reference Group	August	A well organised annual reference group meeting	Held on 15 August (Reitz) and 16 August (Vrede)
d) Reporting	March and September	Six-monthly and annual reports according to specifications	Completed annual report for period October 2015 to September 2016.

8. Implementation of work packages – A detailed report on progress to date (October 2015 to September 2016)

8.1. Coordination and management

Work Package title	**Coordination and management**
Work Package period	October 2015 to September 2016
Lead partner	Riemland and Ascent study groups
Involved partners	All
Objectives	Coordinate activities among all partners Ensure timely reporting to Grain SA Promote synergy among project activities
Justification	Project size, complexity and level of integration/interdependency among different project actions require strict delivery and adherence to project timelines as essential. Partners must often work together to achieve specific project outputs.
Description of work	**Project inception workshop.** A one-day project planning and inception workshop was held at the beginning of the project to enable all project partners to define work packages and procedures to achieve the project outputs and objectives. These WP's are used for the financial control and payment of the project and for the monitoring of the agreed tasks and deliverables. Work package managers were identified at this

	meeting and will present/follow strategies and protocols which are frequently monitored by all partners. **Frequent coordination meetings**. The purpose of these monthly or bi-monthly meetings is to establish and manage an Innovation Platform (IP) for improved communication, integration and sharing. The essence or key action in these meetings will be social learning, characterised by feedback, reflection, planning and coordination between different work packages and stakeholders. A secondary activity is the creation of a wider network in support of communication, sharing, learning and scaling out. **Annual Reference Group Meetings.** Formal reference group meetings will be organised each year with representation from each work package. In order to provide the project with independent monitoring, advice and support and to ensure communication with key stakeholders, a group of experts and end users (reference group) will be formed and invited to participate. Presentations from each work package leader will summarise achievements. Discussions about progress, potential deviations from the work plan and forward planning will be standing items at each meeting. **Activity reporting.** Partners will prepare a two-page activity report *every six months*. The lead applicant and work package managers will use these to assess whether work progresses to plan and take action to minimise the effects of delays on other project activities. **Annual progress reports.** Annual reports will be made following Maize Trust / CA-FIP instructions. Work package managers will be responsible for collating information and making a single work page report. The lead applicant will be responsible for integrating these into a single full report. A similar approach will be used to prepare the final project report covering information from all project years.

Deliverables	• Project actions and reporting delivered on time

Risks	None anticipated

8.2. Assessment of soil quality under CA systems

Work Package title	**Assessment of soil quality under Conservation Agriculture (CA) systems**
Period	October 2015 to September 2016

Lead partners	AgriSol (Mr. GP Schoeman), Vermi Solutins (Ms Paula Lourens)
Involved partners	Riemland & Ascent study groups, ARC-SGI, Grain SA,

Objectives	• To characterize the soil types and soil physical, biologial & chemical parameters, such as particle distribution, pH, Soil Organic Matter (SOM), macro-, micro-nutrients, and microbial activity and -diversity • To compare the effect of different CA treatments on soil quality • To establish relationships between different soil parameters, yield and atmospheric elements

Justification	A number of studies suggest that a soil and nutrient management strategy based on a broader range of ecosystems processes is worth further investigation. The approach shifts the emphasis of soil nutrient (fertility) management away from soluble, inorganic plant-available pools to organic and mineral reservoirs that can be accessed through microbial and plant mediated processes. However, a relatively poor understanding and capacity exist among the local research fraternity to investigate these crucially important subjects.

Description of work	Characterise the effects of different CA practices (treatments) on soil nutrient and physical dynamics as well as crop growth and yield, will involve regular field visits, sampling of soil on selected transects / sites and time intervals, laboratory analyses of the samples, data processing, statistical analyses and report writing.

Activities	1. Monitoring and Sampling 2. Lab Analyses 3. Monthly meetings (project team) 4. Annual reference group meeting (advisory committee) 5. Annual report and admin (technical data) 6. Participate in Awareness events

Risks	• Being a dryland experiment, low and erratic rainfall may compromise crop yields; • Wild animals and birds may jeopardise crop performance and yields; • Instrumental failure can result in incomplete data results

ACTIVITIES AND DELIVERABLES

Activities	Deliverables
1. Monitoring and Sampling	Soil classification (types and depths) Detailed sampling of each trial site; Selected samples in surrounding landscape Root evaluations in soil profiles
2. Lab Analyses	Organic C (%) Standard soil analysis: 4 basic cations, P, pH, ratios, micro-elements Texture (once-off, top- and subsoil) Soil biology (Haney test and others)
3. Monthly meetings (project team) & Training	Participate in monthly forum meetings, discussing problems and possible solutions to that.
4. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of data. Learning from each other.
5. Annual report and admin (technical data)	Written technical report covering trial procedures, results and progress.
6. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

Activities	Progress and Results achieved
1. Monitoring and Sampling (Done with activity 3 above)	**Ascent:** Sampled plots at Izak Dreyer on 19/10/2015: 12 samples were taken on trial plots. Started sampling at Danie Portwig on the same day, but they stopped the process due to the severe drought.
2. Lab Analyses	A comprehensive soil database is being compiled by AgriSol for further relevant analyses and presentations. See preliminary analytical results attached below.
3. Monthly meetings (project team)	Frequent relevant meetings were held.
4. Annual reference group meeting	Held on 15 August (Reitz) and 16 August (Vrede)
5. Annual report and admin	Submitted comprehensive annual report in August 2016.
6. Participate in Awareness events	Participated in green tour on 17 March.

Soil analytical results, Reitz: Soil chemical results of two trial sites at Van Rooyenswoning (Danie Slabbert) are shown below.

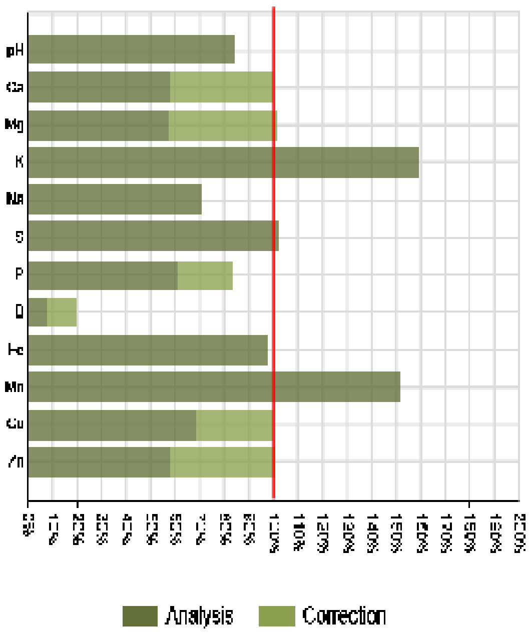
SOIL ANALYSIS AND RECOMENDATION

Summary of precision analysis

Number Of Samples	3	Owner	Pieter Slabbert boerdery
Depth Of Correction	15 cm	Farm	Van Rooyenswoning
Laboratory	SGS	Field	L03
Job Assignment Number	J001270	Date Sampled	07/05/2016
Sample Number	942-07849 - 942-07851		

Nutrient status (Capacity)

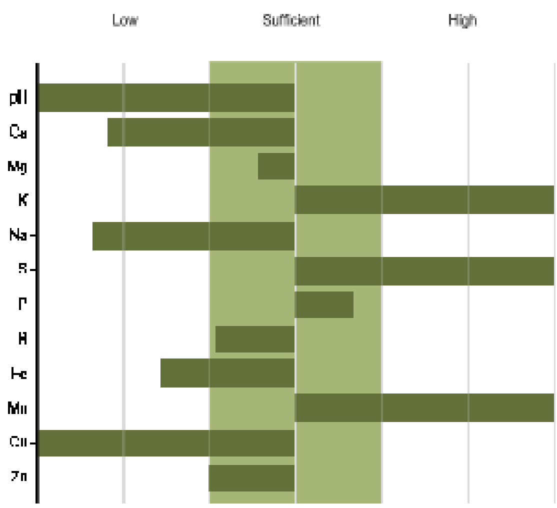
	Analysis	Target
TEC	5.02	-
pH	5.32	6.3
OM	1.24	-
Dissolvable S (ppm)	26	25
P M 3 (ppm)	39	63
Ca (ppm)	360	623
Mg (ppm)	69	120
K (ppm)	191	120
Ca (% of TEC)	35.90	62.15
Mg (% of TEC)	11.47	17.85
K (% of TEC)	9.78	6.14
Na (% of TEC)	0.71	1
Other bases (% of TEC)	6.76	5.1
H (% of TEC)	35.38	7.76
B (ppm)	0.12	1.5
Fe (ppm)	98	100
Mn (ppm)	69	45
Cu (ppm)	2.27	3.31
Zn (ppm)	3.64	6.30



Calculated (kg/ha)	
Borinate	2
Prolime Calcite	927
Copper Sulfate (12%)	16.8
Gypsum	0
Ottoshoop dolomite	870
Manganese Sulfate	0
MAP	125
Potassium Sulphate	0
Zink Sulfate Monohydrate (35%)	14.7

Nutrient availability (Intensity)

	Analysis	Norm Min	Norm Max
pH (H2O)	5.29	6.2	6.5
Ca (ppm)	24.16	30	40
Mg (ppm)	6.57	6	8
K (ppm)	34.24	12	15
Na (ppm)	0.98	3	6
S (ppm)	20.90	1	3
P (ppm)	0.55	0.3	0.6
B (ppm)	0.05	0.05	0.1
Fe (ppm)	0.22	0.5	1.5
Mn (ppm)	0.58	0.07	0.1
Cu (ppm)	0.01	0.05	0.08
Zn (ppm)	0.07	0.07	0.15



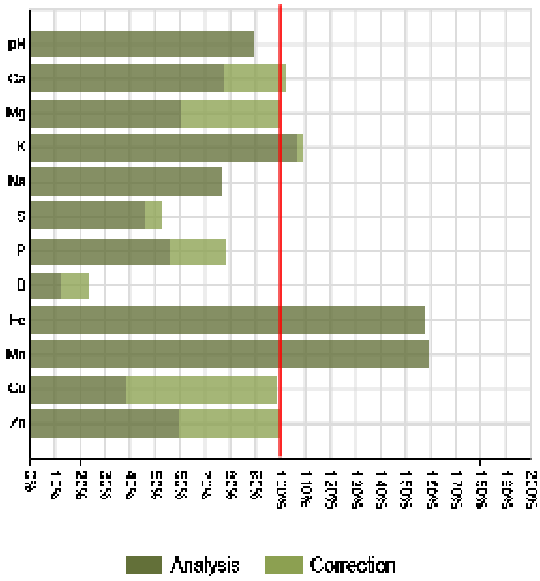
SOIL ANALYSIS AND RECOMENDATION

Summary of precision analysis

Number Of Samples	3	Owner	Pieter Slabbert boerdery
Depth Of Correction	15 cm	Farm	Van Rooyenswoning
Laboratory	SGS	Field	I14 proef
Job Assignment Number	J001270	Date Sampled	07/05/2016
Sample Number	942-07853 - 942-07855		

Nutrient status (Capacity)

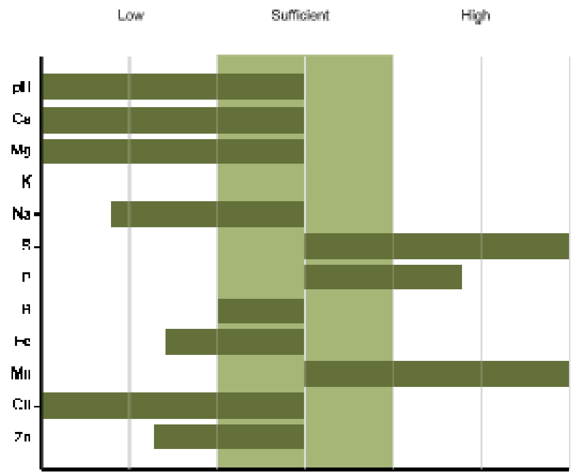
	Analysis	Target
TEC	5.07	-
pH	5.63	6.3
OM	0.89	-
Dissolvable S (ppm)	12	26
P M 3 (ppm)	34	60
Ca (ppm)	487	631
Mg (ppm)	73	120
K (ppm)	128	120
Ca (% of TEC)	48.26	62.24
Mg (% of TEC)	11.99	17.76
K (% of TEC)	6.48	6.10
Na (% of TEC)	0.78	1
Other bases (% of TEC)	6.15	5.1
H (% of TEC)	26.34	7.80
B (ppm)	0.19	1.5
Fe (ppm)	158	100
Mn (ppm)	73	46
Cu (ppm)	1.29	3.34
Zn (ppm)	3.63	6.06



Calculated (kg/ha)	
Borinate	2
Prolime Calcite	417
Copper Sulfate (12%)	33.1
Gypsum	6
Ottoshoop dolomite	822
Manganese Sulfate	0
MAP	122
Potassium Sulphate	12
Zink Sulfate Monohydrate (35%)	13.8

Nutrient availability (Intensity)

	Analysis	Norm Min	Norm Max
pH (H2O)	5.66	6.2	6.5
Ca (ppm)	12.56	30	40
Mg (ppm)	3.80	6	8
K (ppm)	13.49	12	15
Na (ppm)	1.18	3	6
S (ppm)	6.98	1	3
P (ppm)	0.72	0.3	0.6
B (ppm)	0.05	0.05	0.1
Fe (ppm)	0.20	0.5	1.5
Mn (ppm)	0.14	0.07	0.1
Cu (ppm)	0.01	0.05	0.08
Zn (ppm)	0.04	0.07	0.15



8.3. Assessment of cover crop adaptability and suitability

Work Package title	**Assessment of cover crop adaptability and suitability**

Work Package period	October 2015 to September 2016
Lead partner	ARC-API (Mr. Gerrie Trytsman)
Involved partners	Grain SA, Riemland & Ascent study groups / IP's

Objectives	• To establish and maintain an on-farm screening trials • Determining the biological production of different cover crops • Measuring the production of crop residues of each cover cropping system • Measure the adaptability of cover crops in different agro-ecological regions

Justification	Cover crops offer many benefits for agriculture productivity and sustainability while reducing off farm environmental effects. For agricultural productivity, sustainability and soil health these include: erosion control, compaction remediation, increased water infiltration and storage, improved soil biodiversity, increased organic matter, nitrogen fixation, and improved nutrient recycling and retention of macro and micro nutrients. Environmental benefits include: reduced nutrient leaching, reduced sediment and phosphorus deposition, reduced runoff, and increased carbon sequestration; while suppression of weeds, diseases and nematodes and improved beneficial insect habitat results in reduced pesticide use. Other conservation benefits include: pollinator enhancement, wildlife enhancement as well as aesthetic value (Stivers-Young and Tucker, 1999; and Snapp *et al.,* 2005). The use of no-tillage systems greatly increases the benefits of cover crops and vice versa. No-till systems increases water conservation by maintaining cover crop residues on the surface. No-till systems reduce the disruption of the soil reducing: soil erosion, water runoff, organic matter oxidation and increases; infiltration and all of the benefits of improved organic matter accumulation. Stratification of the soil profile as result of no-till is important for macro invertebrates and soil micro-organisms. Tillage leads to unfavorable effects such as: soil erosion, soil compaction, loss of organic matter, degradation of soil aggregates, death or disruption of soil microbes and other organisms including; mycorrhizae, arthropods, and earthworms. Continuous no-till needs to be managed very differently in order to maintain or increase crop yields. Residue, weeds, equipment, crop rotations, water, disease, pests, and fertilizer management are just some of the many details of farming that change when switching to no-till.

	Tillage generally increases the amount and speed of nitrogen mineralization of soil organic matter which may increase or decrease synchrony of nitrogen release depending on the timing of the subsequent crop's nitrogen needs.

Description of work	**On-farm, farmer-led screening trials: around 10 potential cover crops**

Activities	7. Land preparation (finding a suitable location, sourcing materials) 8. Purchase Materials & Equipment 9. Establishing and Planting of trials 10. Seasonal management and maintenance of trials 11. Monitoring and Sampling (including harvesting, biomass and yield determination, nutrient analysis) 12. Lab Analyses 13. Monthly meetings (project team) & Training 14. Annual reference group meeting (advisory committee) 15. Harvesting, biomass and yield determination, nutrient analysis 16. Annual report and admin (production & technical data) 17. Participate in Awareness events

Risks	Finding a suitable site for a trial of this magnitude Getting the right equipment and seed to do the job well Acts of God (drought, hail, etc.) Labour (weed control, harvesting, etc.)

ACTIVITIES AND DELIVERABLES

Activities	Deliverables
1. Land preparation	Weeding and management of cover crops prior to planting.
2. Purchase Materials & Equipment	Acquisition of seed, inoculum, stickers, implements, chemical inputs.
3. Establishing and Planting of trials	Established trial according to the field plan.
4. Seasonal management and maintenance of trials	Regular visits to the trial site for inspection of weeds and insect damage and control if needed. Top dressing of grass cover crops. Treatment of cover crop at appropriate time (usually before seed set) using appropriate equipment. Submission of technical report after each visit.

	Photos from trial during visits
5. Monitoring and Sampling	Completed data sheets for 1. Input cost 2. Germination 3. Cover % 4. Height of cover of each addition 5. Biological productivity t/ha^{-1}
6. Lab Analyses	C:N content of plant material
7. Monthly meetings (project team) & Training	Partake in monthly forum meetings, discussing problems and possible solutions to that.
8. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of trials. Learning from previous mistakes.
9. Annual report and admin (production & technical data)	Written technical report covering trial procedures, results and progress.
10. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

Background

The previous report indicated that some problems occur with early planting of cover crops (CC) at trials on the farm Skulpspruit of Mr Izak Dreyer. Cold weather killed some crops such as cowpeas; these crops were replanted. Early planted crops also needed to be hand weeded because weeds became a problem. Crops recoverd well and DM was determined in the second half of March. A winter CC mixture was planted by Mr Dreyer after harvesting his soybeans (300 ha). He also bought a new Equalizer no-till planter, to improve the integration of CC with his CA package. The benefits associated with CC for his cash crops, soil and livestock are well recogniced.

Mr. Callie Meintjies farms on the farm Driefontein in Reitz area. He received less than half (350 mm) his annual rainfall for the year. The establishment of the crops in the screening trial was impeded due to the drought conditions. This also was a contributing factor to the grass invasion that took place later in the season. The livestock integration trial however did well under the less than ideal circumstances. Active holes of rodents are still present in the plots and needs some attention before continuation of the trial. Callie also planted a mixture of CC after harvesting his soya fields (200 ha). Moisture remained a problem and the development of these crops were delayed after initial gemination. The 40 mm of snow and rain received during the cold spell late July will benefit these crops if the extreme cold temperatures dissipate. A 12 row 50cm planter was bougth by Mr. Meintjies to plant his crops the coming season.

Activities	**Deliverables**	**Progress and Results achieved**
1. Land preparation (finding a suitable location, sourcing materials, action planning)	Description of natural resources. This will include positive and negative factors that can impact on plant growth. Selection of suitable site(s). Action plan that will include acquisition of seed, inoculum, stickers, implements, chemical inputs, monitoring and evaluation of	The trial was discussed with farmers and the objectives made clear. The roles of every stakeholder were discussed. Sites on the different locations were identified to plant the trials. At both location herbicides were sprayed before planting.
	trial, harvesting, collecting and interpretation of data. The action plan should clarify the roll of all parties involved.	Summer annuals and winter annuals were delivered to the participatory farmers.
2. Purchase Materials & Equipment	Acquisition of seed, inoculum, stickers, implements, chemical inputs.	Summer annuals were delivered to Izak and Callie 11/2015. Seed was delivered by courier after receiving it from Simon Hodgson of Cover Crop Solutions. During February all farmers received winter CC seed
3. Establishing and Planting of trials	Drawing up a field plan Experimental design discussed with ARC Biometric Unit. Established trial according to the field plan.	Izak planted his trial towards the end of November. The trial was established on 20/1/16 at Reitz. Both farmers received a trial plan and were comfortable with the design and lay-out.
4. Seasonal management and maintenance of trials	Regular visits to the trial site for inspection of weeds and insect damage and control if needed.	Being stretched for time because of the delayed planting; in other provinces regular visits to trial sites

	Top dressing of grass cover crops. Treatment of cover crop at appropriate time (usually before seed set) using appropriate equipment. Submission of technical report after each visit. Photos from trial during visits	were not always possible. At Vrede the VKB farmer facilitator, Mr. Robert Steynberg, gave support and did some data gathering on infiltration rates between different practises. Gaps were filled in and plots not germinating well were replanted. Photos of the trial were taken at regular intervals. On the 18/3/16 the trial at C. Meintjies was visited and photo's were taken. At Skulpspruit data was recorded from the CC site
5. Monitoring and Sampling	Completed data sheets for 6. Input cost 7. Germination 8. Cover % 9. Height of cover of each addition 10. Biological productivity tha^{-1} (Dry Matter, DM)	DM will be determined at a later stage. At the same time cover %, height of the cover and actual stand will be determined. The summer annuals were havested at C. Meintjies on the 5/5/16 to determine DM. Winter annuals was planted by Mr. Meitjies after receiving seed. Planting was late May.
6. Lab Analyses	C:N content of plant material	Dried DM samples will be sent to the lab.
7. Monthly meetings (project team) & Training	Partake in monthly forum meetings, discussing problems and possible solutions to that.	Participated in meetings. Three visits for discussions and feedback will be undertaken through the growing season. 1-3/6/16 all trials were visited with the facilitator.
8. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of trials. Learning from previous	On-going process. On 28/7/16 planning meeting and report back meeting at Reitz

	mistakes.	
9. Annual report and admin (production & technical data)	Written technical report covering trial procedures, results and progress.	Annual report will be finished by end August 2016
10. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits.	Farmers day was held at Ascent on the 16/2/2016. CA workshop 24/2/2016 a presentasion of CC trials. Farmers day 17/3/16 Danie Slaberts farm. Monthly article in Grain SA on CC.

8.3.1. Terminating cover crops (CC)

Farmers expressed a need to be informed on when to and the best ways to terminate CC. Information on this topic was put together and send to farmers at the different locations. A short summary of this might be appropriate in this report:

Plant cool season CC and mixtures on time

In order to maximize benefits—or to work at all—cover crops need to be planted early, sometimes before the summer crop is harvested. Timely planting results in:

- good root establishment and top growth before the crops go dormant
- reduced chance of winter kill
- more biomass production compared to later planting dates
- greater uptake of residual soil N

Summer annuals will be killed by frost. In some occasions legumes such as cowpeas and lablab are planted to maximize N availability and cycling in the soil. In such cases, termination will be executed at an early reproductive phase (flowering stage). Tall growing crops such as babala and sorghum tends to lodge and can impede the planting process.

Cover crops are unique in that most are planted primarily to address multiple or specific problems, for example to reduce soil erosion and otherwise enhance soil quality, and are not harvested for their seed, fruit, or forage (although some are grazed or used as forage). Instead, cover crops are terminated before planting of summer annual grain crops such as soybeans and maize. When not effectively terminated, cover crops have the potential to become weeds in the grain crop. Many cover crop species have characteristics that make them both desirable as cover crops, and troublesome as weed species. Weedy cover crops not only affect the current production crop, but also can produce seeds and establish a seed bank that will result in future weed problems. Cover crops can be terminated by a number of methods, although herbicide application is the most common method. When selecting an herbicide program for termination of a cover crop, consider:

- the cover crop species
- the cover crop growth stage
- other weed species present
- the production crop to be planted
- the weather conditions at application

Use of herbicide to terminate CC

Killing cover crops with a non-selective herbicide is the standard method used by CA farmers. They favor this option because they can cover many acres quickly and herbicides are relatively cheap. Herbicides can be applied at any time or growth stage to terminate the cover crop. **Precaution:** Applying non-selective herbicides at reduced rates could lead to weed resistance. The half rate of herbicide may not completely eradicate the weed, increasing the chance that the weed will produce seed. Under these circumstances, such seeds are more likely to be resistant to the herbicide. Therefore, it is safer to completely eliminate the use of the non-selective herbicide with a roller or use the non-selective herbicide at the labelled rate, with or without the roller.

Killing cereal rye, small grains, brassicas and vetch using herbicide

Cereal rye is fairly easy to kill with glyphosate. But there are multiple factors to consider when terminating it. Keep in mind that if it turns warm, cereal rye can grow at a very rapid rate, it can get away from you, especially if you have a lot of hectares to treat. In addition to creating a very large quantity of biomass that some no-tillers may not be prepared to deal with when planting the following crop, the cereal rye becomes lignified. The woody residue takes a much longer time to break down due to a higher C:N ratio. The termination-timing standard for cereal rye has been 14 to 21 days ahead of planting. One of the reasons for that interim period is to give pests such as snails and cutworms time to move out of the cover crop, rather than being present when the new crop emerges, as well as giving time for residue to breakdown before planting. This also allow time for moisture recharge, drying of the CC will also help the planting process if the material is brittle, less hairpinning will result.

A non-ionic surfactant should also be added if it's not included in the glyphosate source. The type of nozzles used isn't particularly important with the herbicide. Glyphosate doesn't work as well at low temperatures, so rather wait and apply during the heat of the day. Since there are likely weeds that need to be controlled in the CC, it's a good idea to include some 2,4-D. The addition of 1l of 2,4-D significantly improves broadleaf control and reduces selection pressure for glyphosate-resistant weeds when used in combination with glyphosate products.

The labels of 2,4-D products do specify a waiting period between application and maize or soybean planting. Although those periods vary somewhat, they are generally about 7 to 10 days, with ester formulations of 2,4-D having a shorter waiting period than amine formulations. Gramoxone (Paraquat) is another burndown option, but control can be more variable. Stage of growth at application is more critical. Gramoxone should be applied during the intermediate growth stage, ideally prior to stem elongation. Applying at full tiller or after head emergence is fine, but in between can be more challenging. Sunny weather at application is more important with Gramoxone, and spraying in the late afternoon is less effective than a mid-morning application. Although adding UAN as a carrier can reduce glyphosate activity on plants, it can increase Gramoxone activity. A photosynthesis-inhibiting herbicide — such as atrazine or metribuzen — can also enhance activity with Gramoxone. Flat-fan nozzles, rather than flood nozzles, should be used. The benefit with Gramoxone is it's very fast-acting and probably less temperature sensitive. It desiccates the cereal rye or small-grain cover crop within days, rather than the much slower kill you get with glyphosate.

As a brassica, radishes are not particularly sensitive to glyphosate herbicides, so 2,4-D is a good choice for termination. Also notes that radishes, turnips and other brassicas are frequently part of a cover-crop mix with a small grain, like cereal rye, wheat or barley. Targeting the more difficult-to-control species in any cover-crop mix, no-tillers must remember that while glyphosate may be effective on small grains, the addition of a broadleaf herbicide may be necessary for other components.

To terminate Vetch a mix of glyphosate and 2,4-D, or a dicamba product, such as Banvel, is used. Glyphosate alone isn't a good choice, because of its variable performance on legumes. But it can help control winter annual weeds that may be present. With either dicamba or 2,4-D, a delay of 2 to 3 weeks between herbicide application and maize planting is necessary to avoid maize herbicide injury.

Terminating CC with a roller-crimper

Cover crops can be killed using a mechanical roller (often called a roller-crimper). The roller kills the cover crop by breaking (crimping) the stems. The crimping action aids in cover crop desiccation.

Cover crop rollers are manufactured in various designs, but are generally made from a hollow steel drum or cylinder 30-60 cm in diameter. The roller/crimpers used today generally have blunt blades or knives arranged on the cylinder that crimp or crush the stems of the living cover crop, which then kills it. Rollers flatten and crimp susceptible cover crops leaving an intact mat of soil protective mulch oriented in the direction of planting. This unidirectional mulch can help facilitate planting and improve seed to soil contract and ultimately cash crop emergence. In contrast to mowing the cover crop, there is less risk of cover crop regrowth when it is rolled, the intact residue decomposes slower, and weed suppression is better from the uniform surface residue. A common design used today has metal blades welded onto a cylinder in a chevron pattern that allows for smooth operation.

Cover crop rollers can be effective for terminating annual crops including cereal grains; rye, wheat, oats, and barley as well as annual legumes and other forbs. Most of the research with roller/crimpers has been with cereal grain cover crops, although legume cover crops such as hairy vetch, winter pea, and crimson clover have also been evaluated (Wilson 2007, unpublished). Previous work showed that control of cereal cover crops improves with increasing plant maturity (Ashford and Reeves, 2004). The cereal grain generally needs to be well into flowering in order for the roller-crimper to provide acceptable control alone. Cereal rye was consistently controlled at growth stage 61, when the anthers were clearly visible and shed- ding pollen. Rolling prior to this growth stage did not consistently prevent the rye cover crop from competing with the cash crop and producing viable seed. Cereal rye maturity and thus the time one must wait until it reaches the susceptible growth stage for control will depend on several factors including the seeding date and the temperature in the fall and spring. Figure 8.3.1 represent the growth stages of small grain crops. Terminating will vary somewhat by year and can be delayed by unfavorable weather.

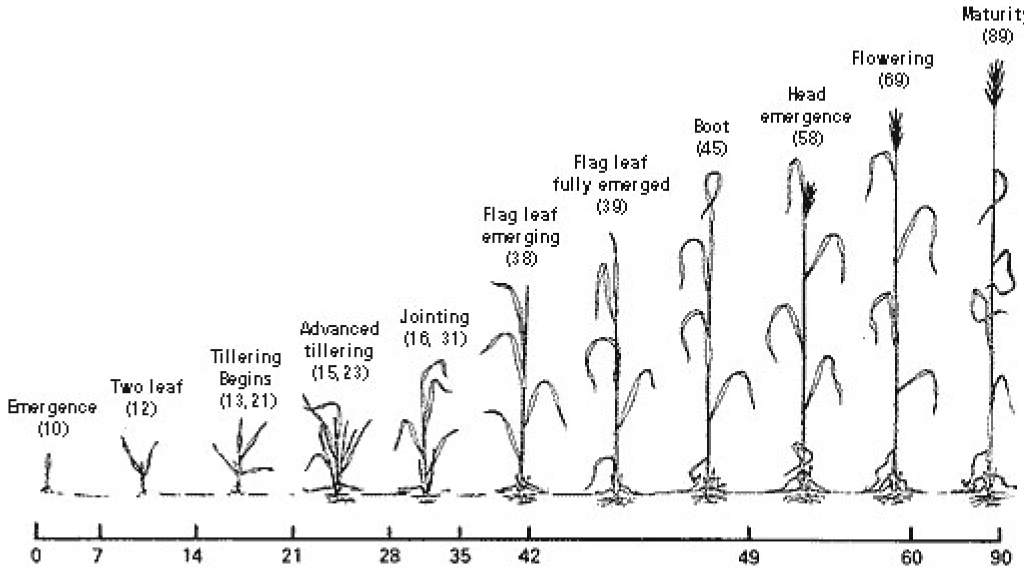
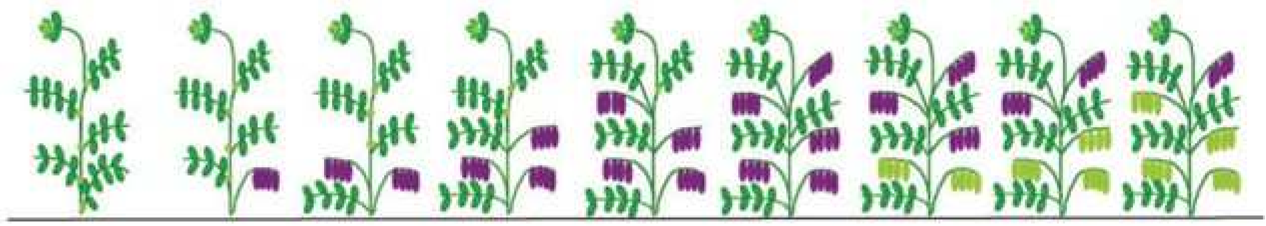


Figure 8.3.1. Small grain growth stages

Hairy vetch is another common cover crop that can be successfully terminated with a roller crimper. Consistent hairy vetch control was achieved when small pods were visible (early pod set) on the upper nodes of the plant counting down from the top (Figure 8.3.2). Although acceptable control was sometimes achieved prior to this growth stage, some regrowth might occur at some locations. Incomplete control of vetch increases the risk for vetch seed production, which can be a serious problem in subsequent winter annual crops such as wheat. The roller crimper can also work well on mixtures of cereals and legumes such as hairy vetch seeded with rye, wheat, or triticale. The timing of the operation should be based on the latest maturing species or multiple passes with a roller may be necessary.



Vege-tative 1	20% Flower 2	40% Flower 3	60% Flower 4	80% Flowe r 5	100% Flower 6	Early Pod 7	Mid Pod 8	Late Pod 9

Figure 8.3.2. Hairy vetch growth stages based on the upper five nodes of the vine. Growth stage depends on the number of buds that have begun to bloom or produce pods. Vegetative (1), no flower buds are visible; early pod set (7), when 1-2 pods are

visible; and late pod set (9) when 4+ pods are visible. Consistent control with the roller-crimper was achieved at early pod set (7).

A number of cover crops are not controlled by the roller crimper including biennial or perennial legumes (lucerne, red clover, etc.), canola, and annual ryegrass to name just a few. More cover crop species need to be tested for their suitability for using a roller-crimper.

Combination with herbicide

Although much of the interest in the roller-crimper in North America comes from organic farmers that do not use herbicides, there is some potential to combine herbicides with the roller and use an integrated approach. This has been the basis for their use in South America where burndown herbicides are generally used. Some research has shown that the roller-crimper in combination with a burndown herbicide like glyphosate can increase the effectiveness of cover crop control. The roller in combination with a half rate of herbicide equaled the effectiveness of the herbicide alone at the full rate. Reduced rates of glyphosate in combination with the roller desiccated cereal rye more quickly than the herbicide alone. Several weeks after application, rye control was similar between rolled and unrolled treatments that included glyphosate.

Although not tested in the previous study, the rolled cover crop mat potentially provides greater weed suppression than a more upright unrolled cover due to reductions in weed emergence and reduced competition. Finally, the combination of a burndown herbicide plus the roller alleviates the need to "wait" until the cover crop is susceptible to control by the roller alone and can provide an earlier window for cash crop establishment. Small grain cover crops should be in the late boot stage or in early heading to benefit from rolling. Rolling prior to this does not generally provide sufficient cover crop biomass nor the quality (higher fiber content) necessary to suppress weeds or persist long enough to impact weed emergence. In some soybean research, a sprayed and rolled rye cover crop at the late boot stage or beyond provided weed control results similar to a post-emergence glyphosate.

8.3.2. Infiltration studies to assess soil health in Ascent and Reitz study areas

What it is: Infiltration is the downward entry of water into the soil. The velocity at which water enters the soil is infiltration rate. Infiltration rate is typically expressed in mm per hour. Water from rainfall or irrigation must first enter the soil for it to be of value.

Why it is important: Infiltration is an indicator of the soil's ability to allow water movement into and through the soil profile. Soil temporarily stores water, making it available for root uptake, plant growth and habitat for soil organisms.

Specific problems that might be caused by poor function: When water is supplied at a rate that exceeds the soil's infiltration capacity, it moves downslope as runoff on sloping land or ponds on the surface of level land. When runoff occurs on bare or poorly vegetated soil, erosion takes place. Runoff carries nutrients, chemicals, and soil with it, resulting in decreased soil productivity, off-site sedimentation of water bodies and diminished water quality. Sedimentation decreases storage capacity of reservoirs and streams and can lead to flooding.

Restricted infiltration and ponding of water on the soil surface results in poor soil aeration, which leads to poor root function and plant growth, as well as reduced nutrient availability and cycling by soil organisms. Ponding and soil saturation decreases soil strength, destroys soil structure, increases detachment of soil particles, and makes soil more erodible. On the soil surface rather than in the soil profile, ponded water is subject to increased evaporation, which leads to decreased water available for plant growth.

Figure 8.3.3. Infiltration test being performed.

A high infiltration rate is generally desirable for plant growth and the environment. In some cases, soils that have unrestricted water movement through their profile can contribute to environmental concerns if misapplied nutrients and chemicals reach groundwater and surface water resources via subsurface flow.

Conservation practices that lead to poor infiltration include:

- Incorporating, burning, or harvesting crop residues leaving soil bare and susceptible to erosion,
- Tillage methods and soil disturbance activities that disrupt surface connected pores and prevent accumulation of soil organic matter, and
- Equipment and livestock traffic, especially on wet soils that cause compaction and reduced porosity.

What you can do: Several conservation practices help maintain or improve water infiltration into soil by increasing vegetative cover, managing crop residues, and increasing soil organic matter. Generally, these practices minimize soil disturbance and compaction, protect soil from erosion, and encourage the development of good soil structure and continuous pore space. As a short-term solution to poor infiltration, surface crusts can be disrupted with a rotary hoe or row cultivator and plough plans or other compacted layers can be broken using deep tillage.

Long-term solutions for maintaining or improving infiltration include practices that increase soil organic matter and aggregation, and reduce soil disturbance and compaction. High residue crops, such as sorghum and small grains, perennial sod, and cover crops protect the soil surface from erosion and increase soil organic matter when reduced tillage methods that maintain surface cover are used to plant the following crop. Application of animal manure also helps to increase soil organic matter. Increased organic matter results in increased aggregation and improved soil structure leading to improved infiltration rates. No-tillage, reduced soil disturbance, and reducing the number of trips across a field necessary to produce a crop help leave continuous pore spaces intact and minimize the opportunity for soil compaction.

Conservation practices resulting in infiltration rates favourable to soil function include:

- Conservation Crop Rotation
- Cover Crops
- Mob Grazing
- Residue and Tillage Management
- Waste Utilization

Measuring infiltration:

Materials needed to measure infiltration:

15cm diameter ring, plastic wrap, 500 mL plastic bottle, water and stopwatch

Make sure the sampling area is free of residue and weeds or that vegetation is trimmed to the soil surface before inserting the ring. With the 15cm diameter ring in place, use your finger to gently firm the soil surface only around the inside edges of the ring to prevent extra seepage. Minimize disturbance to the rest of the soil surface inside the ring.

Line Ring with Plastic Wrap

- ➢ Line the soil surface inside the ring with a sheet of plastic wrap to completely cover the soil and ring as shown. This procedure prevents disturbance to the soil surface when adding water.

Add Water

- ➢ Fill the plastic bottle. This will represent 28 mm of rain.

Remove Wrap and Record Time

- Remove the plastic wrap by gently pulling it out, leaving the water in the ring. Note the time.
- Record the amount of time (in minutes) it takes for the of water to infiltrate the soil. Stop timing when the surface is just glistening.
- If the soil surface is uneven inside the ring, count the time until half of the surface is exposed and just glistening.
- Repeat Infiltration Test: In the same ring, perform Steps 2, 3, & 4 with a second 28 mm of water. Enter the number of minutes elapsed for the second infiltration measurement. If soil moisture is at or near field capacity, the second test is not necessary.

Interpretation of infiltration data at the two locations in the Ascent and Reitz study areas

The soil quality test kit put together by the USDA gives clear indicators of how the data gathered can be interpreted. Infiltration rate of 28 mm under 3 minutes will be regarded as rapid infiltration. In a CA system the infiltration rate will be influenced by compaction, texture, aggregate stability and moisture content of the soil.

Data gathered at the two locations indicated that soils under conventional tillage and grazing summer annuals at Skulpspruit (ascent study area) that are degraded to certain extend. A newly ploughed field however at Driefontein (Reitz study area) responded better to the infiltration test, but the overgrazed degraded veld is problematic. At Skulpspruit veld inside a protected area had the quickest infiltration rate of all the treatments, indicating to healthy soils. Figure 8.3.4 and 8.3.5 represents infiltration times for the different treatments at the two locations.

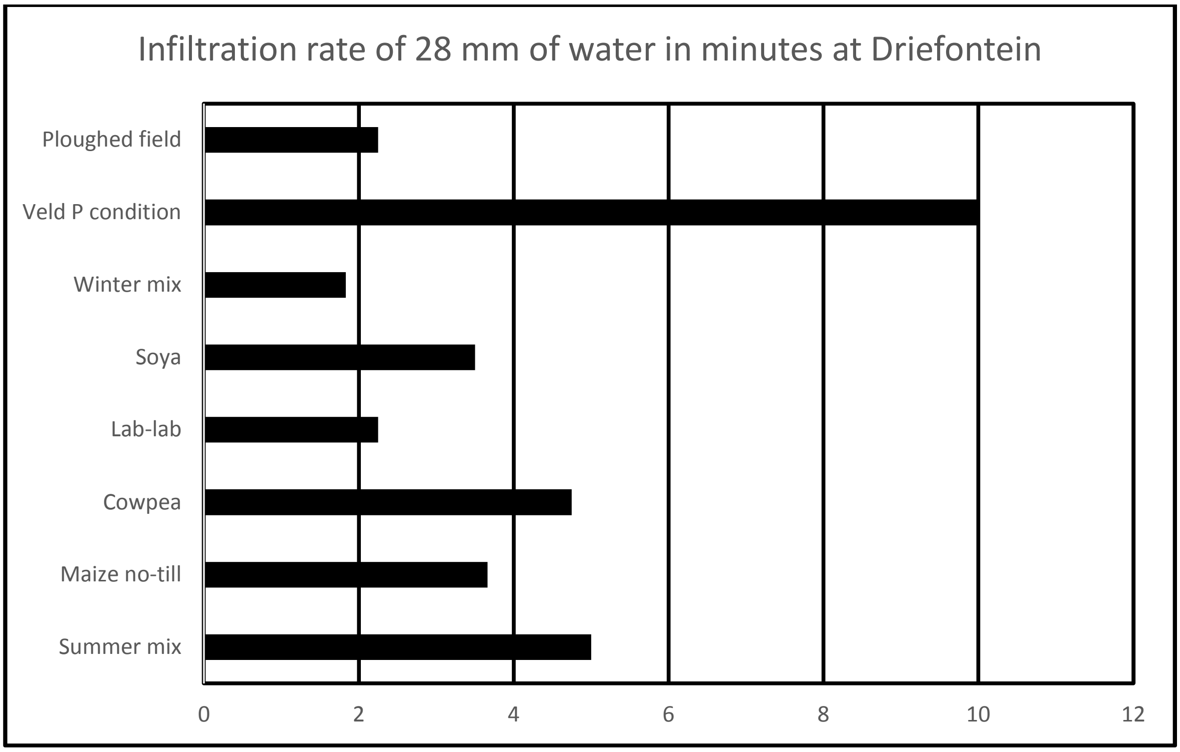


Figure 8.3.4. Infiltration rate of different treatments at Driefontein, Reitz study area

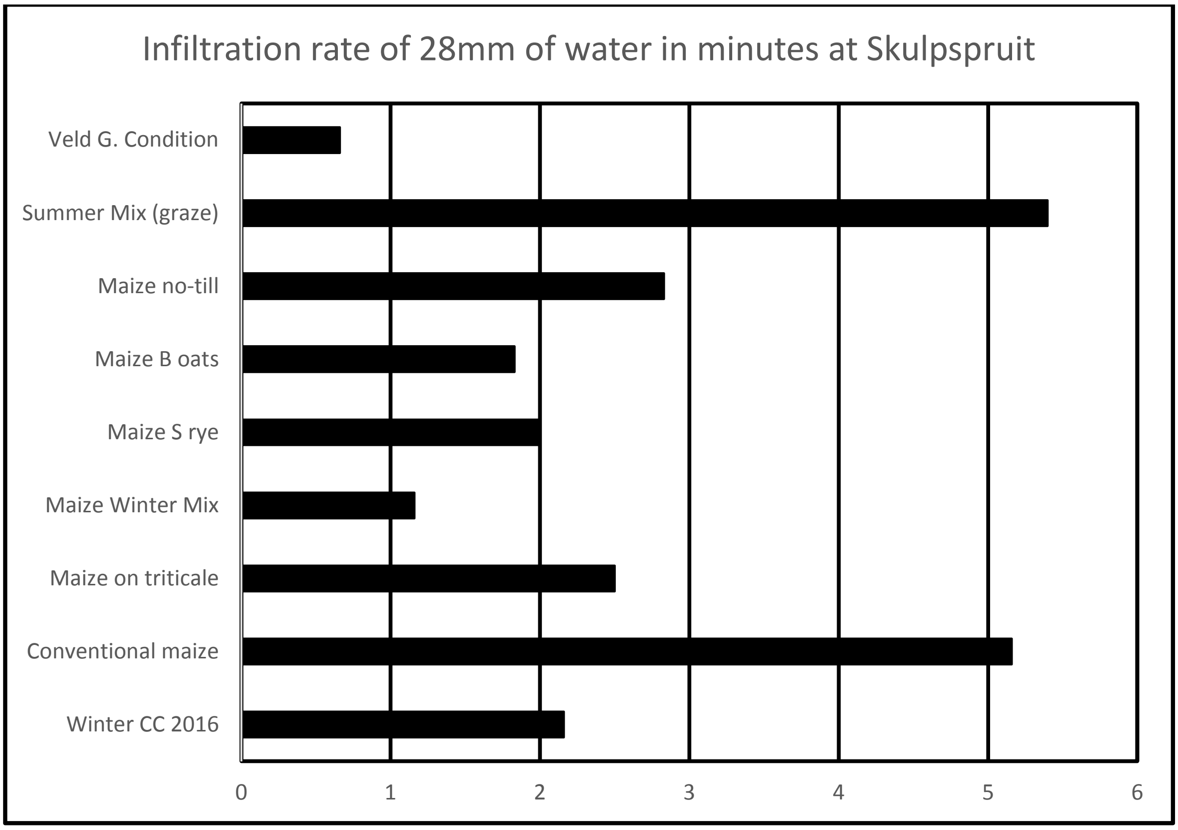
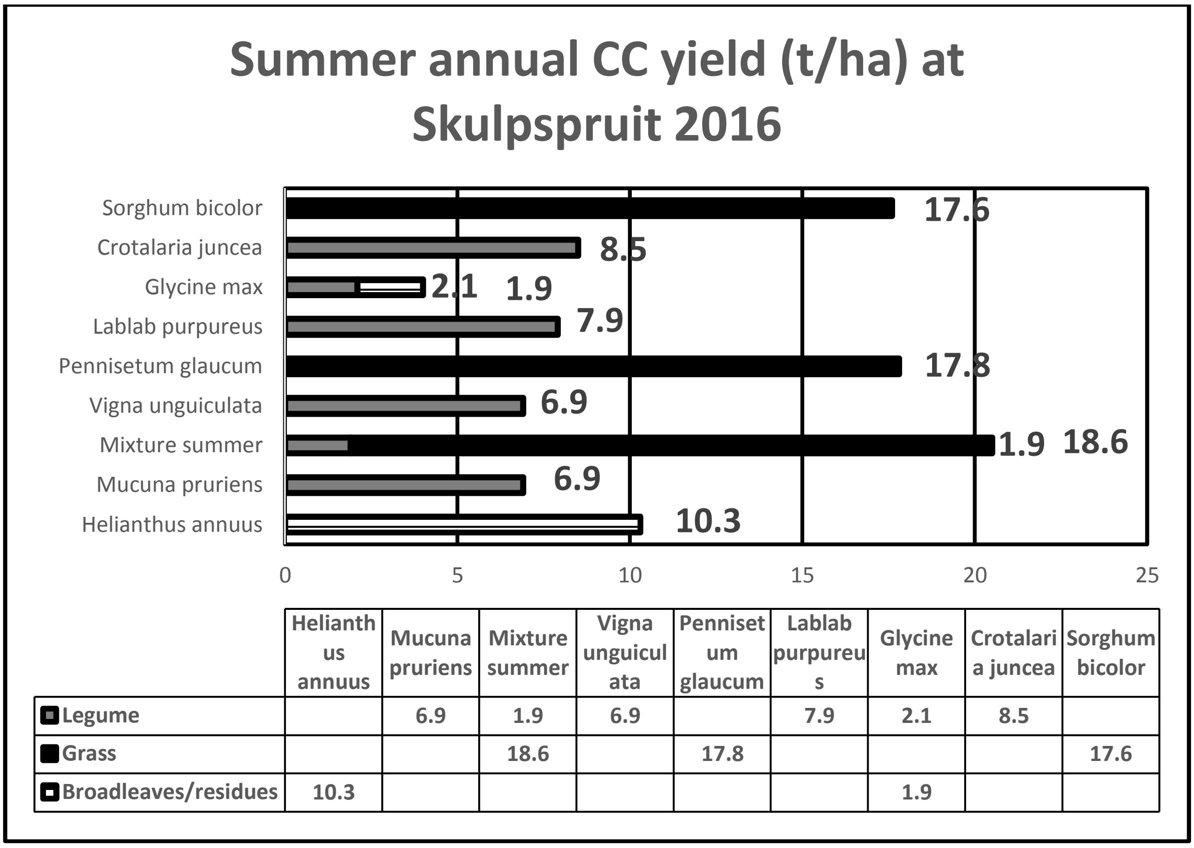


Figure 8.3.5. Infiltration rate of different treatments at Skulpspruit, Ascent study area

Biomass data for the two locations.

Skulpspruit: In a previous report the traits of different crops were discussed in detail. It will be more appropriate to concentrate on the yield during this report. Soils at Skulpspruit have a clay texture and the high biomass production from Sorghum is expected in the cover crop mixtures planted on those sites, compared to the pure stands, portrayed in Figure 8.3.5. The Babala also produced well at the trial site. These CC crops are not just a viable forage crop in an integrated system but can also contribute to enrich the soil carbon content significantly.

The legumes also produced well with Sunhemp producing 8,5 t ha^{-1}. Lablab with 7.9 t ha^{-1} (Figure 8.3.6) outperformed Cowpeas and Velvetbean by quite a margin. These CC crops can lower input cost of the cash crops in a rotation system, through N fixation. Soybean produced 1.9 tons of grain. The mixture of Sorghum and Lablab had the highest yield of the treatments. Biomass data gathering took place middle of March.



	Helianthus annuus	Mucuna pruriens	Mixture summer	Vigna unguiculata	Pennisetum glaucum	Lablab purpureus	Glycine max	Crotalaria juncea	Sorghum bicolor
Legume		6.9	1.9	6.9		7.9	2.1	8.5	
Grass			18.6		17.8				17.6
Broadleaves/residues	10.3						1.9		

Figure 8.3.6. DM production of cover crops at Skulpspruit, Ascent study area

Figure 8.3.7. Lablab doing well at Skulpspruit , Ascent study area

Driefontein: Harvest was delayed due to late planting and took place early in May.

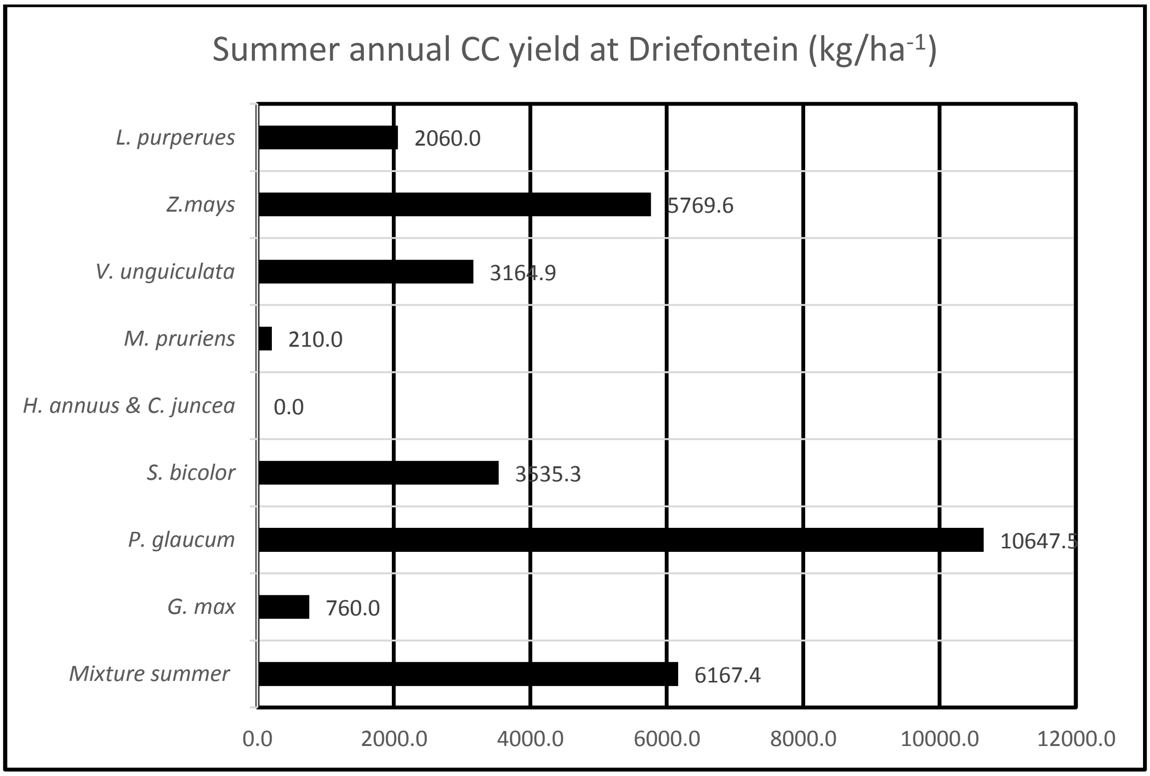


Figure 8.3.8. DM production of CC at Driefontein, Reitz study area

At Driefontein Sunflower seed was unavailable and was not planted. Sunhemp was planted but failed to germinate and Velvet bean planting was delayed because the planter's plates could not handle the large seeds. Babala and summer radish (Figure 8.3.9.) did well in the trial. The sandy soil condition suited these crops. The summer mixture which was also meant to be used for livestock integration produced some of the largest radishes possible (see Figure 8.3.9). Drought conditions played a part in the less than optimal biomass production in the trial. The rest of the crops were drought stricken.

Figure 8.3.9. Summer planted Radish in mixture at Driefontein.

Livestock integration:

At Skulpspruit 300 heifer grazed 12ha of summer CC (Figure 8.3.10). The CC was divided into camps by a solar electric fencing system. Data is still outstanding and will be forth coming.

Figure 8.3.10. Heifers grazing on CC, Skulpspruit, Ascent

4. Problems encountered with the project:

The establishment of cover crop trials were somewhat delayed due to the lack of rain. Still at this late stage the ongoing drought creates problems in the study areas.

5. Milestones that have not been achieved and the reasons for that:

None.

8.4. Agronomic field trial planning and analyses

Work Package title	**Agronomic field trial planning, design and analyses**

Work Package period	October 2015 to September 2016
Lead partner	ARC-SGI (W Killian, L Visser, R Steynberg, Pieter de Wet)
Involved partners	Riemland & Ascent study groups and other Innovation Platform (IP) partners

Objectives	• To plan and design the on-farm maize plant population density trials • To plan and design the on farm crop rotation trials • To (statistically) analyse and report the results of the maize plant population density trials • To (statistically) analyse and report on the results of the crop rotation trials

Justification	Plant population density is one of relatively few variables that farmers can manage easily. Current recommendations for maize plant population were derived from trials under conventional tillage. Physically, the soil is very different in no-tillage than in tilled soil. This might require an adjustment in the plant population density of crops. Recommendations from elsewhere in the world is that plant population densities should be increased and row width should be decreased for no-till cropping. Crop rotation, another easily manageable variable, is one of the principles of conservation agriculture. No information on how crops respond to rotation in conservation agriculture systems in this semi-arid environment is available. Crop responses to changes in management and the environment is usually liable to interactions resulting in variation of the results, which might lead to wrong conclusions and recommendations. In order to generate scientifically sound recommendations on these two agronomical variables, proper planning and analyses of the results is needed.

Description of work	**Planning and designing of trials in collaboration with participating farmers and partners. Analyses of farmer collected results and reporting of findings.**

Activities	Planning of trials through the attendance of the frequent coordination meetings where aims and procedures will be discussed with farmers. Planning of trial layout and compiling of data sheets to be completed by participating farmers. Collection of data from farmers at the after harvest of the trials. Statistical analyses, interpretation, discussion and drawing

	of conclusions from the results. Presentation and reporting of the results to participants and MT as required.

Deliverables	• Annual trial plans and analysis report • Regular attendance of meetings • Reporting as required • Popular article once enough results have been acquired.

Risks	Adequate involvement and participation of farmers

ACTIVITIES AND DELIVERABLES

Activities	**Deliverables**
Attendance of meetings, planning, analyses and reporting	Trial plans and reports on the analyses of results

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

Activities *(as specified in Work Package or project proposal)*	**Deliverables or Milestones** *(as specified in Work Package or project proposal)*	**Progress and Results achieved;** and/or **Problems and Milestones not achieved** (in report period)
Planning of trials through the attendance of frequent coordination meetings where aims and procedures will be discussed with farmers	Regular attendance of meetings. Compiling van trial plans and procedures	Trial plans were compiled and discussed with coordinator / facilitator and participating famers. Helped the farmer co-workers to measure and prepare the trial sites. Assistance were also given with the planting of the trials, where possible.
Planning of trial layout and compiling of data sheets to be completed by participating farmers	Data sheets	Data sheets were e-mailed to facilitators (Robert Steynberg and Pieter de Wet). Trial data is included in annual reports – see below

To (statistically) analyse and report the results of the maize plant population density trials	Annual report	Trial data was analysed and reported at a reference group meeting – 29 July 2016 and included in the annual report. (see technical annual reports below)

8.4.1. Annual report for trial results in Ascent study area

The following trials were planted:

1. **MAIZE** – in rotation with soya beans;

Plant population and row width trials with differential tillage practices

- No till: I Dreyer planted four trials (1 x 0,5 m and 3 x 0,76 m rows)
- Strip till: C Cronje planted one trial (0,76 m rows)
- Conventional: D Portwig planted one trial (0,91 m rows)
- Plant populations consisted of 30; 40; 60; 80; 100 (thousand/ha)
- Total: 6 Trials

2. **MAIZE** – in rotation with soya beans and cover crops

Winter cover crops

- No till: I Dreyer (10 treatment combinations)
- Total: 1

3. **SOYA BEANS** – in rotation with maize

Planting date, row width and plant population

- No till: I Dreyer planted three trials (two planting dates with different row widths and different maturity classes; one row width trial (Pierobon planter)
- No till: J v Dyk planted one trial (planting density and four maturity classes in 0,5 m rows – Apache planter)
- Conventional: P Zietsman planted one trial (0,91 m and 0,455m rows)
- Total: 5 Trials

EXPERIMENTAL PROCEDURES, ASCENT STUDY AREA

A. Maize plant population trials

The maize plant density trials were planted according to the normal practices and preferred cultivars of the participating farmers. Strip plots were planted and replicated once. Three sub plots per strip were harvested by hand so that standard errors could be determined and used as statistical tools to compare treatment results. Although it isn't technically correct, standard analysis of variance was also done to make it easier to determine which effects tended to be significant. The subplots consisted of two 5 m rows (total row length of 10 m). Numerous large gaps without plants occurred sporadically due to drought or pests (guinea fowl, porcupine or field mice). Care was thus taken to select rows where the plant population looked close to that which was aimed for by the treatments so that a true reflection of plant population effects could be obtained.

After the sub plots were harvested by hand, the cob samples were threshed by a small threshing machine. Kernels were weighed and the yield presented on a 12.5% moisture content basis.

The following cultivars, which also influenced results, were used in the various experiments:

1. Conventional - 0.91 m rows: DKC 78-45
2. Strip till – 0.76 m rows: DKC 68-56 R
3. No till – 0.76 m rows (Skulpspruit): DKC 78-87 B
4. No till – 0.76 m rows (Genoeg): PAN BG 3492 B
5. No till – 0.50 m rows (Genoeg): DKC 73-70 B
6. No till – 0.76 m rows (Vrede): DKC 73-70 B

B. Maize winter cover crop trial

Strips of winter cover crops were planted after the previous year's no till maize. Row widths were generally 0.76 m but as is shown in the results, some treatments were planted in 0.5 m rows as well where a Pierobon planter was tested. The 8 treatments consisted of the following:

1. Control – no till
2. Oats
3. Triticale
4. Radish
5. Black oats
6. Vetch
7. Rye
8. A mixture of mentioned crops

C. Soya bean row width trial (including the Argentinean system)

Soya beans of the cultivar LS 6146 were planted no till after maize. Two planters were used (Pierobon and John Deere) to achieve different row widths (0.5 m and 0.76 m). Planting was done at the highest plant populations that the planters could do. Plants were then thinned by hand a month after emergence to obtain varying plant densities. Four rows of 5 m length were thus treated and only the inner 2 rows were used for determining yield. Three replications were used. Whole plants were pulled up and put in bags to be moved from the field. They were then threshed with a small threshing machine. Moisture determinations were made by a grain silo so that the yields could be presented on a 12.5 % moisture content basis.

D. Soya bean row width, plant population and cultivar trial (planted early: October 26)

This was a hand planted 4x4x2 factorial experiment with factors: cultivar, plant population and row width. Three replicates were used. The cultivars used were N5009, N5909, N6448 and N7211 representing maturity classes 5; 5.9; 6.4 and 7.2. Cultivar

N7211 is a determinate grower and the others are indeterminate growers. All four cultivars are of a well defined bushy growth type.

Planting rows were marked with a planter (0.76 m row width) from which the seed was removed. These rows were then planted by hand using different spacing for the seed. A second row width was obtained by marking by hand another row in the middle of the 0.76 m row. Two row widths (0.76 m and 0.38 m) could be compared one to another. The inter row spacing were 3, 4, 5 and 8 cm respectively for the different plant populations (160 000 plants/ha to 430 000 plants/ha) of the 0.76 m rows. The comparable spacing for the 0.38 m rows were 4, 5, 6 and 8 cm (327 000 to 751 000 plants/ha) Harvesting was done according to procedures explained above and final plant populations were determined, which were far less than the intended populations due to poor emergence because of heat and dry planting conditions.

E. Soya bean row width and plant population trial (planted late: 3 December)

This trial was a replicate of the previous trial. The only difference was the late planting date and the removal of maize stubble in this no till land to enable easier hand planting conditions.

F. Soya bean cultivar and plant population trial (planted late: Argentinean system)

This trial was planted with an Apache planter in 0.5 m rows. The four cultivars used in the previous two trials were also used. Four planting densities were planted and three replicates were used. This trial was unintentionally planted late on the 3rd of December because of the lateness of rains.

G. Soya bean row width in replacement planting

This trial was done after the farmer had to do replacement planting because of poor emergence following the first planting. Some of the replacement rows were exactly in the middle of previously planted rows. Previously planted rows emerged quite well in places so that plots could be marked and made containing four rows 0.91 m apart and others were then made containing 0.455 m apart. Figure 1 illustrates how the plots initially looked and then how it looked after a while during the vegetative stage. Yields were determined by hand harvesting and machine threshing as described for the other soya bean trials.

a) b)

c) d)

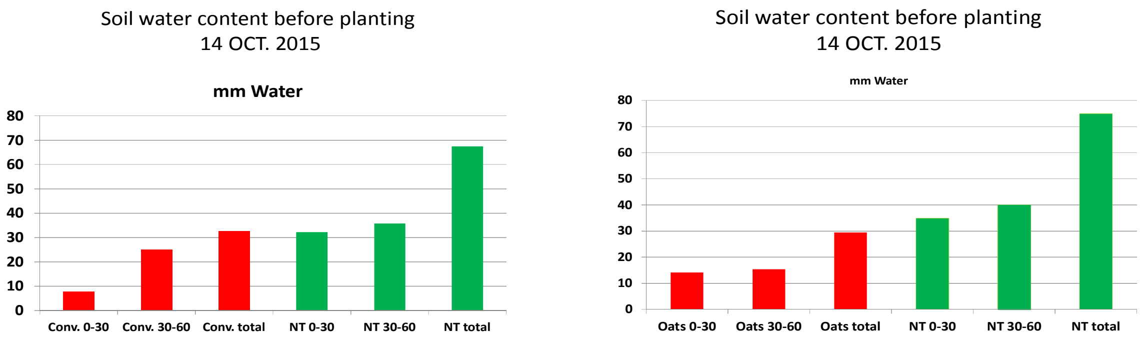
Figure 8.4.1. Wide rows (a and c) were achieved by removing replacement rows on a farm while narrow rows (b and d) resulted from leaving replacement planted rows intact.

PRE HARVEST MEASUREMENTS

Some soil water samples were taken and soil infiltration rates were determined to demonstrate differences between tillage practices and cover cropping in terms of soil moisture conservation and efficiency of rain water infiltration. Some slides that were used for a Farmers day presentation (Figures 8.4.2 to 8.4.5) are included to show what was found.

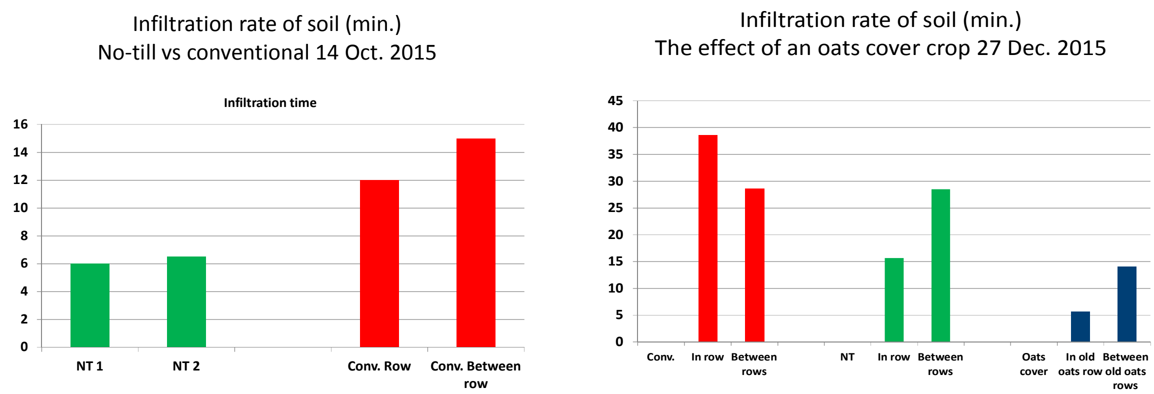
Infiltration rate becomes extremely important in a dry year because water runs off easily and run off differences occurs depending on tillage practices. Figure 8.4.4 shows that ponding can occur after a small shower of 18 mm which makes run off losses possible.

Figure 8.4.5 shows that maize plants struggled to germinate and emerge due to low rainfall and lack of water after carry-over water was depleted by a winter cover crop. Yet, the crop continued to grow amid the worst early summer drought the area had seen in decades. Effective use (better infiltration) of rain that did fall might explain why the crop still grew and at this stage the only negative impact that was observed, was a one and a half week delay in flowering date. It will later be shown that final yields were not significantly affected.



a) b)

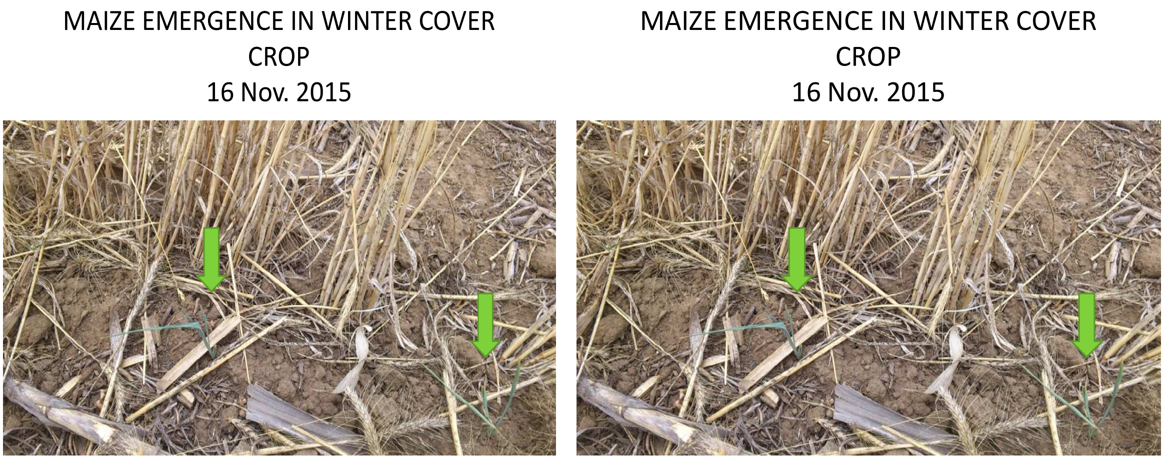
Figure 8.4.2. Comparison of soil water in a) conventional tillage and no till and b) no till with and without oats as a winter cover crop.



a) b)

Figure 8.4.3. Comparison of water infiltration rate in a) conventional tillage and no till and b) conventional tillage and no till with and without oats as a winter cover crop.

Figure 8.4.4. Rain water runoff on strip till after a shower of 18 mm.



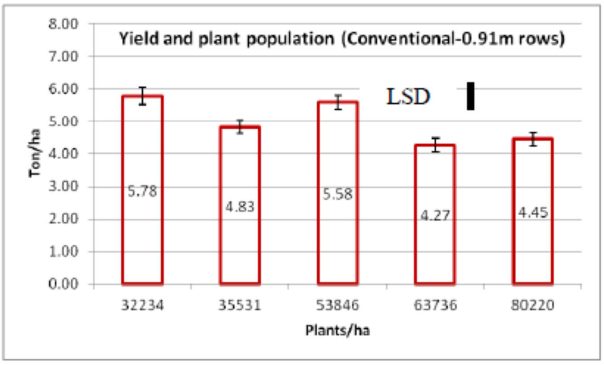
a) b)

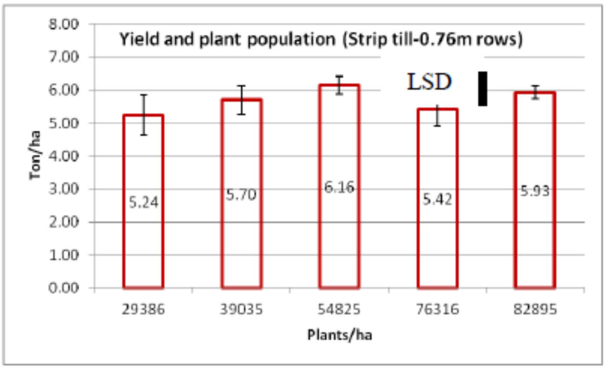
Figure 8.4.5. Maize plants struggling to emerge (a) due to low water content in winter cover crops and b) growing a month after emergence.

POST-HARVEST RESULTS

A. Maize plant population trials

Figure 8.4.6 shows that yields were generally higher than 4 t/ha which is exceptionally good regarding the extreme drought that prevailed during the first half of the season. No clear trends were observed. The conventional plots with 0.91 m rows (Fig. 8.4.6 a) suggested a small declining yield with increased plant population above 53000 plants per ha. Conversely, one of the no till trials with 0.76 m rows suggested an opposite trend (Fig. 8.4.6 c). These observations weren't really conclusive and one cannot generalize in terms of the yield responses to differential plant populations.





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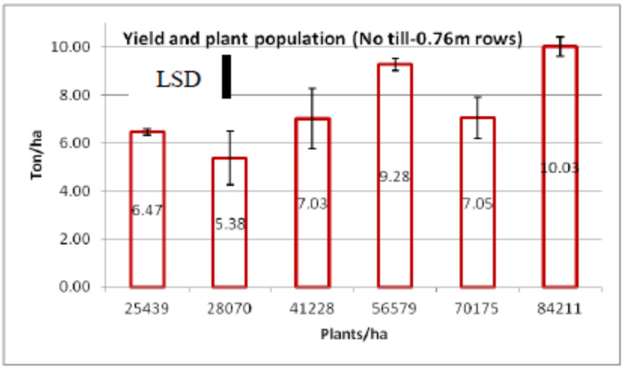

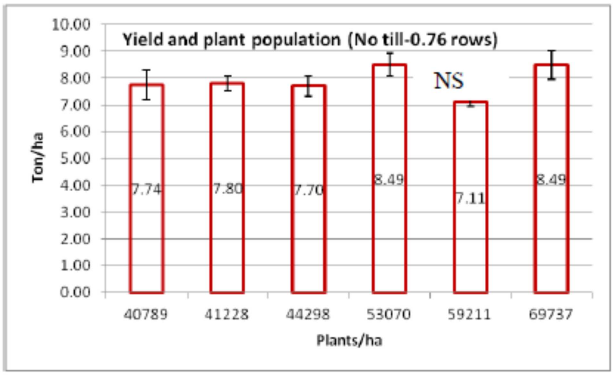

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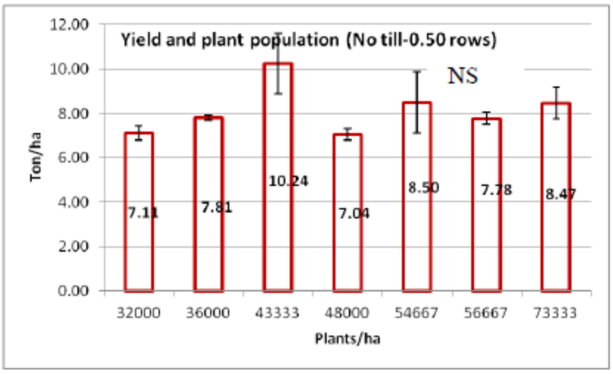
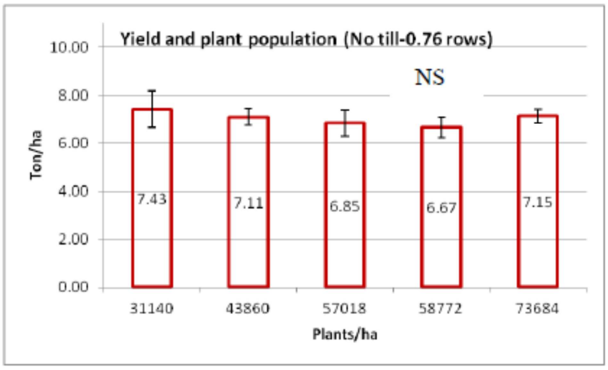




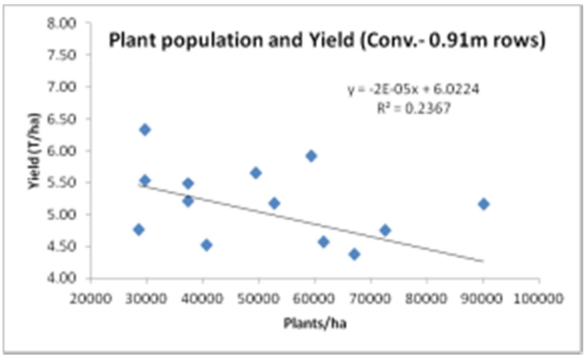
e)

f)

Figure 8.4.6. Response of maize yield to varying plant populations (planted various row widths and tillage practices)

Figure 8.4.7 confirms the conclusions that were made from Figure 8.4.6. Linear regressions fitted the data rather poorly as can be seen from the low R^2 values.

Different fits were tried (quadratic and forcing the regression through zero) without improving the fit as measured by R^2. It seems that these maize plants had a very good ability to compensate for differential population densities. It thus seems that growth factors such as available water and interception of sunlight energy played a larger role in determining the yield ceiling than plant population.



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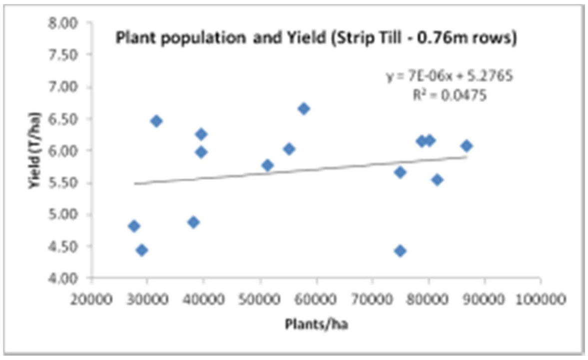

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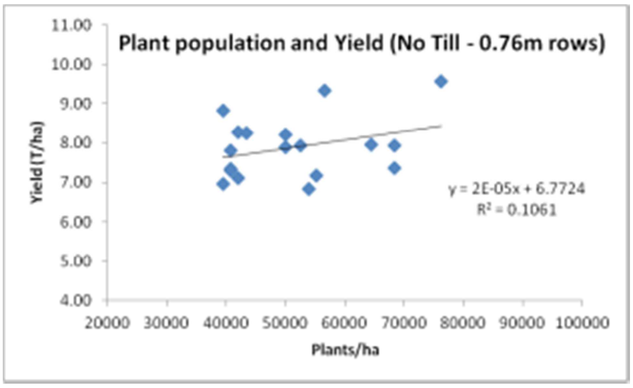

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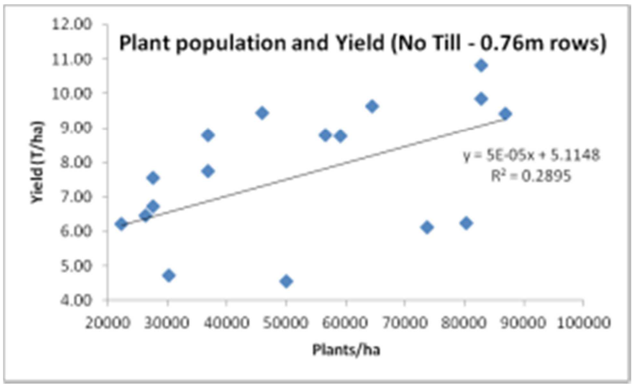

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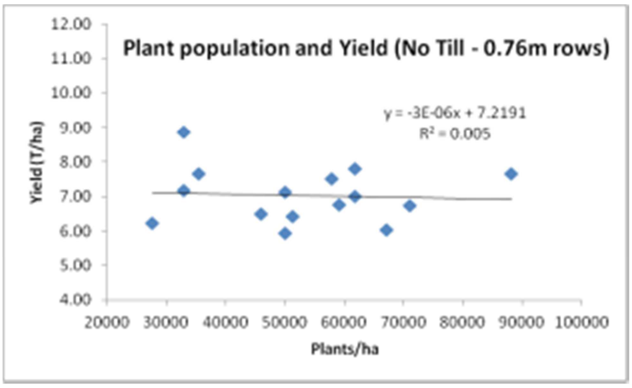

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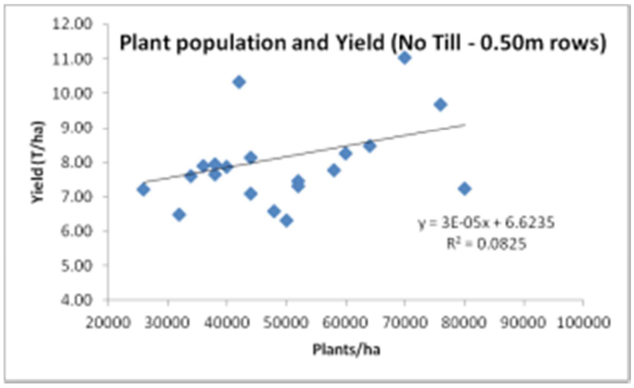

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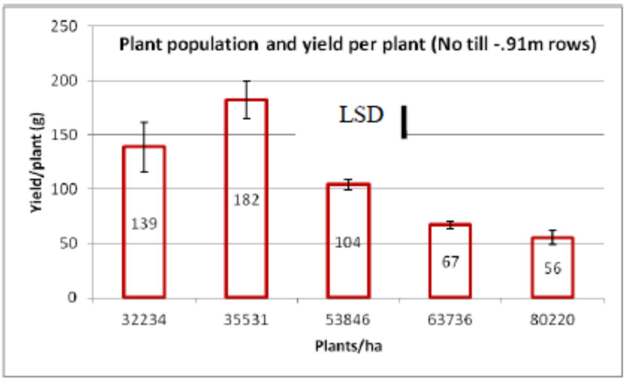
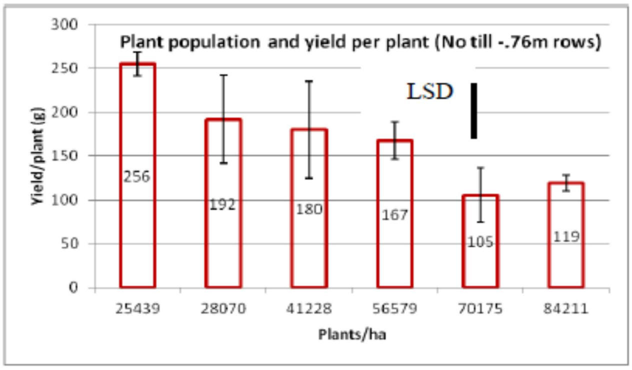
Figure 8.4.7. The relationship of plant population and yield for maize grown under different tillage practices and planted in different row widths.

Figure 8.4.8 shows how the plants compensated in terms of yield per plant. There was a general tendency that plants at lower planting densities produced more grain per plant than plants grown at higher densities. Figure 8.4.3 e) suggests that the trend looked a little different for 0.5 m rows than the other row widths. In these rows plants yielded equally well over different planting densities at the lower range of densities after which (more than 43000 per ha) a very pronounced decline was seen. This is however, only one data set and more work needs to be done to confirm this observation.





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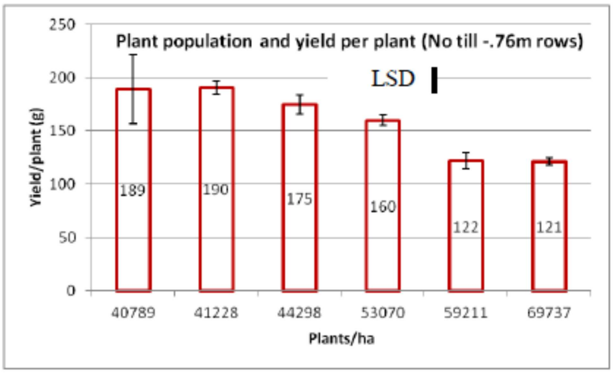

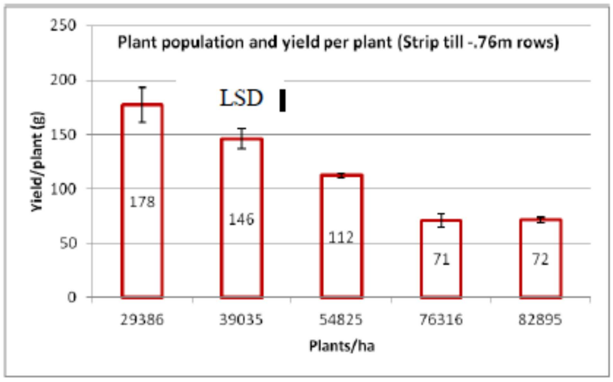

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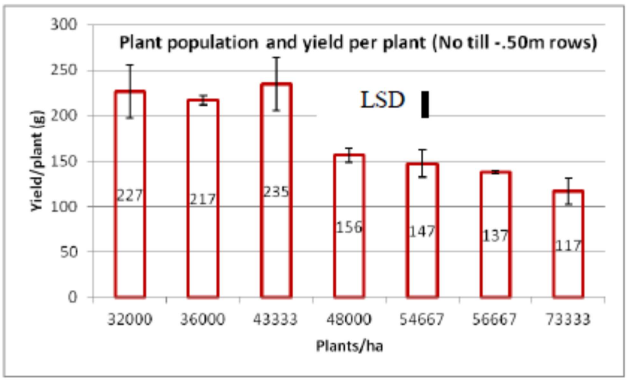

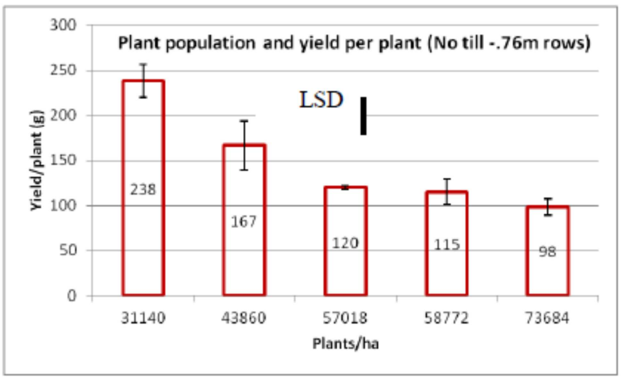

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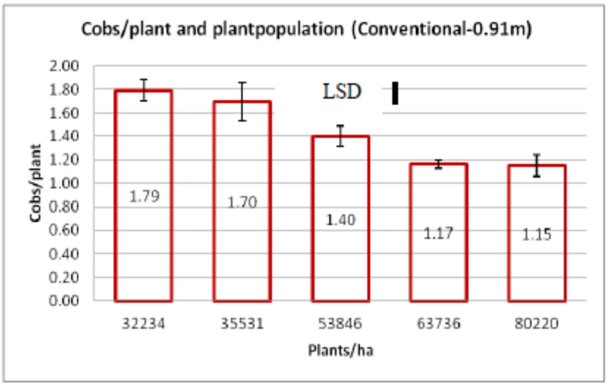
Figure 8.4.8. Yield per plant for maize grown under different tillage practices and planted in different row widths.

Figure 8.4.9 shows that some of the compensation was done by more cobs being formed at lower plant densities. Cultivar characteristics obviously also played a role because it can be seen that the cob number effect was different between the different trials. Cob size *per se* was not measured but must also have played a compensatory role. Figure 8.4.8 (d) for instance, shows an increase of 56% in terms of mass per plant when plant population decreased from the highest to the lowest population. Figure 8.4.9 (d) then shows an increasing cob number of only 27% for the same range of plant populations.



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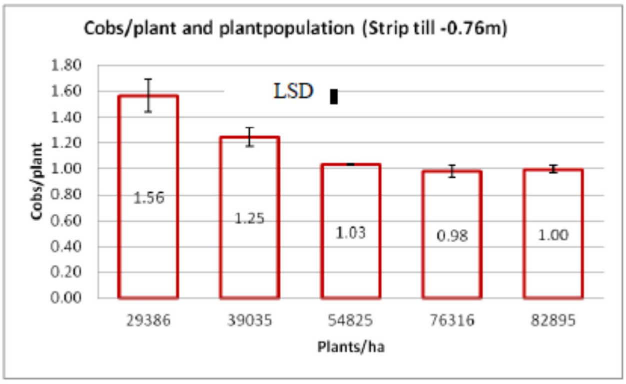

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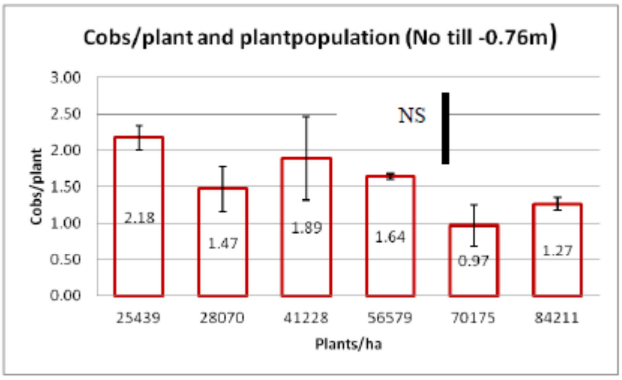

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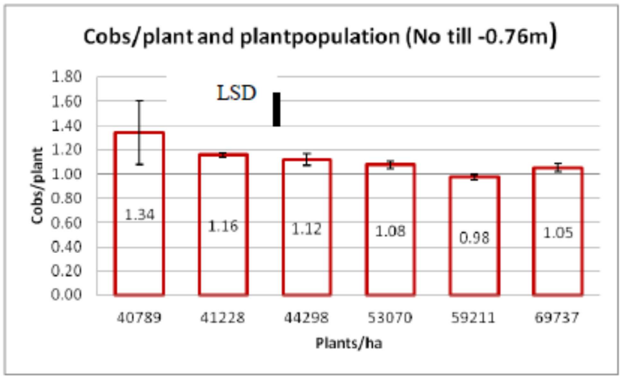

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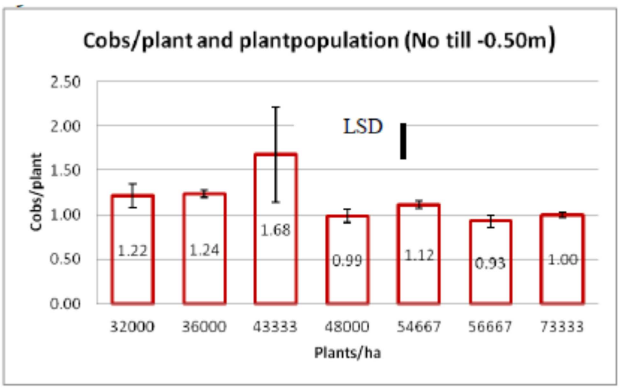

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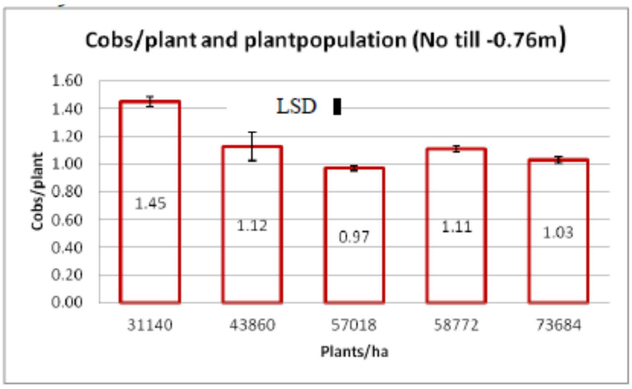

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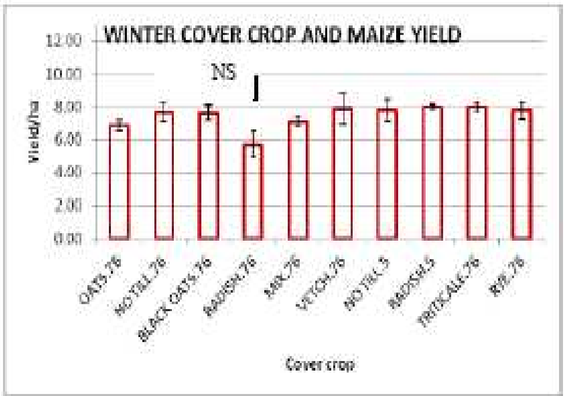
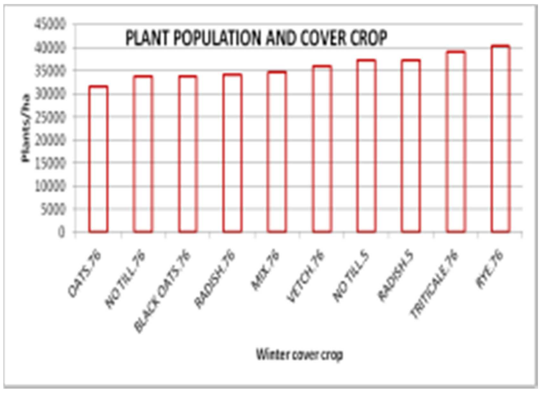
Figure 8.4.9. Number of cobs per plant for maize grown under different tillage practices and planted in different row widths.

B. Maize winter cover crop trial

Figure 8.4.10 (a) shows that the winter cover crops did not affect the following maize yield in a significant way. Plant populations varied between 32000 and 40000 plants/ha (Fig. 10 b) but this factor obviously also played no significant role in influencing the final yields.



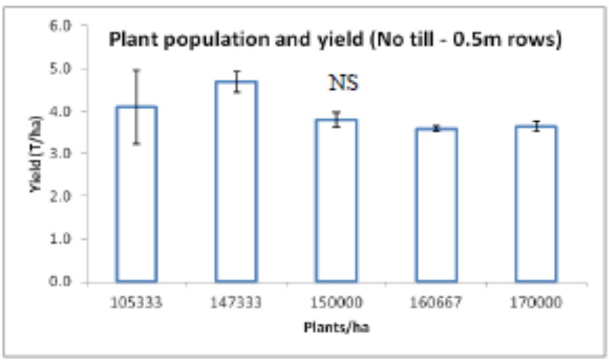


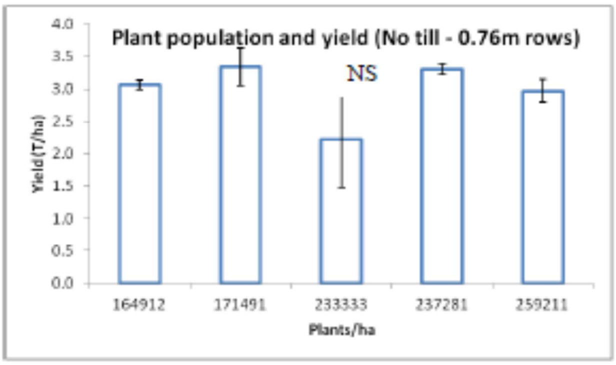
a) b)

Figure 8.4.10. a) Yield and b) plant population of maize planted in two row widths after various combinations of winter cover crops were planted the previous winter.

C. Soya bean row width (Argentinean way) trial

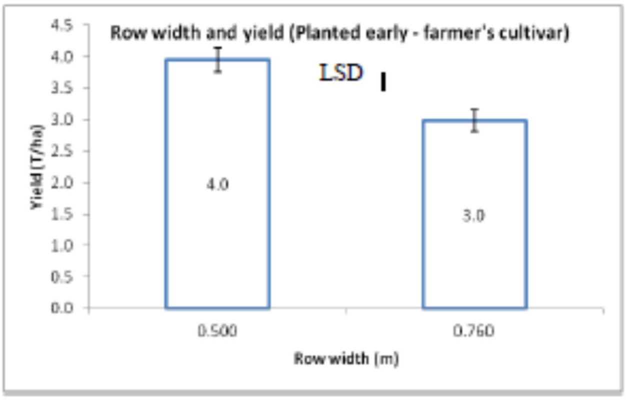
There were no significant plant population effects on yield in either the narrow (Fig. 8.4.11 a) or wider rows (Fig. 8.4.11 b). Figure 8.4.12 (a) shows a large yield benefit (1 t/ha) when 0.5 m rows are used. This benefit is not explained by plant population because it is shown that the narrow rows had a lower mean plant population (Fig. 12 b).





a) b)

Figure 8.4.11. Soya bean yield at different plant populations in a) 0.5 m rows and b) 0.76 m rows



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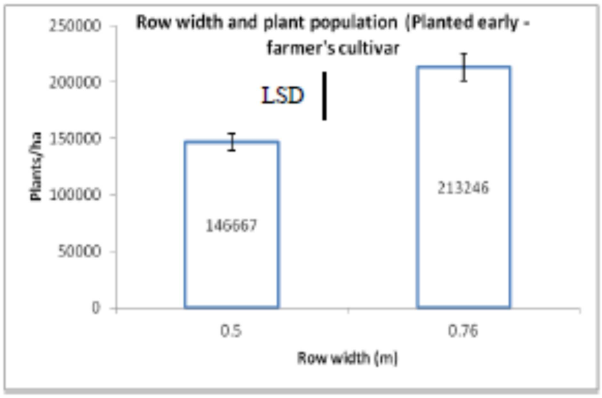
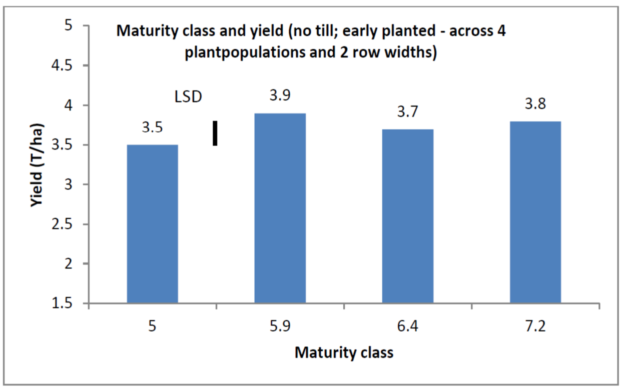


b)

Figure 8.4.12. Effect of row width on a) soya bean yield and b) the difference in plant population achieved.

D. Soya bean row width, plant population and cultivar trial (planted early: October 26)

Figure 8.4.13 (a) shows that the early maturity class yielded the lowest but the other classes did not differ much one from another. No significant plant population effects were recorded (Fig. 8.4.13 b) but the narrow rows yielded significantly more than the wider rows (Fig. 8.4.13 c).



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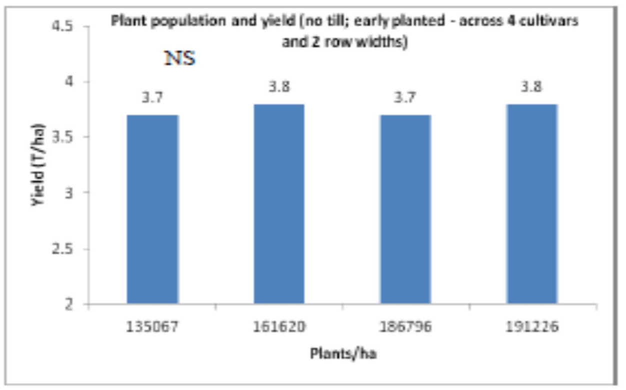

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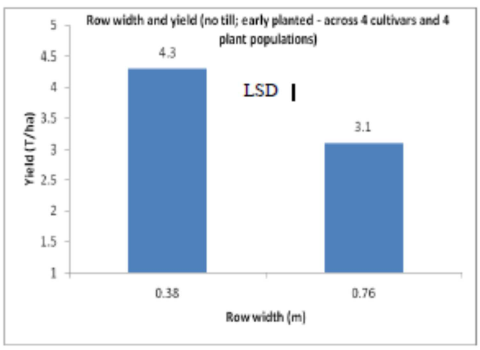
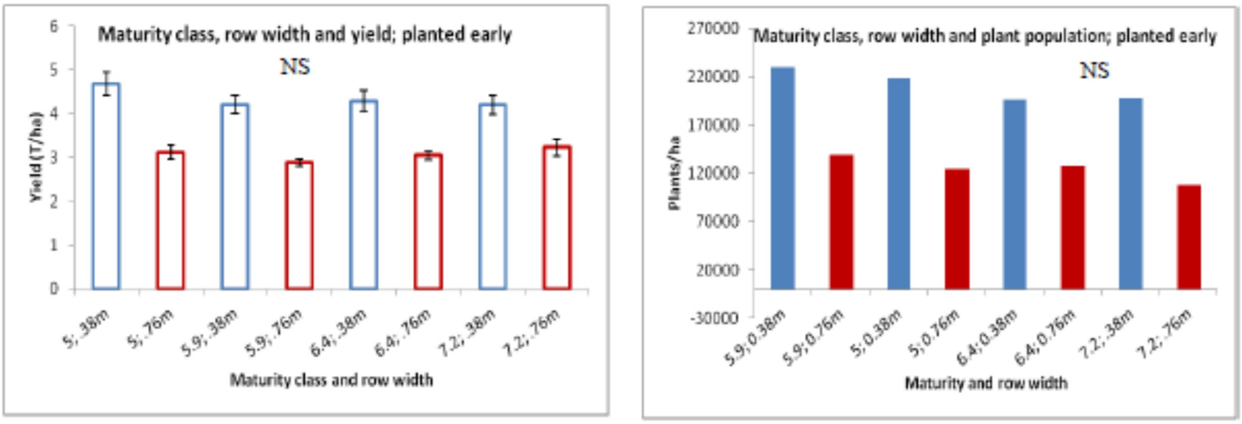


c)

Figure 8.4.13. Effect of a) plant population and b) row width on soya bean yield.

Figure 8.4.14 shows interaction effects that were not significant, meaning that all cultivars reacted in the same way to row width. Having worked with and seen how their growth characteristics differed one would have expected the early maturity class to react more to row width. It has a smaller plant frame which should favour narrower row widths. It does seem as if maturity class 5 did in fact react to row width a little bit more even if the ANOVA did not show it. Figure 8.4.14 (b) suggests that the yield increase of narrow rows had something to do with the increased plant population. This observation is actually contrary to what was seen in the previous trial and it could be coincidental.



a) b)

Figure 8.4.14. a) Soya bean yield for different maturity classes and row widths and b) the respective mean plant populations for the treatment combinations.

Figure 8.4.15 shows that the maturity class x row width interaction was not significant in terms of pod numbers per plant. Pod numbers were generally increased by wider rows which could be the result of lower plant populations in the wider rows. Figure 8.4.16 confirms the suggestion that plant population influenced pod numbers and that pod number is an important way of compensating for lower plant populations. The R^2 values in Figure 16 are not very good but the trends are always there. The pod numbers were determined in a very crude way (only two to three plants per plot sampled). It is supposed that more representative measurements would have resulted in higher R^2 values.

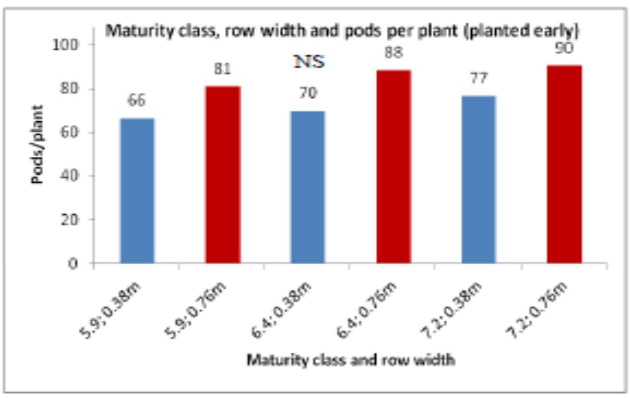
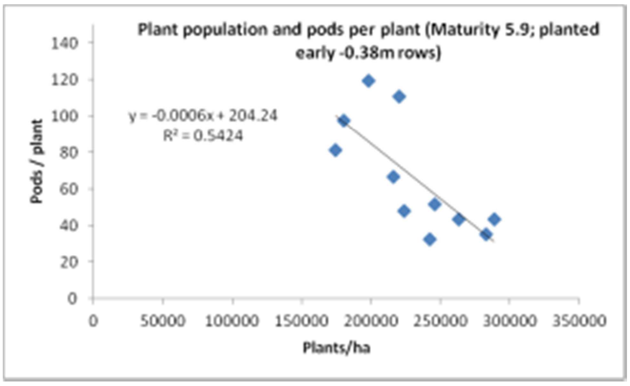


Figure 8.4.15. Effect of maturity class and row width on pod number per plant.



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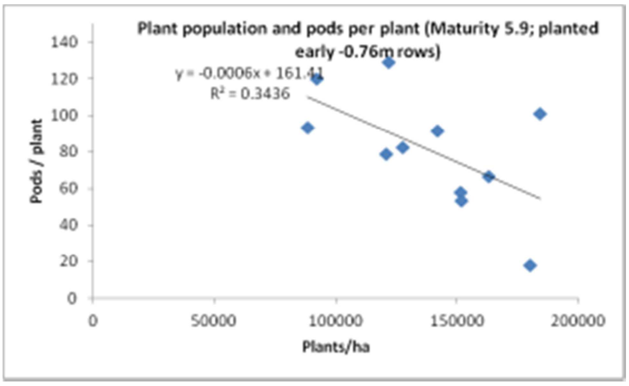

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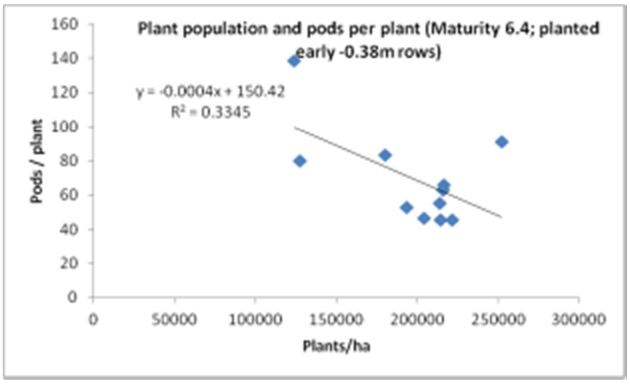

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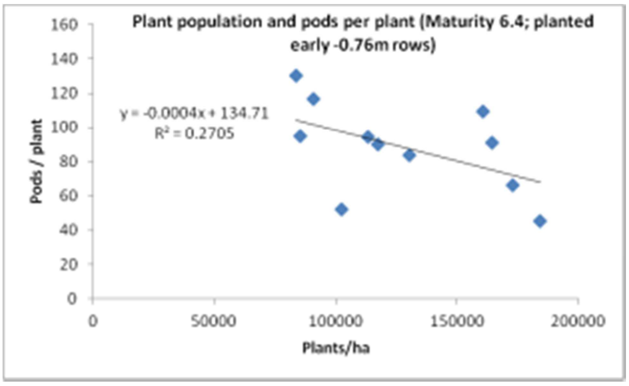

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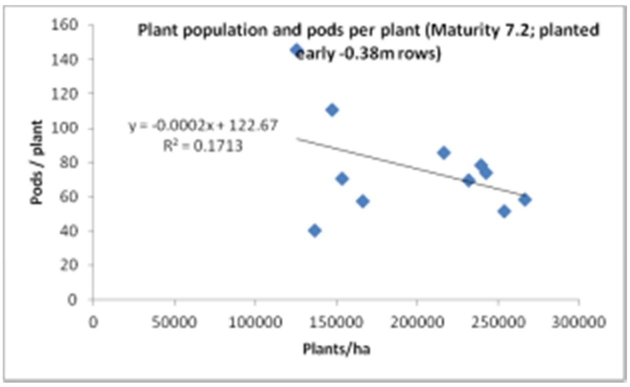

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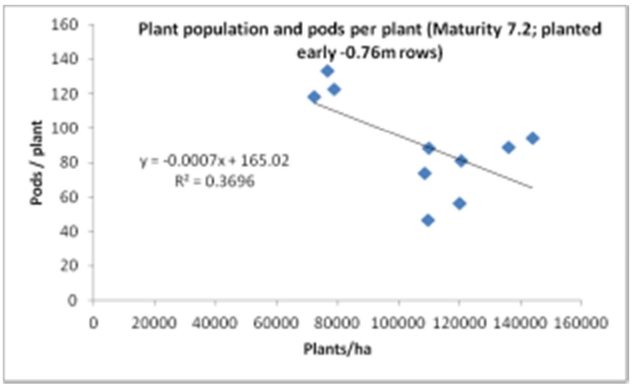
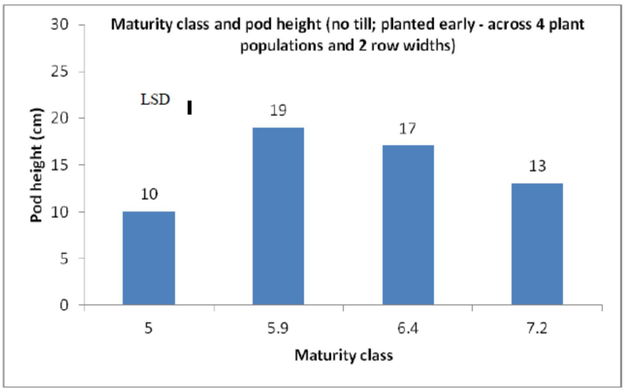
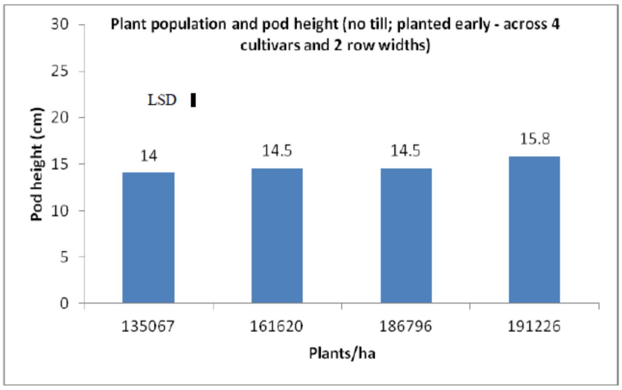


f)

Figure 8.4.16. Regression analysis showing pod number declined with increased plant population in two row widths using three soya bean maturity classes.

Figure 8.4.17 (a) confirms the general belief that early maturing cultivars carries their pods lower than longer growers. There was also a tendency that increased plant population increased pod height in general (Fig. 8.4.17 b). The increase was not much but might have been more if higher populations could have been achieved in this trial.



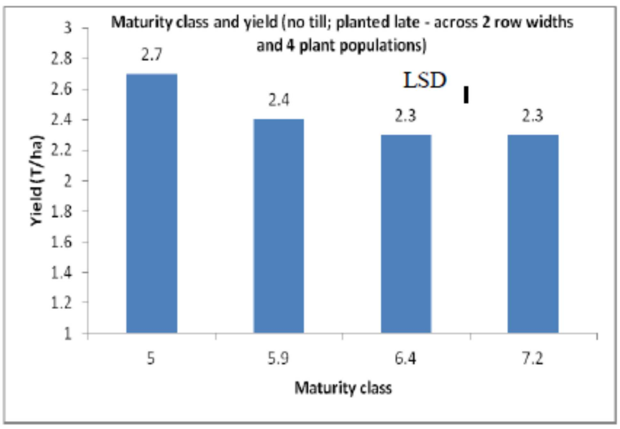


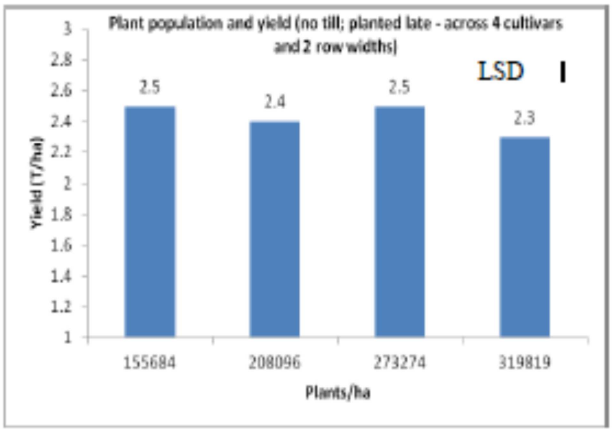
a) b)

Figure 8.4.17. Significant effects of a) maturity class and b) plant population on soya bean pod height.

E. Soya bean row width and plant population trial (planted late: December 3)

Yields were generally lower for the late planting date than the early planting date (Fig. 18 (a) and Fig. 13 a). The higher yield of maturity class 5 in this trial might be explained by the unseasonal early frost of the last week of March this year. The longer growers were more negatively influenced because they were less advanced than the short grower. As with the previous trial, one could not determine a definite trend between plant population and yield (Fig. 18 b). This again alludes to the ability of soya beans to compensate for plant population differences.





a) b)

Figure 8.4.18. Significant effects of a) maturity class and b) plant population on soya bean yield.

Figure 8.4.19 confirms the positive yield effect of narrow rows that was also seen in previously discussed trials. It was however, not so pronounced as those previously discussed.

Figure 8.4.20 again shows how pod number and plant population were related. The general compensation mechanism for low plant populations seems to be increased pod numbers per plant.

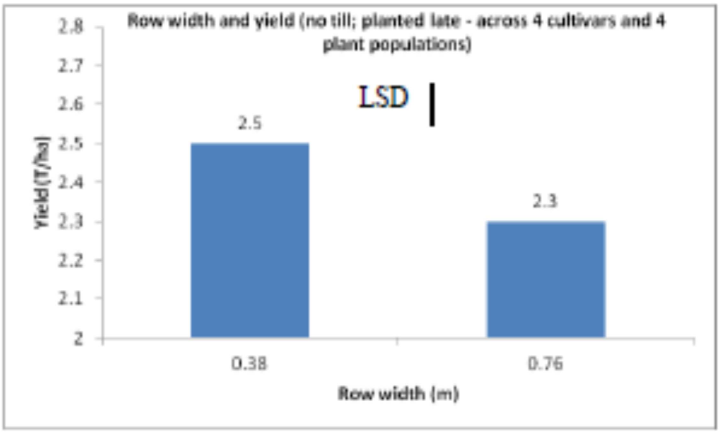
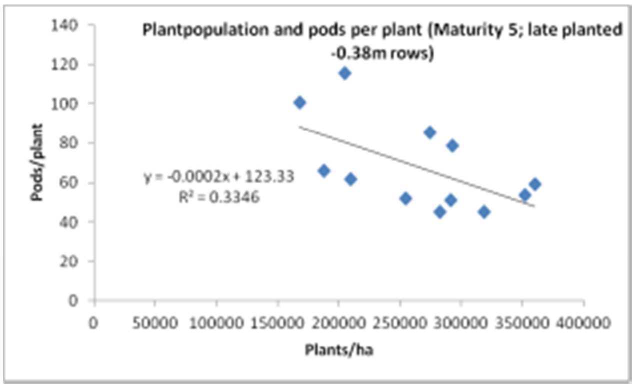
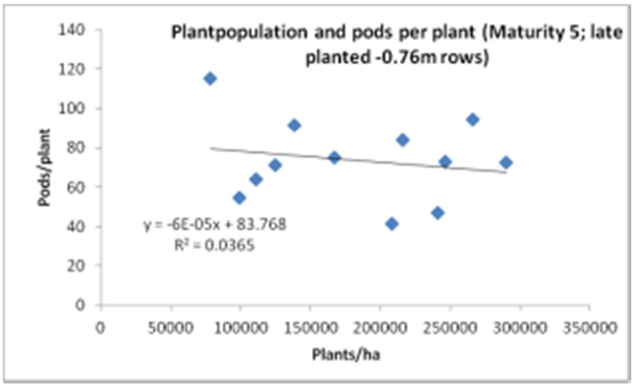


Figure 8.4.19. Effect of row width on the yield of soya beans.



a)



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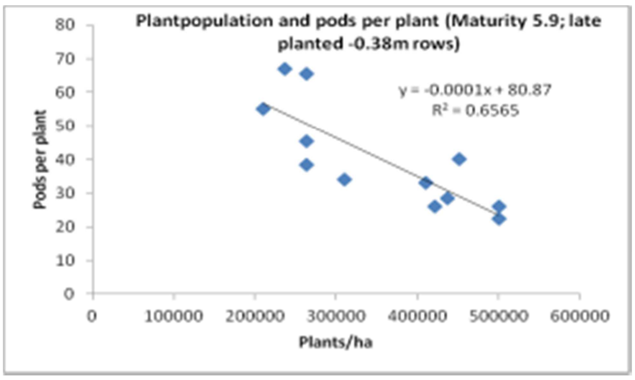

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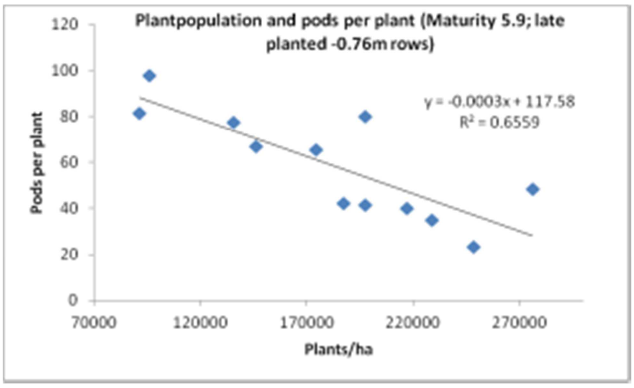
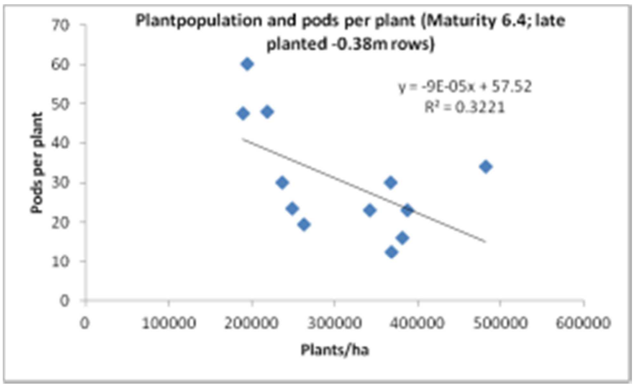


d)

Figure 8.4.20. Regression analysis showing pod number declined with increased plant population of in two row widths using four soya bean maturity classes.



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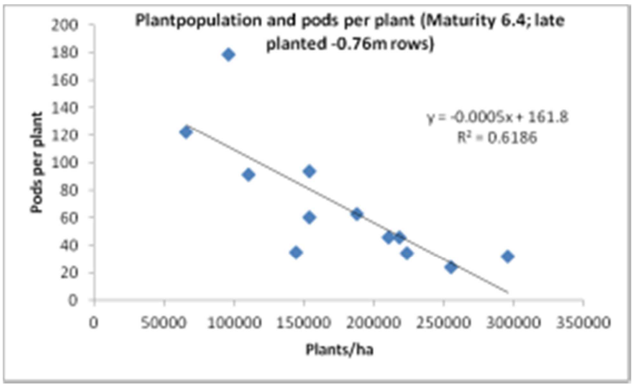

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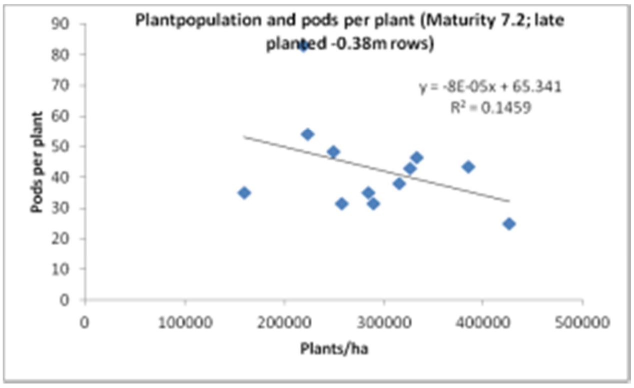

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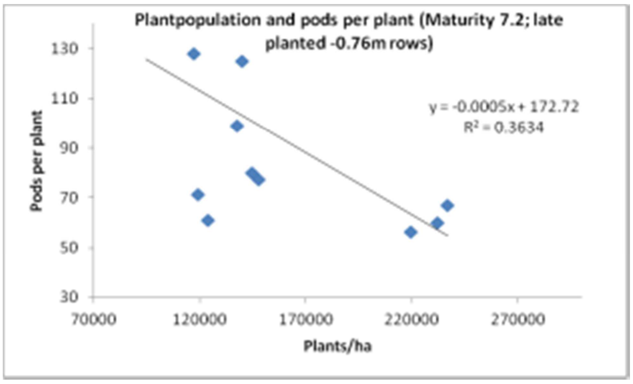
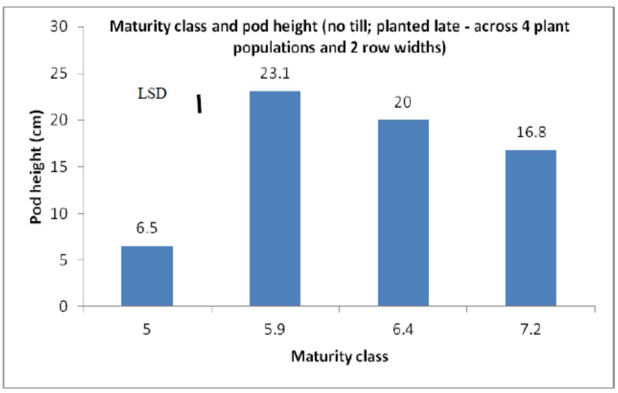


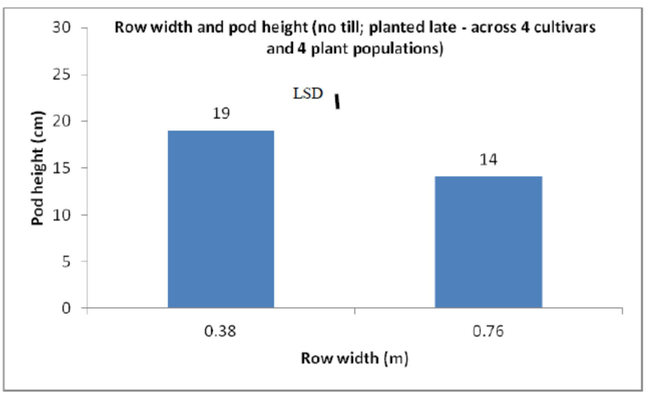
h)

Figure 8.4.20 continued.

Figure 8.4.21 shows the lowest pod heights for the earliest maturity class. This was also seen in the early planted trial. No significant effect from plant population was measured but the row width effect was significant (Fig. 8.4.21 b). This suggests that node length was increased by increased shading in the narrow rows.



a)



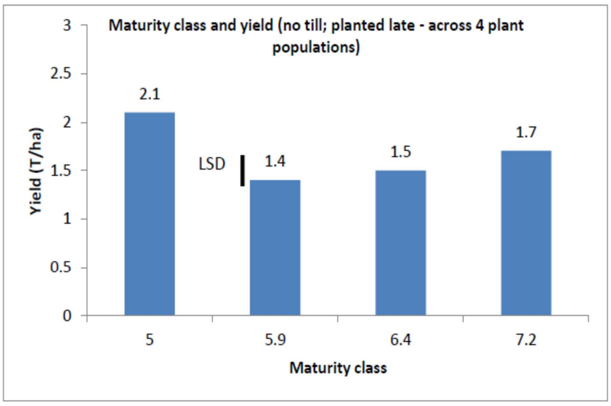
b)

Figure 8.4.21. Effect of a) maturity class and b) row width on pod height of soya beans.

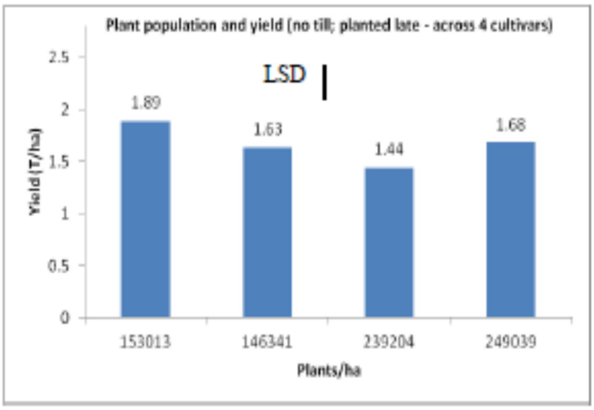
F. Soya bean cultivar and plant population trial (planted late: Argentinean way)

This trial was planted late (December 3) in a very high clay content soil under very dry conditions. Rainfall did not improve much during the season and early frost stopped the growing season prematurely. The yields were generally in the region of between 1,5 and 2 tons per ha (Fig. 8.4.22 a). As the previously reported trials suggest, these yields would not have been achieved had it not been for the narrow rows (0.5 m). As was explained for the previously discussed late planted trial, the short growing cultivar had advanced farther through its growth cycle when the frost came which explains its highest yield.

Figure 8.4.22 (b) shows significant plant population effects on yield. There was however, no clear trend. Only the lowest plant population and the second highest plant populations differed significantly.



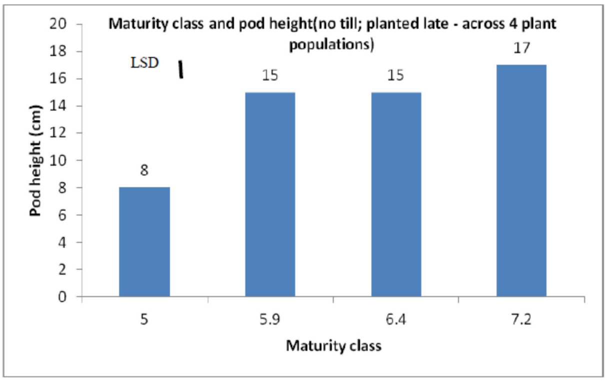
a)

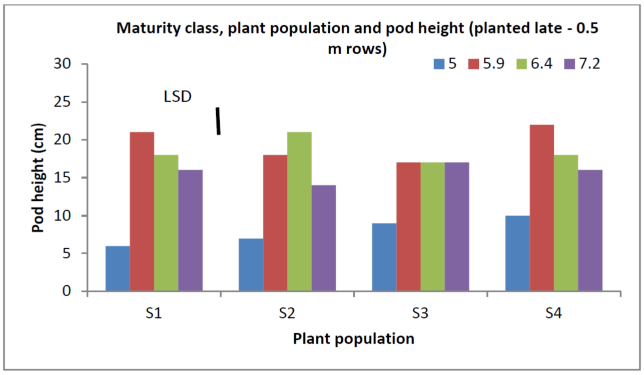


b)

Figure 8.4.22. Effect of a) maturity class and b) plant population on yield of soya beans.

Figure 8.423 (a) shows the lowest pod heights once again for the earliest maturing class. The main effects for plant population are not shown, but it was not significant and ranged between 15 and 17 cm over all the plant populations. The interaction effect between maturity class and plant population showed that there was a plant population effect at the early cultivar. Pod heights increased from about 6 cm at the lowest plant population to 10 cm at the highest plant population. There was not a general trend for the other cultivars.



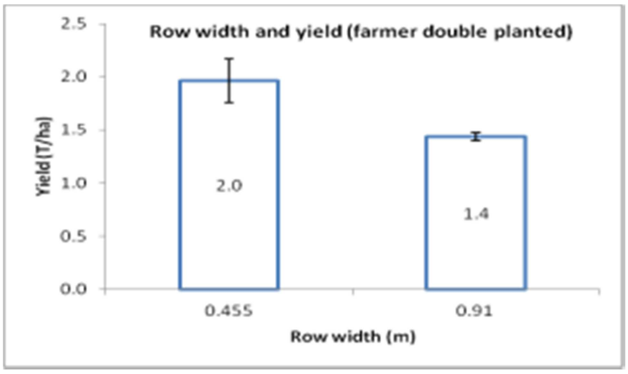


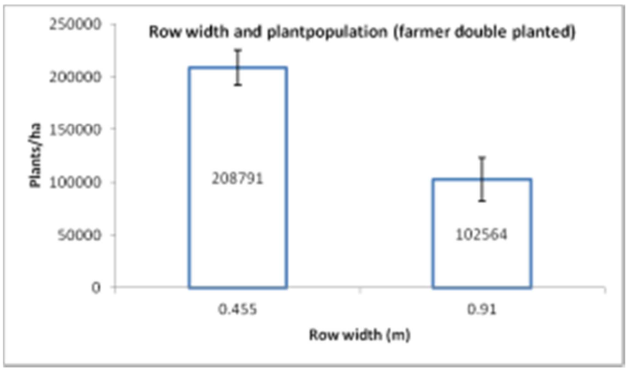
a) b)

Figure 8.4.23. Main effect a) and interaction effects b) of maturity class and plant population on pod height of soya beans.

G. Soya bean row width effects in replacement planting

Figure 8.4.24 (a) shows the positive effect of a second row (narrow row) that was planted through replacement planting. The plant population was doubled (Fig. 24 b) but this increase was not necessarily the reason for the increased production. The first row width trial that was discussed in this paper showed an increased yield in narrow rows where the plant population was actually lower than in wider rows.





a) b)

Figure 8.4.24. Effect of a) row width on yield and b) plant population achieved for soya beans that were replacement planted.

CONCLUSIONS – ASCENT CA TRIALS

Maize trials

A lot of variables such as cultivar, tillage practices, fertilizer applications, rain fall and soil types differed from trial to trial. It made it difficult to interpret different plant population reactions between trials. It was however still evident that maize has a remarkable compensatory ability when plant populations vary. The compensation comes to a great degree from larger and more ears under lower plant population conditions. Generally it seemed that 30 000 to 40 000 plants/ha were enough to ensure that the highest potential for the existing circumstances could be reached. There was one exception where higher plant populations were needed to reach a higher yield. More work need to be done to determine if this result was an aberration. It also seemed possible that certain cultivars might be more adapted to lower plant populations and that high plant populations might in fact be detrimental to yield.

The variables mentioned above have a lot to do with the production of maize but rainfall is probably the one overriding factor. More will be done in future to get rainfall figures per site location and to bring rainfall affectivity into the equation to try and understand how and why plant population response curves seem to differ from trial to trial.

Soya bean trials

The soya bean trials were also planted under different conditions and it was also evident that this crop can compensate very effectively for varying plant populations. Pod number per plant seemed to be an important variable in terms of compensation. The row width parameter was investigated under more controlled conditions than for the maize trials. It could be shown that narrower rows are far more effective in manipulating soya bean yield than plant population. The row effect could have been expected for a dry year such as this year because plant sizes were a little smaller and the available space was utilized more effectively in terms of covering the ground and intercepting sunlight in narrow rows. It remains to be seen if the effect will be as pronounced in a high rainfall season.

The early maturing cultivar did not outperform the other cultivars when planted early but did the best when planted later. It seems that the early maturing cultivar had an advantage in terms of escaping early frost damage. Some of its yield advantage could however, be lost due to higher harvesting losses caused by its pods being carried low.

The early cultivar had a smaller growth habit which made it more likely to perform better in narrower rows and that is exactly what was observed.

PROBLEMS ENCOUNTERED AT ASCENT TRIALS

The only problems that were encountered were poor planting conditions due to a severe drought. Some farmers who were supposed to participate in the maize trials could therefore not plant. Hail occurred sporadically but was generally not damaging enough to abandon trials except for one farmer whose trial had to be abandoned.

RECOMMENDATIONS – ASCENT TRIALS

The feasibility of acquiring some soil probes to get a better understanding of water infiltration and usage was discussed at the bi-annual meeting. Probes have in the meantime been made available through the new budget for the next season. This will really help in gaining good quality information. Rain gauges should and will also be positioned at every trial to monitor this important parameter.

8.4.2. Annual report for trial results in Reitz study area

Background

The trial was planted on the 14th of December 2015. The 20 000 population x 50cm row treatment was out of specs for planters used. Therefore, data were analysed as follows:

1) Without treatment 20 000 population,
2) Without treatment 50cm rows,
3) Treatments combined for yield. Each combination handled as a single treatment and rated from 1-11.

Maize yield (12.5 moisture) ton/ha

The 20 000 population taken out

Plant population	**Row width (cm)**			**Average**
	50	**76**	**100**	
40 000	3.46^{b}	3.93^{a}	3.48^{a}	3.62^{a}
60 000	5.84^{a}	4.29^{a}	5.16^{a}	5.09^{b}
80 000	5.48^{ab}	4.97^{a}	5.16^{a}	5.20^{b}
Average	4.93^{a}	4.40^{a}	4.59^{a}	***4.64***
LSD $_{\text{(plant pop. x row width (0.05))}}$ = 2.13; LSD $_{\text{(plant pop. (0.05))}}$ = 1.23; LSD $_{\text{(row width(0.05))}}$ = 1.23; cv = 26.6 %				

The yield of the 60 000 population was significantly higher than the yield of the 40 000 population in the 50 cm rows. The average yield of the 40 000 population of all three row width treatments was significantly lower than the average yield of the other two plant population treatments.

The 50cm rows taken out

Plant population	Row width (cm)		Average
	76	100	
20 000	3.71[a]	2.98[a]	3.45[a]
40 000	3.93[a]	3.48[a]	3.70[ab]
60 000	4.29[a]	5.14[a]	4.17[ab]
80 000	4.98[a]	5.16[a]	5.06[b]
Average	4.23[a]	4.19[a]	***4.21***
LSD $_{\text{(plant pop. x row width (0.05))}}$ = 2.26; LSD $_{\text{(plant pop. (0.05))}}$ = 1.60; LSD $_{\text{(row width(0.05))}}$ = 1.13; cv = 30.6 %			

The average yield of the 40 000 population of all three row width treatments was significantly lower than the average yield of the 80 000 plant population of the three row width treatments. Row width had no influence on yield.

Combined treatments

Rating	Plant population x row width	Yield (ton/ha)
1	50/60000	**5.84**[a]
2	50/80000	5.48[a]
3	100/80000	5.16[ab]
4	100/60000	5.14[ab]
5	76/80000	4.97[ab]
6	76/60000	4.29[ab]
7	76/40000	3.93[ab]
8	76/20000	3.71[b]
9	100/40000	3.48[b]
10	50/40000	3.46[b]
11	100/20000	2.98[bc]
$LSD_{(0.05)}$ = 1.93; cv = 10.9%; Mean yield = 4.40 ton/ha		

The first two treatments combinations were significantly higher than the last four treatment combinations.

Maize: Plant emergence %

The 20 000 population taken out

Plant population	Row width (cm)			Average
	50	76	100	
40 000	86[a]	53[a]	72[a]	70[a]
60 000	83[a]	57[a]	77[a]	72[a]
80 000	80[a]	44[a]	69[a]	64[a]
Average	83[a]	51[c]	73[b]	***69***
$LSD_{(plant\ pop.\ x\ row\ width\ (0.05))}$ = 16.8; $LSD_{(plant\ pop.\ (0.05))}$ = 9.7; $LSD_{(row\ width(0.05))}$ = 9.7; cv = 14.1 %				

The plant emergence % of the average row widths differs significantly from one another.

The 50 cm rows taken out

Plant population	Row width (cm)		Average
	76	100	
20 000	87[a]	91[a]	89[a]
40 000	53[b]	72[b]	63[b]
60 000	57[b]	77[b]	67[b]
80 000	44[b]	69[b]	56[b]
Average	60[a]	77[b]	***69***
$LSD_{(plant\ pop.\ x\ row\ width\ (0.05))}$ = 17.8; $LSD_{(plant\ pop.\ (0.05))}$ = 12.6; $LSD_{(row\ width(0.05))}$ = 8.9; cv = 14.8 %			

The plant emergence % of the 20 000 plant population x 76 cm row width treatment was significantly lower than the plant emergence % of other plant populations x 100 cm treatments.

Maize: Plant population/ha at harvest

The 20 000 population taken out

Plant population	Row width (cm)			Average
	50	76	100	
40 000	32 667[a]	21 930[a]	23 000[a]	26 865[a]
60 000	52 667[b]	34 649[b]	39 333[b]	42 216[b]
80 000	56 667[b]	42 105[b]	45 667[b]	48 146[c]
Average	47 333[a]	32 895[c]	37 000[b]	***39 076***
LSD $_{(plant\ pop.\ x\ row\ width\ (0.05))}$ = 9 784; LSD $_{(plant\ pop.\ (0.05))}$ = 5649; LSD $_{(row\ width(0.05))}$ = 5649; cv = 14.5 %				

The average plant population/ha differed significantly per row width treatment, as well as plant population treatment, at harvest.

The 50 cm rows taken out

Plant population	Row width (cm)		Average
	76	100	
20 000	21 930[a]	17 000[a]	19 465[a]
40 000	21 930[a]	26 000[a]	23 965[a]
60 000	34 649[b]	39 333[b]	36 999[b]
80 000	42 105[b]	45 667[b]	43 886[b]
Average	30 154[a]	32 000[a]	***31 077***
LSD $_{(plant\ pop.\ x\ row\ width\ (0.05))}$ = 10 196; LSD $_{(plant\ pop.\ (0.05))}$ = 7 210; LSD $_{(row\ width(0.05))}$ = 5 098; cv = 18.7 %			

Higher plant populations treatments, 60 and 80,000, had significantly more plants/ha at harvest, but plant populations were not influenced by the two row width treatments.

Conclusions

The 2015 season was one of the most challenging production seasons ever. Only the maize was harvested. Drought caused low plant emergence percentages, which resulted in data with high variation (cv%).

The 20 000 population x 50cm row treatment was out of specs for planters used. It was decided on a meeting (29 July 2016) that the 20 000 population treatment will be replaced with a 100 000 population treatment in future.

8.5. Coordination and facilitation of project activities among farmer participants

Work Package title	**Coordination and facilitation of project activities among farmer participants**
Work Package period	October 2015 to September 2016
Lead partner	Local facilitators (Pieter de Wet, VKB, Riemland study group and Robert Steynberg, VKB, Ascent study group)
Involved partners	Riemland & Ascent study groups and other Innovation Platform (IP) partners Willem Killian, Lientjie Visser (ARC), Gerrie Trytsman (ARC), Paula Lourens (Vermi Solutions), Wynn Dedwith (Valtrac), Martiens De Bruin (Farmquip)
Objectives	• Coordinate on-farm experimentation activities among all participating farmers • Ensure timely and correct implementation of relevant activities and treatments • Assist with the use of specialised implements for trial purposes • Promote synergy among farmer participants • Monitor selected indicators (through field form, sampling & visits) and report on project activities and progress related to farmer involvement.
Justification	On-farm experimentation involving farmers as 'researchers' are seen as central to research projects under the banner of the CA-Farmer Innovation Programme at Grain SA. This implies that trial treatments or replications are implemented on the farm by the respective farmer participants. A range of support measures are needed to ensure the success and quality of these farmer-led actions, including the engagement of relevant research and technical team members around these farmers. **A particular role and function identified by the project team is that of a local farmer facilitator, primarily assisting,**

	guiding, calibrating and coordinating the participating farmers to implement the experimental designs (treatments) correctly. This person also has to manage and move specific specialised implements (e.g. a no-till planter) between the farmers, allowing timely and correct use of it. The person selected should be locally based and should have an intimate knowledge of the local natural resources and stakeholders, especially the farmers. Expected result of this function is the elimination of undesirable variables and the increased quality of the trials and data.

Description of work	Prepare farmers and implement on-farm trials. Manage, maintain and move specialised implements to be used by the various farmers involved in the trials. Making sure that farmers understand the treatments and what is expected from them. Calibrate or train farmers on specific implements / practices where necessary. Conduct regular field/farm visits, monitor and coordinate relevant activities, assist with sampling of soil where necessary. Attend regular project meetings and assist with report writing.

Activities	1. Land preparation 2. Planting 3. Seasonal management 4. Monitoring and Sampling 5. Monthly meetings (project team) 6. Annual reference group meeting (advisory committee) 7. Annual report and admin 8. Participate in Awareness events

Risks	• Being a dryland experiment, low and erratic rainfall may compromise crop yields; • Wild animals and birds may jeopardise crop performance and yields; • Instrumental and logistical failure can result in incomplete activities and results

ACTIVITIES, DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

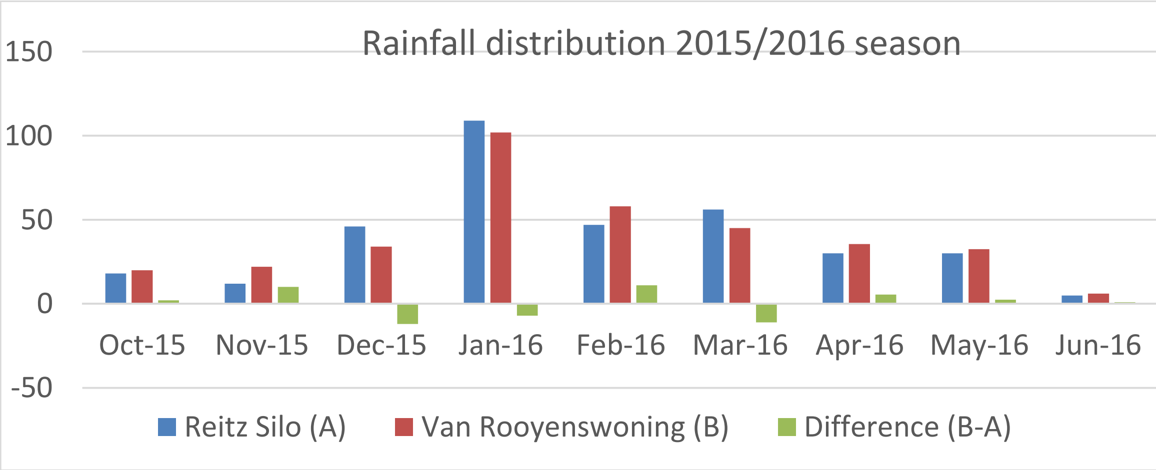
Activities	**Deliverables +** **Progress and Results achieved**
1. Land preparation	Assist farmers to lay out their trial plots Prepare (calibrate and train) farmers on the trial treatments Make sure land preparation (e.g. weeding) is done according to specifications. Make sure the correct type and quantity of production inputs are ready and used. Weather station installed. Agrixtreme discussing weed management and product use

2. Planting	Prepared planters for planting Moved planters between farmers for timely planting, where necessary Make sure farmers plant according to standard treatment specifications Planted according to the treatments although certain barriers forced for some alterations.
3. Seasonal management	Assist farmers in weeding and pest/disease management Agrixtreme weekly farm visits; weed management. Weather station data and crop growth data.
4. Monitoring and Sampling 5. (Done with activity 3 above)	Assist farmers to complete field forms Assist to collect soil samples Monitor the farmer-led actions Collected the following data: • Leaf area index • General plant development • Root development/Compaction (GP Schoeman and Pieter de Wet) • Discussions with farmers during the season • ARC and VKB soil moisture sampling • Herbicide treatments • Plant Emergence • Production (yield per hectare) • Crop residue cover • Rainfall data – see graphs below Soil erosion meeting Piet Theron 18 March VKB and members of Study Group
6. Monthly meetings (project team) & Training	Participate in monthly forum meetings, discussing problems and possible solutions to that. Active discussions on Whatsapp group chat Farmer visits Project team meetings and discussion session between farmer co-workers. 13 July 2016 - Discussion Pieter de Wet and ARC Data analyses
7. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of data. Learning from each other. 29 July: Key role players discussed the seasons trail results, general progress and shortcomings. Compiling presentations and reporting on activities.
8. Annual report and admin	Written report covering trial implementation, results and progress.
9. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits (see below)

Awareness events

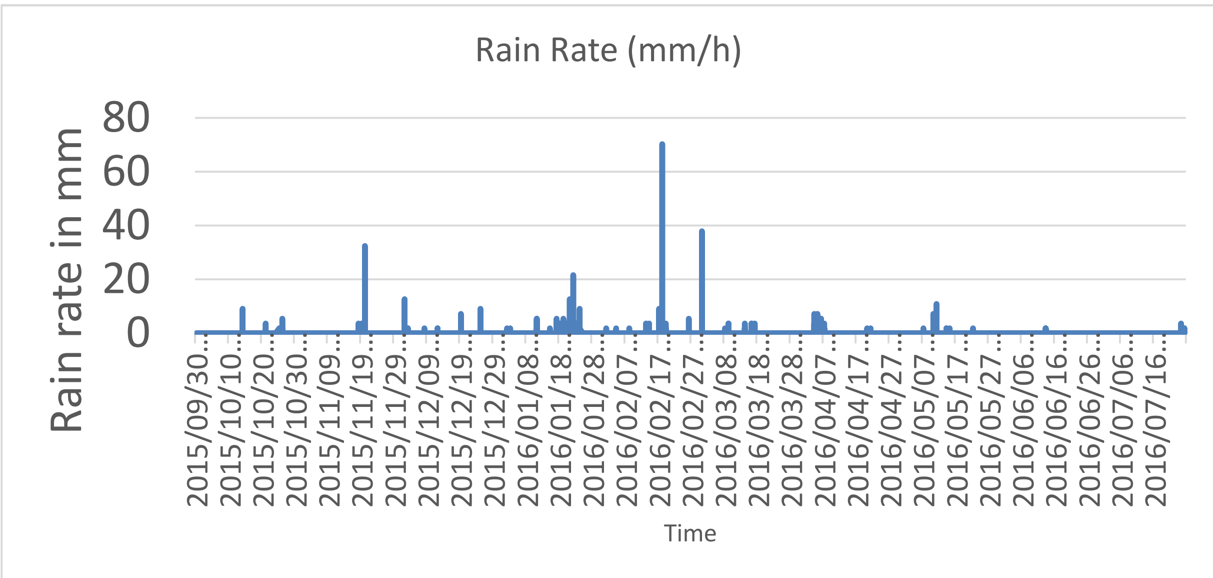
The measurements taken thus far and information gathered from it can be seen as significant. Another highlight is definitely a successful Farmers day that was held on the 18th February 2016 (Ascent) and 17 March (Reitz). A number of 77 and 80 participants attended these events respectively. Invited speakers conveyed information and a questions and answers session was held. Some of the experimental plots were visited on the farm of Izak Dreyer (Ascent) and Danie Slabbert (Reitz). See photos below.

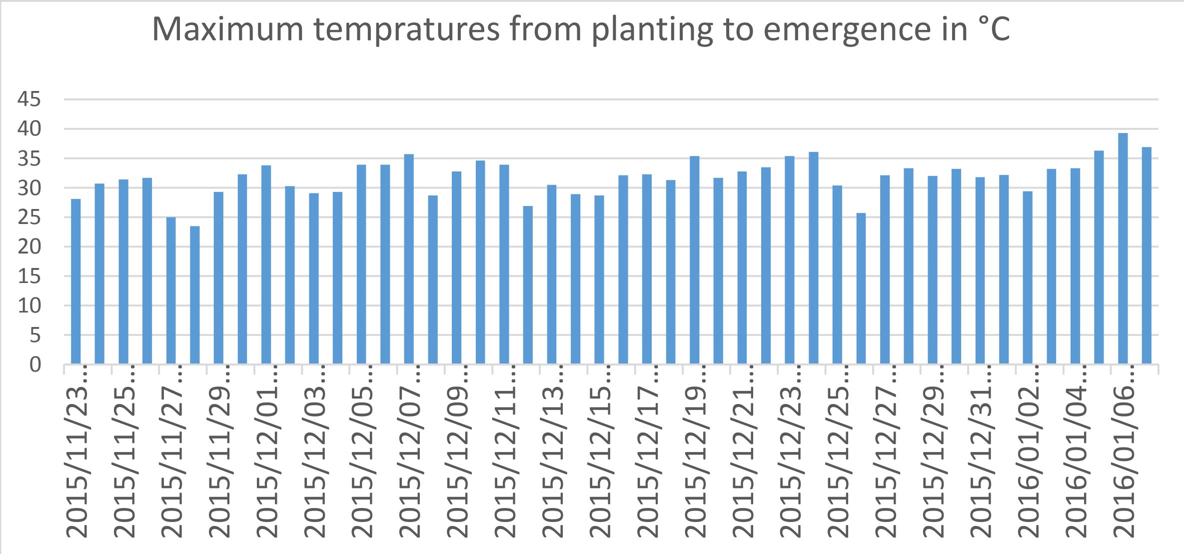
Climate data for Reitz, 2015/16 season



Rainfall distribution 2015/2016 season

Location	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Reitz Silo (A)	18	12	46	109	47	56	30	30	5
Van Rooyenswoning (B)	20	22	34	102	58	45	35.5	32.5	6
Difference (B-A)	2	10	-12	-7	11	-11	6	3	1
Location	Total:								
Reitz Silo (A)	353								
Van Rooyenswoning (B)	355								
Difference (B-A)	2								





9. Project budget

The project budget and expenditure to date for both study areas is indicated in **Table 2** below as per work package and activity.

Table 2: Project budget and expenditure by August 2016

Project Description	Total Actual YTD Aug16*	Total Budget YTD Sept16	Available to use
NE FS, Reitz: Soil	-	40 300	40 300
NE FS, Vrede: Soil	28 680	40 300	11 620
NE FS: Cover crops	98 473	147 800	49 327
NE FS; Reitz: Agronomy	20 824	84 280	63 456
NE FS; Vrede: Agronomy	4 422	84 700	80 278
NE FS; Reitz: Grain SA	39 343	65 000	25 657
NE FS; Vrede: Grain SA	56 483	65 000	8 517
NE FS, Reitz: Farmer Facilitation	102 951	150 308	47 357
Total	**351 176**	**677 688**	**326 512**

*** Expenses and invoices still expected which will affect the final amount until 30 September.**

ATTACHMENT 1:

TRIAL LAYOUTS

(REITZ AND VREDE SITES)

Protocol for research on planting densities of crops produced in conservation agriculture systems in the Eastern Free State

1. Background

Adoption of conservation practices (CA) in the Eastern Free State is much slower than expected. Grain SA has partnered with two farmer study groups (Ascent in Vrede and Riemland in Reitz) to identify research needs and to implement various activities, of which on-farm trials are the main one, in the identified two project sites. Both groups saw plant density in CA systems as a high priority research need. Plant population play an important role in optimising grain production and in other regions research indicated that planting densities needed to be adapted for CA practises. It is expected that this research might lead to the adaptation of new planting densities in the Eastern Free State as well.

2. Purpose of trial

The standard planting densities of conventional systems in the area will be tested at lower, as well as higher levels, to determine the effect thereof on the crop yield in conventional systems. The influence of two treatments, namely plant rows and plant density, as well as the interaction between the two treatments on crop yield will be determined. A factorial block design will be used and treatments will be randomised in four replicated blocks.

3 Method – Riemland Study group

3.1 Localities

Locality one – Danie Slabbert
Planned maize cultivar – 774 (Monsanto) RR
Planned Soy bean cultivar year 1 – 1664, year 2 – 1545
Planters:
Danie Slabbert - Jumil with cutting wheels - plant 12 rows
Callie Meintjies – Jumil

3.2 Fertiliser programme

No fertiliser on Soybean

Maize: 370kg/ha of 8.2.1(28 +0.5%Zn + 6% S mixture

Weed and disease control

Will be managed according to seasonal needs.

3.3 Harvest

3.4 Treatments

The plot include an annual rotation of maize and soy bean.

Two treatments are applied on both crops namely three row widths and four plant populations.

Maize treatments:

Row width (m)	Plant population (plants)			
0.50 m – Danie	20 000	40 000	60 000	80 000
0.76 m – Callie	20 000	40 000	60 000	80 000
1.00 m - Danie	20 000	40 000	60 000	80 000

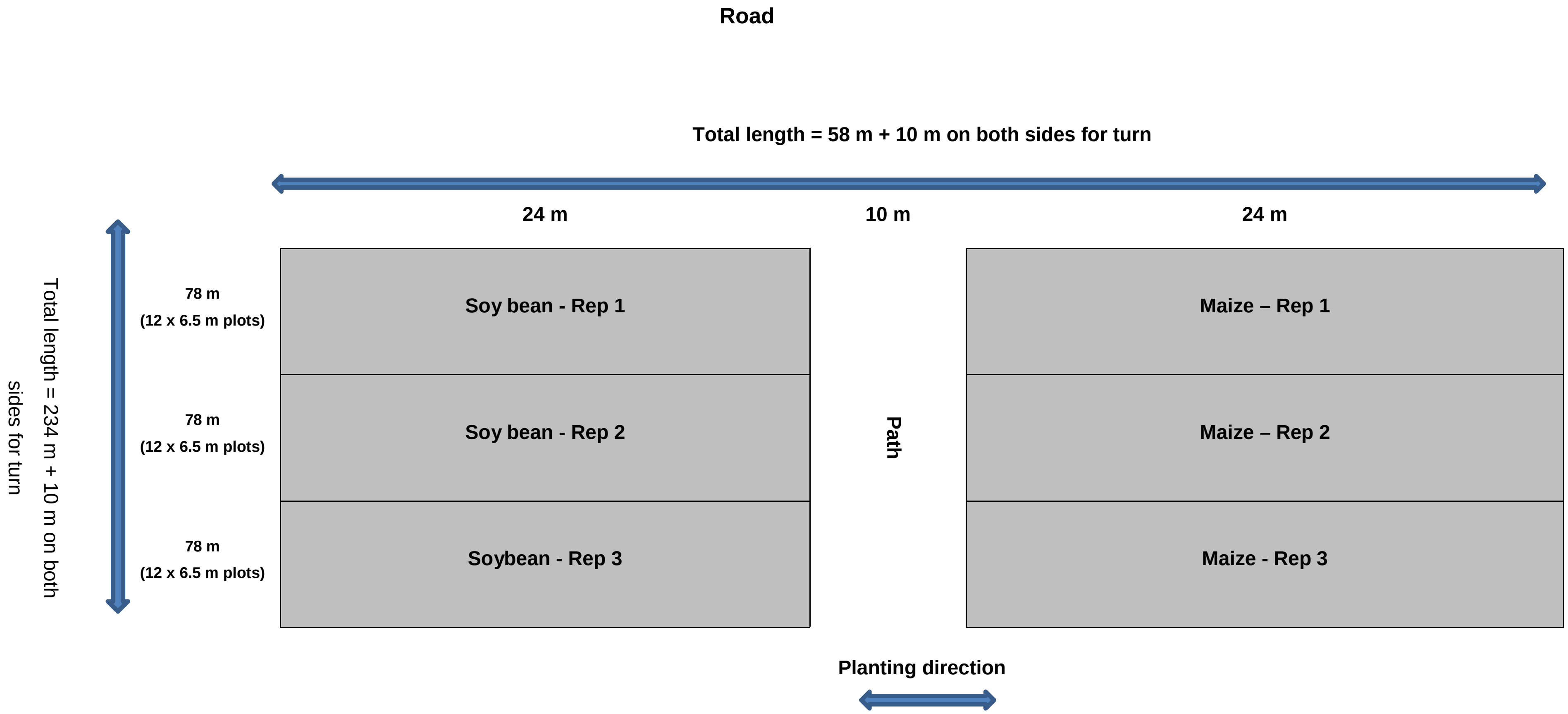
Soy bean treatments:

Row width (m)	Plant population (plants)			
0.50 m – Danie	150 000	250 000	350 000	450 000
0.76 m – Callie	150 000	250 000	350 000	450 000
1.00 m – Danie	150 000	250 000	350 000	450 000

A factorial block design will be used for the trial as follows.

3 x Row Widths x 4 Plant Populations X 4 replicates = 36 plots per crop

3.6 Trial layout



	SOY BEAN	MAIZE
Replicate 1	0.76 m x 150 k	0.76 m x 20 k
	0.76 m x 450 k	0.76 m x 80 k
	0.50 m x 150 k	0.50 m x 20 k
	1.00 m x 250 k	1.00 m x 40 k
	0.50 m 250 k	0.50 m 40 k
	0.76 m x 250 k	0.76 m x 40 k
	0.76 m x 350 k	0.76 m x 60 k
	0.50 m x 350 k	0.50 m x 60 k
	1.00 m x 350 k	1.00 m x 60 k
	0.50 m x 450 k	0.50 m x 80 k
	1.00 m x 450 k	1.00 m x 80 k
	1.00 m x 150 k	1.00 m x 20 k
Replicate 2	0.50 m x 350 k	0.50 m x 60 k
	1.00 m x 350 k	1.00 m x 60 k
	0.76 m x 250 k	0.76 m x 40 k
	1.00 m x 250 k	1.00 m x 40 k
	0.50 m x 450 k	0.50 m x 80 k
	1.00 m x 150 k	1.00 m x 20 k
	0.76 m x 350 k	0.76 m x 60 k
	0.76 m x 450 k	0.76 m x 80 k
	1.00 m x 450 k	1.00 m x 80 k
	0.50 m x 150 k	0.50 m x 20 k
	0.76 m x 150 k	0.76 m x 20 k
	0.50 m 250 k	0.50 m 40 k
Replicate 3	1.00 m x 250 k	1.00 m x 40 k
	0.50 m x 350 k	0.50 m x 60 k
	0.76 m x 450 k	0.76 m x 80 k
	0.50 m x 450 k	0.50 m x 80 k
	1.00 m x 150 k	1.00 m x 20 k
	1.00 m x 350 k	1.00 m x 60 k
	0.76 m x 150 k	0.76 m x 20 k
	0.7 6m x 350 k	0.76 m x 60 k
	1.00 m x 450 k	1.00 m x 80 k
	0.50 m x 150 k	0.50 m x 20 k
	0.50 m 250 k	0.50 m 40 k
	0.76 m x 250 k	0.76 m x 40 k

<u>Planting Notes:</u>

Planting date: 14 December 2015

Locality: Danie Slabbert

Cultivars:

Planned maize cultivar – 774 (Monsanto) RR

Planned Soy bean cultivar year 1 – 1664, year 2 – 1545

Planted cultivars:

Soybean – K2 5009;

Maize 7374 Dekalb (Roundup-ready)

Planters:

Danie Slabbert – Jumil Plant Grafica Magnum 3080 PD - planted the 1m and 0.5m rows could not plant 20 000 population for maize – replaced it with 40 000 plant population.

Callie Meintjies – Jumil – planted the 0.78m rows

Plant population per planter:

Plant population	Danie (0.5 m and 1 m rows)	Callie (0.78 m rows)
Soy bean -150	150	*145
Soy bean - 250	250	250
Soy bean - 350	*390	*330
Soy bean - 450	450	*462
Maize – 20	*40	*25
Maize – 40	40	40
Maize – 60	60	60
Maize - 80	80	*83

Fertiliser:

No fertiliser on Soybean

Maize: 370kg/ha of 8.2.1(28 +0.5%Zn + 6% S mixture (Supplier – High Fert; 071 659 2712 – Batch 2015/12/09)

Soil moisture at plant (gravimetric):

In progress!

An evaluation of different crop rotation systems in the Eastern Free State

1. **Background**

   Crop rotation is one of three pillars on which conservation agriculture (CA) are build. Research in the Western Cape, as well as overseas, indicated that adoption of CA practices increased when data regarding successful rotation crops and -systems became available in a region. The Riemland study group in Reitz are being used as platform to launch a series of on-farm trials on this topic as part of The Maize- and Winter Cereal Trust project with Grain SA and the ARC to evaluate different crop rotations in their existing CA systems.

2. **Purpose of trial**

   To evaluate the potential and success of six crop rotation systems, which was identified by the study group, in the Eastern Free State, namely:

   - Soy beans : Maize
   - Soy bean : (Wheat and, or Sunflower) (sunflower will be planted directly after wheat if soil moisture is enough) : Maize
   - Soy bean : Wheat : Maize
   - Soy bean : Sunflower : Maize
   - Soy bean : Winter cover crop : Maize
   - Soybean : (Wheat and, or Sugar bean) - (sugar bean will be planted directly after wheat if soil moisture is enough) : Maize

3. **Objectives of the trial**

- To evaluate the impact of crops on the growth, development, yield and quality on the follow-up crop.
- To establish any negative impacts (diseases, weeds and pests) specific crops may have on the follow-up crop.

- To establish any beneficial effects a crop may have on the next crop in the sequence (disease breaks, elevation of compaction, availability of nutrients, fixation of nitrogen).
- To establish the effect crops may have on nutrient availability of subsequent crops.
- To determine most profitable sequences of crops.

4. Method

The trial will be replicated on two localities on the farms of Danie Slabbert and Armand Muller. Both trials will be planted as randomised blocks with four replicates of the six crop rotation treatments. Each rotation will be planted on the same plot every year to measure the effect of the crop sequence on the specific plot. Plots will be 72 m in length and the row widths will be 50 cm. Total plot width will be 39 m, which includes 1 m strips between each treatment. Each trial will exist of a total of 24 plots. The trial need to be protected from possible bird, or animal damage.

4.1 Fertiliser programme

Will fertilise maize for a 5 ton yield potential.
Soy bean will be planted without any fertiliser.
Soy bean seed will be treated with MBFI before planting.
A100kg/ha NH_4SO_4 will be applied on soy bean plots before planting.

4.2 Weed and disease control

Managed according to the season.

4.3 Measurements

- Rain
- Soil moisture at planting time.
- Soil analyses – before planting and after harvest.
- Seedling survival rate
- Number of plants, tillers and ears, biomass yield and residue yield

- Thousand Kernel Mass, Grain Yield, Harvest Index
- Quality of wheat – Protein, Hectolitre mass, Falling number
- Nitrogen use parameters - Available nitrogen supply, Nitrogen uptake, Nitrogen use
- Precipitation use efficiency (PUE)

4.1 Planting times

Year	Month	Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5	Sequence 6
2015	Nov	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Dec	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
2016	Jan	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Feb	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Mar	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Apr	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	May						
	Jun						
	Jul		Wheat	Wheat		Cover crop (W)	Wheat
	Aug		Wheat	Wheat		Cover crop (W)	Wheat
	Sep		Wheat	Wheat		Cover crop (W)	Wheat
	Oct	Maize	Wheat	Wheat	Sunflower	Cover crop (W)	Wheat
	Nov	Maize	Wheat	Wheat	Sunflower	Cover crop (W)	Wheat
	Dec	Maize	Wheat	Wheat	Sunflower	Cover crop (W)	Wheat
2017	Jan	Maize	Sunflower		Sunflower		Sugar bean
	Feb	Maize	Sunflower		Sunflower		Sugar bean
	Mar	Maize	Sunflower		Sunflower		Sugar bean
	Apr	Maize	Sunflower				Sugar bean
	May	Maize	Sunflower				Sugar bean
	Jun	Maize					
	Jul	Maize					
	Aug						
	Sep						
	Oct		Maize	Maize	Maize	Maize	Maize
	Nov	Soy bean	Maize	Maize	Maize	Maize	Maize
	Dec	Soy bean	Maize	Maize	Maize	Maize	Maize
2018	Jan	Soy bean	Maize	Maize	Maize	Maize	Maize
	Feb	Soy bean	Maize	Maize	Maize	Maize	Maize
	Mar	Soy bean	Maize	Maize	Maize	Maize	Maize
	Apr	Soy bean	Maize	Maize	Maize	Maize	Maize
	May		Maize	Maize	Maize	Maize	Maize
	Jun		Maize	Maize	Maize	Maize	Maize
	Jul		Maize	Maize	Maize	Maize	Maize
	Aug						
	Sep						
	Oct	Maize					
	Nov	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Dec	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean

Year	Month	Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5	Sequence 6
2019	Jan	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Feb	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Mar	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	Apr	Maize	Soy bean	Soy bean	Soy bean	Soy bean	Soy bean
	May	Maize					
	Jun	Maize					
	Jul	Maize	Wheat			Cover crop (W)	Wheat
	Aug		Wheat			Cover crop (W)	Wheat
	Sep		Wheat			Cover crop (W)	Wheat
	Oct		Wheat	Maize	Sunflower	Maize	Wheat
	Nov	Soy bean	Wheat	Maize	Sunflower	Maize	Wheat
	Dec	Soy bean	Wheat	Maize	Sunflower	Maize	Wheat
2020	Jan	Soy bean	Sunflower	Maize	Sunflower	Maize	Sugar bean
	Feb	Soy bean	Sunflower	Maize	Sunflower	Maize	Sugar bean
	Mar	Soy bean	Sunflower	Maize	Sunflower	Maize	Sugar bean
	Apr	Soy bean	Sunflower	Maize		Maize	Sugar bean
	May		Sunflower	Maize		Maize	Sugar bean
	Jun			Maize		Maize	
	Jul			Maize		Maize	
	Aug						
	Sep						
	Oct	Maize	Maize		Maize		Maize
	Nov	Maize	Maize	Soy bean	Maize	Soy bean	Maize
	Dec	Maize	Maize	Soy bean	Maize	Soy bean	Maize
2021	Jan	Maize	Maize	Soy bean	Maize	Soy bean	Maize
	Feb	Maize	Maize	Soy bean	Maize	Soy bean	Maize
	Mar	Maize	Maize	Soy bean	Maize	Soy bean	Maize
	Apr	Maize	Maize	Soy bean	Maize	Soy bean	Maize
	May	Maize	Maize		Maize		Maize
	Jun	Maize	Maize		Maize		Maize
	Jul	Maize	Maize		Maize	Cover crop (W)	Maize
	Aug					Cover crop (W)	
	Sep					Cover crop (W)	
	Oct			Maize		Maize	
	Nov	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
	Dec	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
2022	Jan	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
	Feb	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
	Mar	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
	Apr	Soy bean	Soy bean	Maize	Soy bean	Maize	Soy bean
	May			Maize		Maize	
	Jun			Maize		Maize	
	Jul			Maize		Maize	

4.4 Trial plan

Path	Rep 1		Path	Rep3		Path
	Soy bean: (Wheat +/ Sugar bean) : Maize	Total length 39 m Each plot 6.5 m (5.5 + 1 m strip)		Soy bean : Maize	Total length 39 m Each plot 6.5 m (5.5 + 1 m strip)	
	Soy bean : Sunflower : Maize			Soy bean : (Wheat +/ Sunflower) : Maize		
	Soy bean : Maize			Soy bean : (Wheat +/ Sugar bean) :Maize		
	Soy bean : (Wheat + /Sunflower) : Maize			Soy bean : Wheat/Maize		
	Soy bean : Wheat : Maize			Soy bean : Winter cover crop :Maize		
	Soy bean : Winter cover crop : Maize			Soy bean : Sunflower : Maize		
	Rep 2			Rep 4		
	Soy bean : Wheat : Maize	Total length 39 m Each plot 6.5 m (5.5 + 1 m strip		Soy bean : (Wheat +/ Sunflower) : Maize	Total length 39 m Each plot 6.5 m (5.5 + 1 m strip	
	Soy bean : (Wheat/Sugar bean) : Maize			Soy bean : Sunflower : Maize		
	Soy bean : Winter cover crop : Maize			Soy bean : Maize		
	Soy bean : (Wheat + /Sunflower) : Maize			Soy bean : Wheat : Maize		
	Soy bean : Sunflower : Maize			Soy bean : (Wheat +/ Sugar bean) : Maize		
	Soy bean : Maize			Soy bean : Winter cover crop : Maize		
10 m	**72 m**		**10 m**	**72 m**		**10 m**

Protocol for research on planting densities of crops produced in conservation agriculture systems in the Eastern Free State

1 Background

Adoption of conservation practices (CA) in the Eastern Free State is much slower than expected. Grain SA has partnered with two farmer study groups (Ascent in Vrede and Riemland in Reitz) to identify research needs and to implement various activities, of which on-farm trials are the main one, in the identified two project sites. Both groups saw plant density in CA systems as a high priority research need. Plant population play an important role in optimising grain production and in other regions research indicated that planting densities needed to be adapted for CA practises. It is expected that this research might lead to the adaptation of new planting densities in the Eastern Free State as well.

2 Purpose of trial

The standard planting densities of conventional systems in the area will be tested at lower, as well as higher levels, to determine the effect thereof on the crop yield in conventional systems. The influence of two treatments, namely plant rows and plant density, as well as the interaction between the two treatments on crop yield will be determined. Blocks planted at nine different localities will serve as replicates. The nine localities will include four replicates of 0.50 m row widths planted with an Argentine planter; five replicates of the 0.72 m row width – two in no-till systems, two in strip-till systems, one in a conventional and three replicates of 0.90 row widths in conventional systems.

4 Method – Ascent Study group

3.1 Localities

A) <u>Row width 0.50 m – Argentine planter</u>
   Paul, Izak, Stephan, Danie (?).

B) <u>Row width 0.72 m</u>
   No-till – Izak, DD

Strip-till – Christo, Pienaar

Conventional – Paul

C) Row width 0.90 m

Conventional – Willie, Helgaard Stephan

Each farmer uses his own cultivar of choice for maize, as well as soy bean.

Own planters will be used at different locations, except for the localities where the Argentine planter will be used.

4.2 Fertiliser programme

Fertiliser will be applied according to recommendations based on soil analyses results.

4.3 Weed and disease control

Will be managed according to seasonal needs.

4.4 Harvest

Whole plots will be harvested and weigh with weigh cars.

4.5 Treatments

Blocks will include an annual rotation of maize and soy bean. Two treatments will be applied on both crops namely three row widths x five plant populations for maize and three row widths with only one plant population for soy bean.

Maize treatments:

Row width (m)	Plant population (plants)				
0.50 m	30 k	40 k	60 k	80 k	100 k
0.76 m	30 k	40 k	60 k	80 k	100 k
0.90 m	30 k	40 k	60 k	80 k	100 k

Soy bean treatments:

Row width (m)	Plant population (plants)				
0.50 m	300 k	300 k	300 k	300 k	300 k
0.76 m	300 k	300 k	300 k	300 k	300 k
0.90 m	300 k	300 k	300 k	300 k	300 k

3.6 Trial layout

Possible trial layouts

The maize and soy bean plots can be planted per field as one block with a path in-between, or it can be planted as two blocks on different fields – preferably the blocks should be close to one another. In a three year cycle, the planting densities of maize replicates should be kept on the same plots.

4.6 Trial plans for different row widths

A) <u>Row width 0.50 m – Argentine planter</u>

Izak, Stephan, Jaco

Plot length at least 50 m	**MAIZE**				
	0.50 m x **40** k	0.50 m x **30** k	0.50 M **60** K	0.50 m x **100** k	0.50 m x **80** k
10 m	**PATH**				
Plot length at least 50 m	**SOY BEAN**				
	0.50 m x **300** k	0.50 m x **300** k	0.50 m x **300** k	0.50 m x **300** k	0.50 m x **300** k

B) Row width 0.72 m

No-till – Izak, DD ; Strip-till – Christo Conventional – Paul

Plot length at least 50 m	**MAIZE**				
	0.76 m x **80** k	0.76 m x **100** k	0.76 m x **40** k	0.76 m x **60** k	0.76 m x **30** k
10 m	**PATH**				
Plot length at least 50 m	**SOY BEAN**				
	0.76 m x **300** k	0.76 m x **300** k	0.76 m x **300** k	0.76 m x **300** k	0.76 m x **300** k

C) Row width 0.90 m

Conventional – Willie, Stephan

Plot length at least 50 m	MAIZE				
	30 k	**80** k	**60** k	**40** k	**100** k
10 m	PATH				
Plot length at least 50 m	SOY BEAN				
	300 k	**300** k	**300** k	**300** k	**300** k

Trials design: Enhancing whole farm integration applying conservation agriculture principals using Cover Crops.

1. Introduction:

If you are considering planting a cover crop, consider whether the crops might also serve as forage for livestock. Cover crops planted as forage can serve multiple benefits. Not only can they help prevent soil erosion, provide organic matter, and scavenge nitrogen, but an additional benefit can come from using cover crops as forage for livestock grazing. Nutrient content of these forages is generally quite high, meeting or exceeding the nutritional needs of dry, lactating cows and growing calves. With good ground moisture conditions, forage production can be high enough to support a significant amount of grazing.

A variety of species and mixes can be used for cover crops based on multiple goals. For example, millet and radishes (brassicas) can produce a large amount of biomass for grazing and also scavenge nitrogen and help prevent soil compaction.

Cover crops often contain 15 – 25% crude protein and 60 – 75% TDN. The legumes are highest in protein while the grasses are highly palatable. Cover crop forages can be very high in moisture and low in fiber so that it can be difficult for livestock to consume sufficient dry matter. When grazing cover crops, it is essential that the forage mix itself contains biomass of quality, to help livestock consume enough nutrients. Usually no more than about two-thirds of the diet should be legumes. Adding grass-type forages like millets and sorghum-sudan to mixes can help provide bulk for grazing. Legumes such as cowpea and lablab can provide protein for productive animals like growing animals and cows with calves.

Livestock contributes significantly to nutrient cycling. Grazing can speed up break down of plant tissues and affect rates of nutrient release. In addition, grazing livestock excrete nutrients e.g. nitrogen and potassium in their manure that can result in the redistribution of nutrients within a field. Several research studies have shown little impact of grazing cover crops on soil compaction. This can be affected by moisture conditions and the amount of residue in the field. Roots from cover crops may alleviate any minor effects of grazing on soil compaction. Additionally, benefits associated with grazing from the nutrient cycling and the added feed resource may outweigh any negative impacts that might occur.

Several precautions should be taken in grazing certain cover crops. Because of their nitrogen scavenging ability, brassicas can be high in nitrates and recommendations regarding the feeding of high nitrate forages should be followed. Adapt livestock to grazing cover crops and don’t turn them out hungry. Other forages, such as millet can also contain high levels of nitrates if grown under dry conditions. Brassicas can also contain high levels of glucosinolates, which affect thyroid function, so be sure to provide iodized salt during the grazing period.

Incorporating cover crop grazing into a crop rotation does take planning. Herbicides used in the previous crop need to be considered to ensure that they will neither inhibit forage growth nor limit grazing. Pastures dominated by cool season plants can typical increase intake. Nutritional quality of these plants decreases rapidly by early summer. Grazing of cover crops provides an alternative of much greater nutritional value which will promote improved livestock performance. Currently, record high livestock prices suggest this may be an opportune time to consider planting cover crops for grazing. This practice might just impacted positively on cash crop yield in rotation, by altering the soils fertility in all aspects.

2. Background:

Humanskraal is located in the Ottosdal farming community. The farm owner is Mr George Steyn which has a mixed farming operation. Cash crops are planted no-till and rotation between maize, sunflower and soybean are the norm. Cattle graze crop residues during the winter. These lands are big and cattle stay for an extended period on them during winter. The supply of water is limited due to the lack of reservoir and open water sources on the farm.

Mr. Steyn gave permission that we can plant a summer mixture of cover crops on his farm (5-10ha). The main focus at this stage then will be the impact of grazing on the soil health. The cover crop itself will be monitor for biological productivity, utilization patterns, nutritional value and wastage. The biological productivity of the cash crop planted in rotation after the grazing. Animal's feces will be analyzed, to see if the nutritional needs of the cattle are met.

2.1 Summer mixture:

An indication of the crops that will be in the summer mixture and the amounts that are proposed is shown in Table 1. These crops are mostly summer annuals with one temperate crop. Crops have done well in cover crop trials the previous two years. Sunflower and Sunhemp are include to attract beneficial insects such parasitic wasps and bees.

Table 1 Recommended summer mixture with crops, the kg/ha and price.

Crop	Kg/ha	25kgs	Per kg	Price
Millet	8	R 325.00	R 13.00	R 104.00
Sorghum sweet	8	R 300.00	R 12.00	R 144.00
Cowpea Betch white	15	R 650.00	R 26.00	R 390.00
Lablab Rongai	15	R 550.00	R 22.00	R 330.00
Sunflower	2	R 350.00	R 14.00	R 28.00
Sunhemp	2	R 475.00	R 19.00	R 38.00
Radish tillage	2	R 1 900.00	R 76.00	R 152.00
Cost				**R 1186.00**

2.2 Winter Mixture:

Under normal circumstances calves are weaned during early winter month or seven month of age usually weighing between 180-220kg. Establishing winter annuals pastures such as black oats, radish and vetch can impact positively on the growth and development of replacement heifers or bull calves after weaning. A winter mixture as portrayed in Table 2. can be used if late rain is expected. These crop are temperate crops and under normal circumstances usually high in nutritional value and highly digestible.

Table 2 Recommended winter mixture with crops, the kg/ha.

Crops	Kg/ha	Price/kg	Price/25kg
Black oats	30	-------------------------------	-----------------------------
Grazing vetch	15	-------------------------------	-----------------------------
Radish	3		

Treatments:

Grazing + standing	Roll + grazing	Grazing + roll	Grazing + Round-up	Roll + no grazing	Standing + Round-up	Standing + No treatment

3. Grazing:

3.1 Summer annuals:

Rolling a strip and killing a strip with round-up will give a good indication of the ability to conserve moisture for the next crop. The fallow period will be 10-11 month before a cash crop will be planted.

Mob grazing will commence at a stage of plant development when biological biomass production is at its highest. This usually occurs in mixtures with grasses, at a stage when the grasses are in an early reproductive stage. Other treatments will also be implemented at the same stage.

Grazing treatments should be fenced off. The other treatments will only be strips of 4-6m wide. An exclusion cage 2X2m should be randomly placed in every treatments that are grazed. The difference in weight of biomass DM between the grazing treatment and the exclusion cages will give us a good indication of intake of biomass during the grazing period.

3.2 Winter annuals:

Grazing when the small grain (black oats) are at a soft dough stage will gives the highest biomass production. This will also insure that volunteer plants from fallen seed, that can become future weeds, will be limited.

4. **Parameters:**

4.1 Animals: Starting weight (kg)

Finishing weight

Animal feces (nutritional needs are met)

4.2 Plants: Biomass available (kg)

Biomass used

Biomass wasted

4.3 **Soil:** **Haney soil health test** on all treatments