APPENDIX 1

PROGRESS REPORT
Farmer innovations in Conservation Agriculture (CA) systems for sustainable crop intensification in semi-arid, sandy soil conditions, North West Province

For the period:

OCTOBER 2015 TO SEPTEMBER 2016

Compiled by:

HJ Smith, JP Otto, G Trytsman, AA Nel, A Dreyer and E Hugo

September 2016

GRAIN SA
GRAAN SA

Ottosdal No-till Club

The Maize Trust

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1. Coordination and management

Work Package title	**Coordination and management**
Work Package period	October 2015 to September 2016

Lead partner	Ottosdal No-till Club (Mr Hannes Otto / Dirk Laas) and Grain SA (Dr Hendrik Smith)
Involved partners	All

Objectives	Coordinate activities among all partners Ensure timely reporting to Grain SA / The Maize Trust 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	**Activity 1: Project inception workshop**. **Progress and Results achieved:** A one-day project planning and inception workshop was held on 20 August 2013 (at the Ottosdal country club) 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. **Activity 2: Frequent coordination meetings**. The purpose of these monthly or bi-monthly meetings is to establish an Innovation platform 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. **Progress and Results achieved:** Frequent project meetings has taken place involving all the key partners (project team members) in the project. Those include farmers, researchers, input suppliers, Grain SA/MT and manufacturers. These meetings are instrumental in the running of the project, serving as a platform for collective and adaptive project management. Some of the key project events, such as the farmer-led trials and the conference, have been

planned and coordinated form this platform.

Activity 3: 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.

Progress and Results achieved: The annual reference meeting took place on 1 September 2016.

Activity 4: Organise and Coordinate annual awareness event(s)

Progress and Results achieved: Due to the severe drought in the North West Province and particularly the Ottosdal area, the annual conference was cancelled. Despite the drought most of the trials could eventually be planted, but could not prevent the cancellation of the annual conference. However, a successful green tour was held on the 19th April 2016.

Activity 5: Reporting.

All partners participates in the preparation of a six-monthly and annual progress report. The lead applicant and work package managers' report on results and work progress, as well as actions taken to minimise the effects of delays on other project activities.

Progress and Results achieved: Reporting has been done according to the standards and format required by The Maize Trust.

Activity 6: Annual progress reports.

The Annual report will be made following The 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.

Progress and Results achieved: The annual report was completed in September 2016.

Deliverables	• Project actions and reporting delivered on time

Risks	The project study area is experiencing a major drought period and trial results might be affected.

2. Assessment of soil quality

Work Package title	**Assessment of soil quality under Conservation Agriculture (CA) systems in the semi-arid cropping areas of the North-West Province**
Work Package period	October 2015 to September 2016

Lead partner	SGS (Mr Adriaan Dreyer)
Involved partners	Ottosdal No-till Club, ARC-GCI, Grain SA,

Objectives	• To characterize the soil types and soil physical & chemical parameters, such as particle distribution, pH, Soil Organic Matter and macro-, micro-nutrients • 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

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

Activities	Deliverables	Progress and Results achieved
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	Soil classification and analysis were done for every trial and selected farms. Root evaluations and root development problems in different soil profiles will be done.
2. Lab Analyses	Organic C (%) Standard soil analysis: 4 basic cations, P, pH, ratios, micro-elements Texture (once-off, top- and subsoil)	Soil chemical sampling will be done for every trial. Selected biological analyses will be done.
3. Monthly meetings (project team) & Training	Participate in monthly forum meetings, discussing problems and possible solutions to that.	Participated in two meetings that were held.
4. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of data. Learning from each other.	Scheduled for August
5. Annual reports and admin (technical data)	Written technical report covering trial procedures, results and progress.	Submitted before September 2016 - See annual report below - see summary of **soil investigation** reports done in table below
6. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits	Only one green tour held in April. Conference cancelled due to drought.

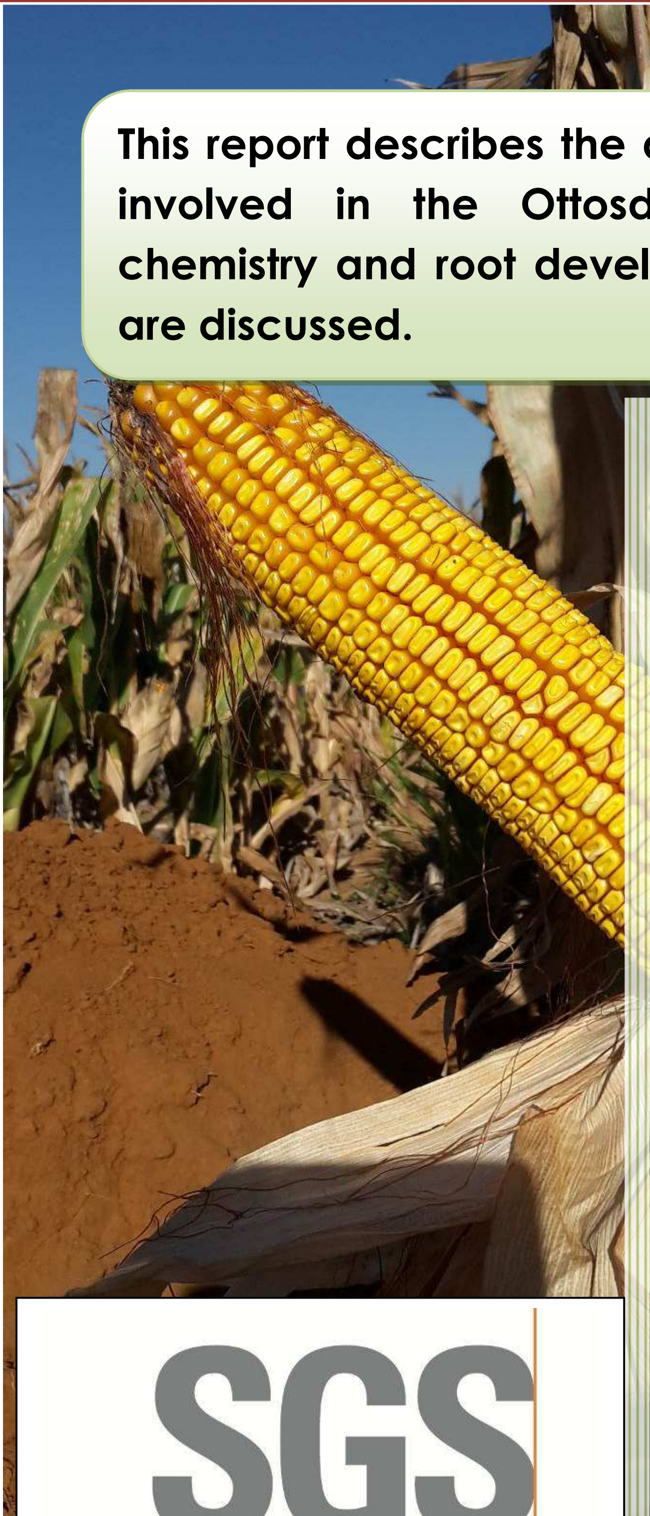
Summary of soil investigations on different farms done in 2015-2016 – individual reports are available from Grain SA or the Ottosdal No-till Club

Activities	**Deliverables or Milestones**	**Progress and Results achieved;** and/or **Problems and Milestones <u>not</u> achieved**
Owner: Attie Smook Soil Investigations & Profile pits Farm: Kameelboom Area: Sannieshof	See report with title: Attie Smook No till Waarnemings Apr-16	Different root development was investigate between rows and also the differences between tine and coulter. * The 2 rows under the tractor and between the tyre tracks were significant poorer than the other rows * The cobs from the tine was also better than the coulter on the soils with a clay and silt % higher than 18%.
Owner: George Steyn Soil Investigations & Profile pits Farm: Humanskraal Area: Ottosdal	See report with title: George Steyn No till Waarnemings Apr-16	Different root and cob development was investigate on soils high in sand. * An area high in sand was planted with maize after 4 years of Bloubuffel grass. Very good root development but poorer cobs.
Owner: Gert v Rensburg Soil Investigations & Profile pits Farm: Kameelpan Area: Scheizer Reneke	See report with title: Gert van Rensburg No till Waarnemings May-16	Second year of no till. Problems occur with root development on the higher sandy soils. Average yield : 1,5t/ha * The low clay % soils which is also low in Ca as well ended up in poor root developments for some plants.

Owner: Gideon Koeglenberg Soil Investigations & Profile pits Farm: Damkraal Area: Makwassie	See report with title: Gideon Koeglenberg No till Waarnemings Mar-16	Different root development was investigate between 1 and 2 years of no till on high sandy soils * In this trail we want to measure the success of no till practises on high sandy soils and the sustainability of the practise. Plants with tines. *No compaction layer could be found even with the low clay %. However the ripper lines from previous ripper action are still visible. More data is needed. * Hence the Ca is high in the soils and explain the need for Ca in sandy soils.
Owner: Beyers Bdy Soil Investigations & Profile pits Farm: Danielsrus Area: Makwassie	See report with title: Jaco en Kobus Beyers No till Waarnemings Mar-16	Also high sandy soils in the Makwassie region but planted with a coulter. 1 and 2 year plantings. * An area high in sand was planted with maize after 15 years of Smutsvinger grass. Poor root development occurs against all the expectations * It indicates the necessary inspections for compaction after cattle grazing fields for long periods. The coulter wasn't efficient enough * Organic C is the highest of all the fields * The ripper lines from the previous ripper action are still visible. More data is needed.
Owner:Hannes Otto Soil Investigations & Profile pits Farm: Korannafontein Area: Ottosdal	See report with title: Hannes Otto No till Waarnemings Apr-16	*The trail was to look at the different root development of 90cm rows (tine) against 45 cm (coulter) in sunflower. There was no significant difference between the 2 practises. * Both root development were good
Owner: Jaco Bamberger Soil Investigations & Profile pits Farm: Frisgewaagd Area: Ottosdal	See report with title: Jaco Bamberger No till Waarnemings Apr-16	A comparison was done between the Argentina system and the local practises on plant population. The trail also compared 3 different cultivation practises namely plough, chisel and no till. The yields were as follows: Argentina 1.6 t/ha (was planted a week earlier) Plough : 2.01 t/ha Chisel : 2.41 t/ha No till : 1.98 t/ha

Owner: Jerry Basson Soil Investigations & Profile pits Farm: Doornbult Area: Sannieshof	See report with title: Jerry Basson No till Waarnemings May-16	Different population was compare 30 000 , 22 000 and 16 000 was planted. Yield: 30 000 : 0.4 t/ha 22 500 : 1.1 t/ha 16 000 : 1.4 t/ha * A comparison between 3 and 5 years of no till was also done. * Old bloubuffel fields were also compare to older fields both are 3 years of no till. No significant differences were seen * No till versus chisel plough was also investigate.
Owner: Johan Niewoudt "Soil Investigations & Profile pits" Farm: Doornhoek Area: Scheizer Reneke Owner:Naas Brits Soil Investigations & Profile pits Farm: Rietfontein Area: Hartbeesfontein	See report with title: Johan Niewoudt "No till Waarnemings Apr-16" See report with title: Naas Brits No till Waarnemings May-16	Problems occur on some of the fields in the old tracks. Trials were also done on maize planted with fertilizer and without fertilizer. The farm Rietfontein is on low clay soils (10% clay) and Naas is doing no till for the last 6 years. Trials were also done without any fertilizer but no results were available because of severe lodging. Compaction occurs on the 8% clay section of the field. Light soil structure can be seen after the 6 years of no till as well as root channels.
Owner: Philip vd Berg Soil Investigations & Profile pits Farm: Katbosch Area: Ottosdal	See report with title: Philip vd Berg No till Waarnemings Mar-16	* A comparison between No till, chisel with one and 3 tines were done. Not harvest yet

SOIL REPORT FOR THE OTTOSDAL NO-TILL CLUB 2016



This report describes the different scenarios of the farmers involved in the Ottosdal No-Till Club. The physics, chemistry and root development of the various soil types are discussed.

SGS

SGS Nvirocrop

Adriaan Dreyer

July 2016

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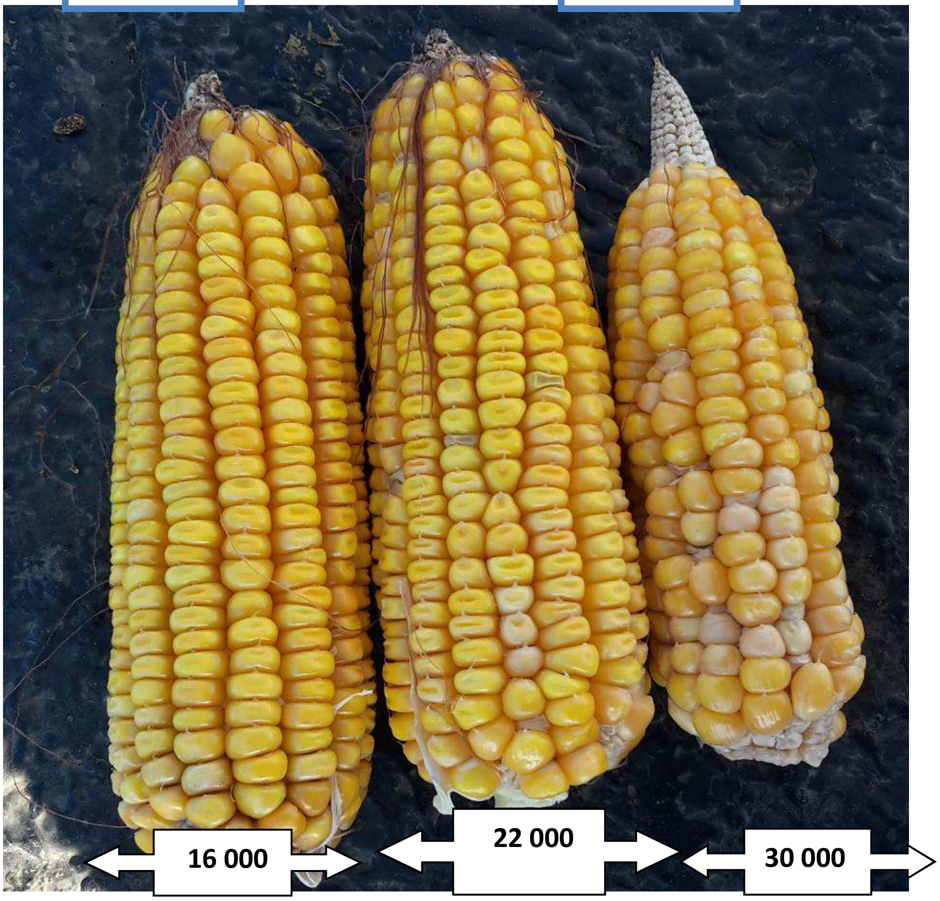
Row width trials 90 cm vs. 45 cm. The same population.

Almost no yield difference:

90 cm row

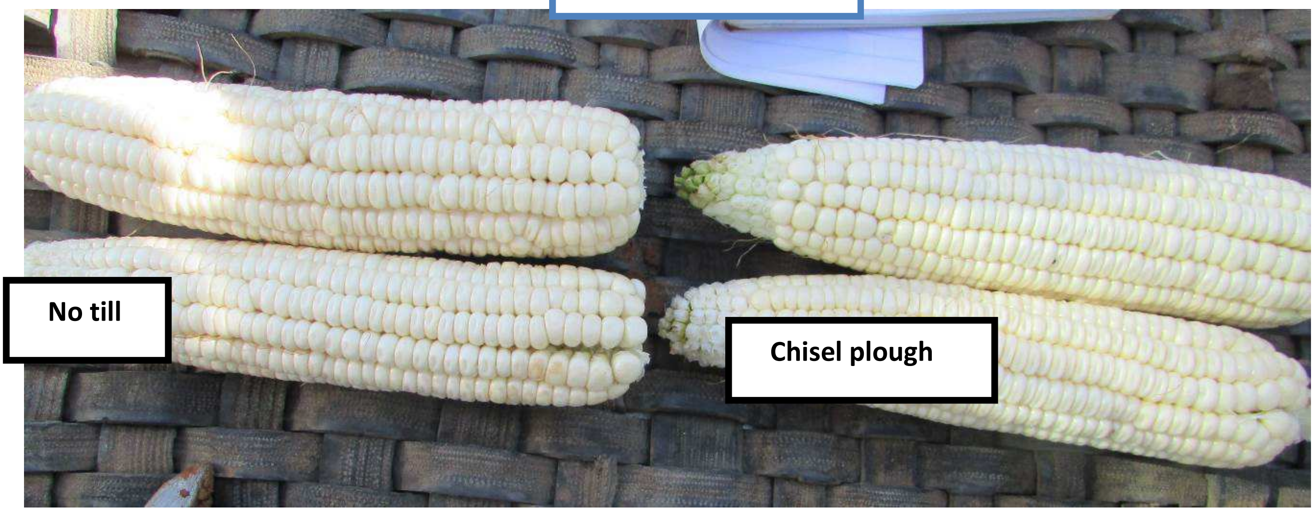
45 cm row

Different population:

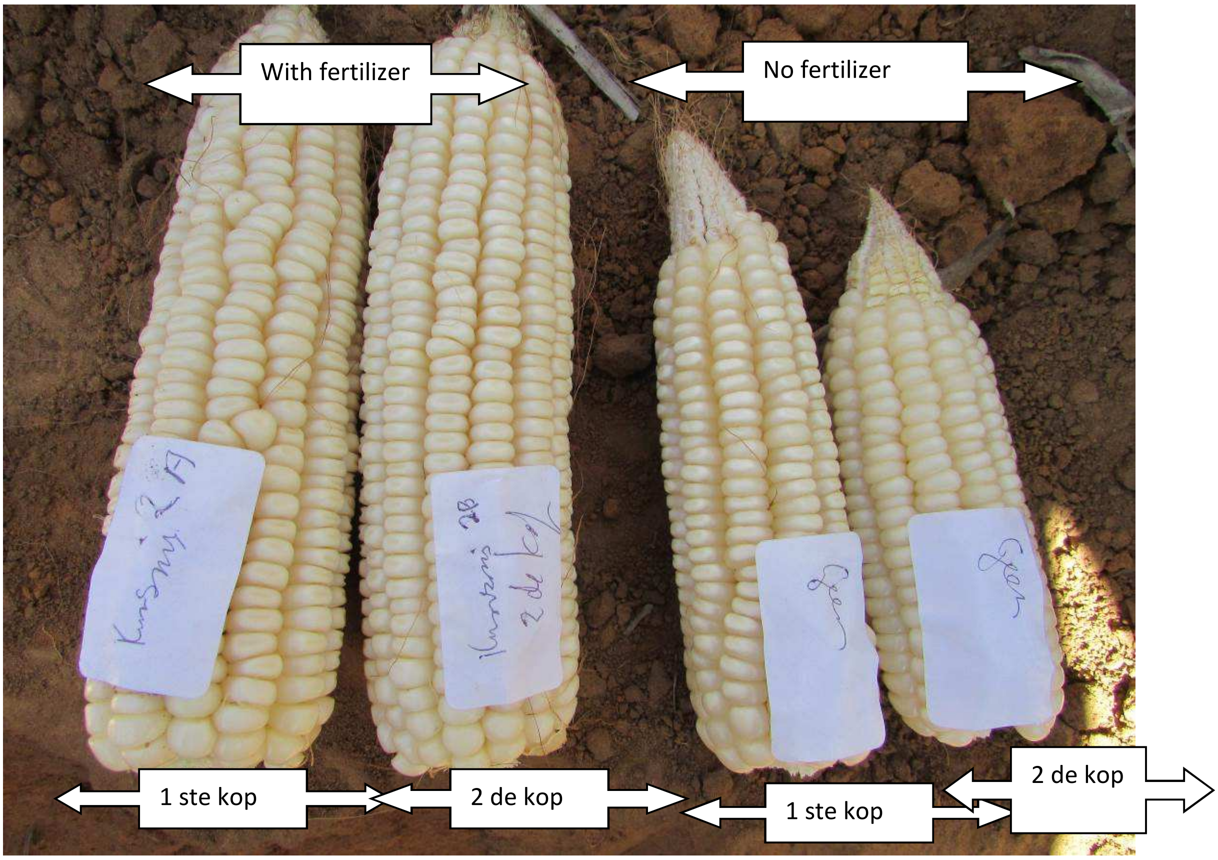


No till versus chisel

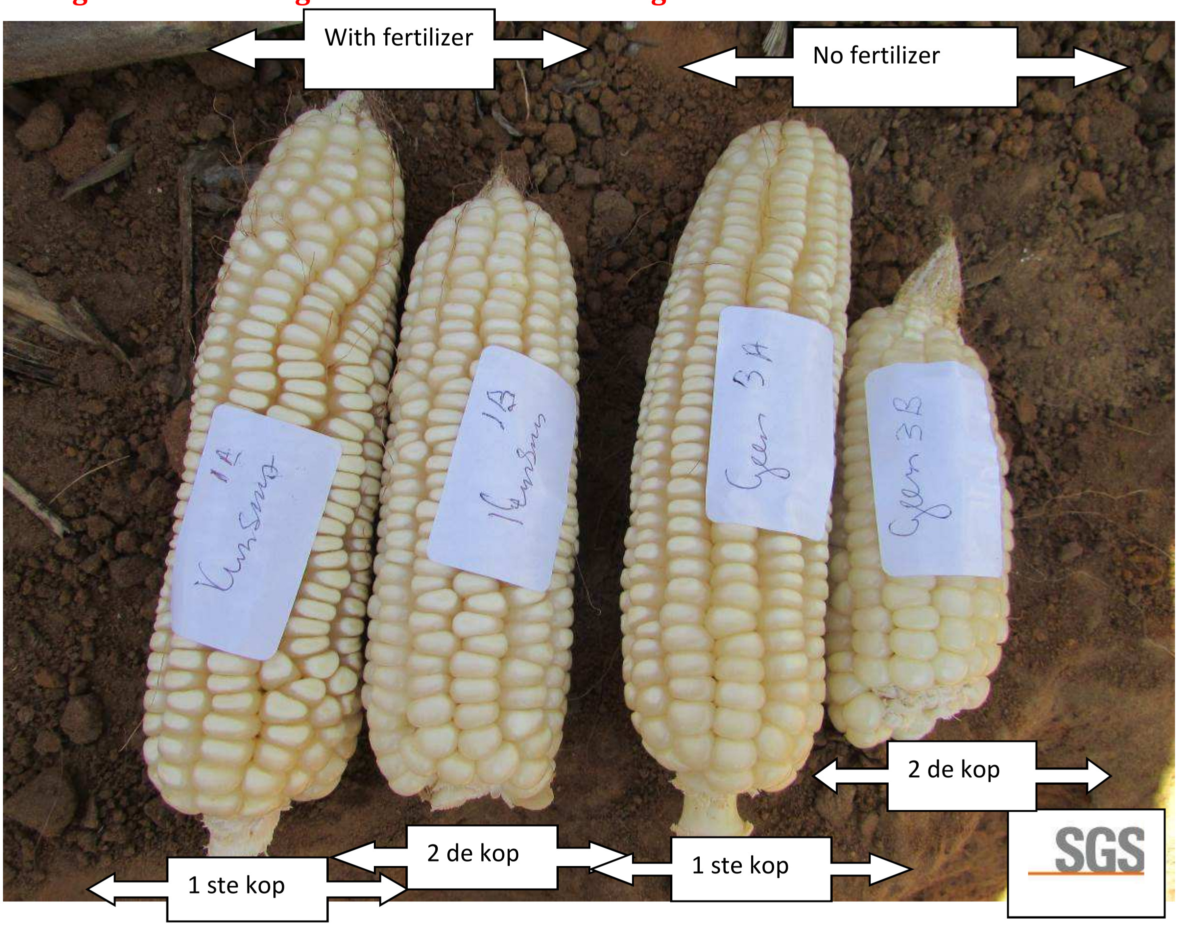
Not harvest yet:



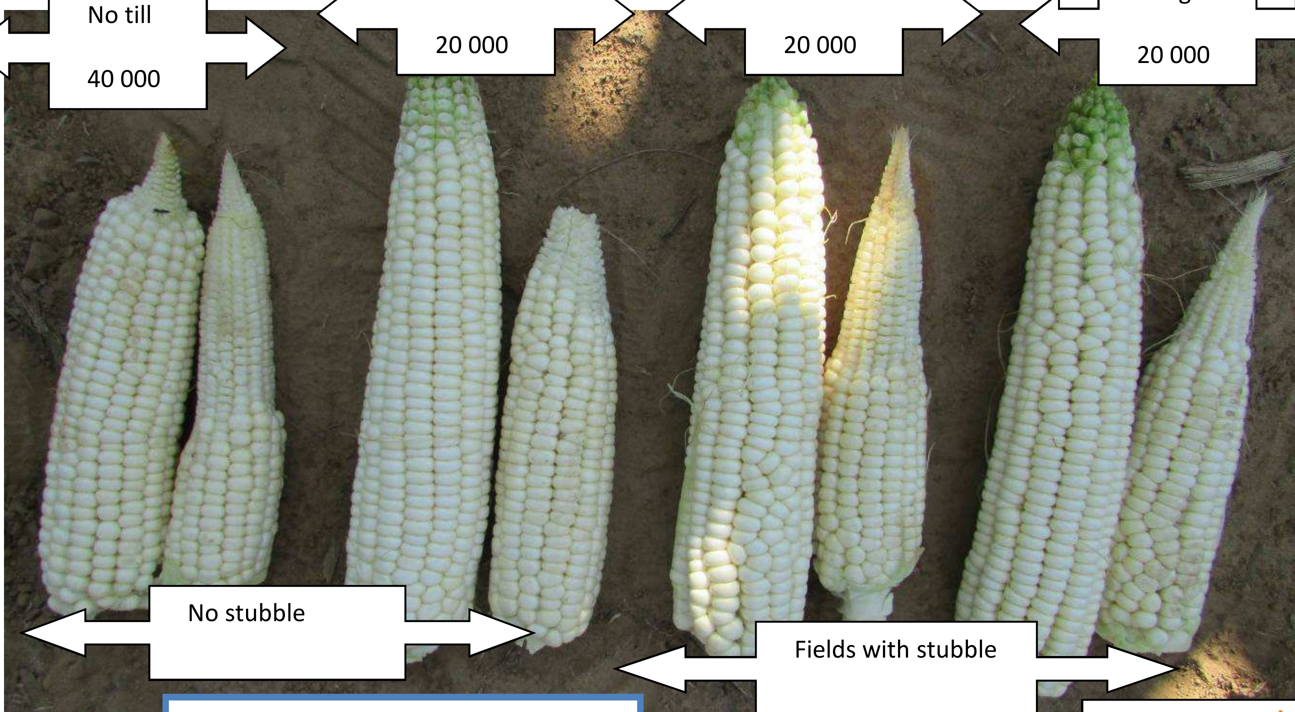
No fertilizer versus fertilizer apply



No big differences. Highest difference was 200 kg



No stubble versus stubble



Different practices

Waiting for results

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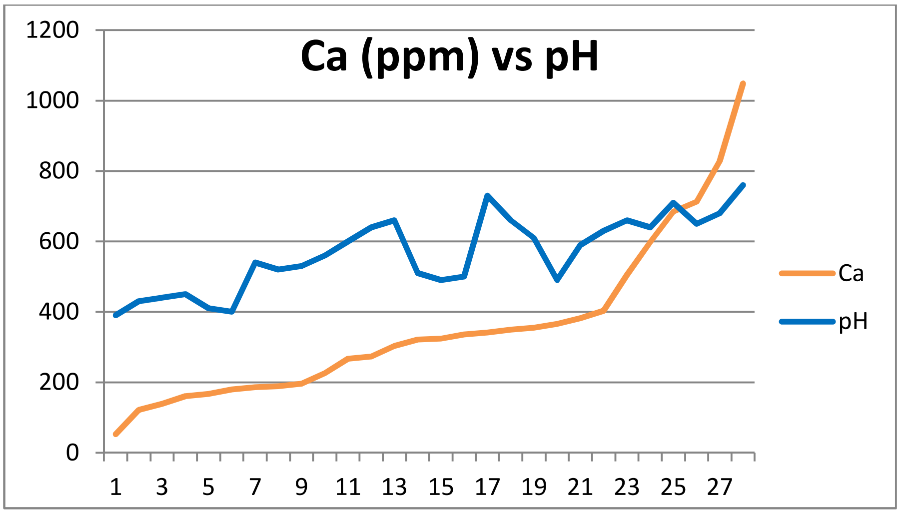
Soil analysis :

Owner	Verwysings no	pH (KCl)	Ca	Mg	%Ca	%Mg	Cob	Root	Vegative
			mg/kg	mg/kg	%	%	developmet	developmet	developmet
Attie Smook	7 Bo	6.6	505	82	65.9	17.5	good	good	good
Attie Smook	2 Bo	7.1	685	76	71.1	13		good	good
Attie Smook	3 Bo	7.6	1049	81	79.2	10.1		good	good
George Steyn	4 Bo	6.5	713	81	71.2	13.2		good	good
George Steyn	6 Bo (Grass)	6.8	828	129	67.8	17.4	poor	poor	poor
Gert v Rensburg	2 Bo	6.4	598	148	60.3	24.4	good	good	good
Gideon Koeglenberg	3 Bo	5.1	321	127	48.5	31.5	good	good	good
Gideon Koeglenberg	3 Bo(Grass)	4.4	139	58	39.1	26.6	average	good	good
Gideon Koeglenberg	4 Bo	4.9	366	104	54.7	25.4	good	good	good
Beyers Bdy	1 Bo	4	180	42	45.7	17.5	poor	average	poor
Beyers Bdy (Veld)	10 Bo	5.4	186	67	48	28.4	average	poor	poor
Beyers Bdy	1 Bo	7.3	341	125	54.7	32.8	good	good	good
Johan Niewoudt	11 BO	5.2	189	49	57.5	24	average	average	average
Johan Niewoudt	12 GEEN KUNSMIS BO	6.6	303	57	62.4	19	good	good	good
Johan Niewoudt	13 KUNSMIS BO	6.4	273	59	60.5	21	good	good	good
Naas Brits	KUNSMIS A	4.1	167	23	58.4	13.0	good	good	good
Naas Brits	SONDER KUNSMIS D	4.5	161	73	46.3	34.6	good	good	good
Naas Brits	SONDER KUNSMIS G	6.1	355	118	52.6	28.7	good	good	good
Naas Brits	VERDIG	5.6	226	83	52.1	31.4	poor	poor	poor
Pietie Lombaard	1 Goed bo	5.0	336	146	49.0	35.0	good	good	good
Pietie Lombaard	1 Swak bo	4.9	324	114	48.3	27.9	poor	poor	poor
Pietie Lombaard	4 Bo Goed	4.3	122	23	57.6	17.5	good	good	good
Pietie Lombaard	4 Bo dood	3.9	53	13	30.5	11.9	poor	poor	poor
Roodt Kielbourne	GOED Bo	6.3	403	77	67.9	21.3	good	good	good
Roodt Kielbourne	SWAK Bo	5.9	382	71	67.9	20.8	poor	poor	poor
Tielan Niewoudt	7 Swak Bo	5.3	196	65	54.4	29.4	poor	poor	poor
Tielan Niewoudt	GEEN KUNSMIS Bo	6.0	267	82	54.0	27.3	good	good	good
Tielan Niewoudt	KUNSMIS Bo	6.6	350	97	58.9	26.9	good	good	good

Owner	Verwysings no	Sand + slik	C	P (Bray1)	Klei	Slik	Sand	**Vegative**
			%	mg/kg	%	%	%	**developmet**
Attie Smook	7 Bo	24	0.44	20	6	18	76	good
Attie Smook	2 Bo	12	0.4	17	4	8	88	good
Attie Smook	3 Bo	14	0.2	11	6	8	86	good
George Steyn	4 Bo	16	0.2	9	8	8	84	good
George Steyn	6 Bo (Grass)	12	0.92	33	4	8	88	poor
Gert v Rensburg	2 Bo	20	0.44	15	14	6	80	good
Gideon Koeglenberg	3 Bo	18	0.36	7	12	6	82	good
Gideon Koeglenberg	3 Bo(Grass)	10	0.32	37	4	6	90	good
Gideon Koeglenberg	4 Bo	16	0.64	33	10	6	84	good
Beyers Bdy	1 Bo	14	0.32	41	10	4	86	poor
Beyers Bdy (Veld)	10 Bo	10	0.28	10	6	4	90	poor
Beyers Bdy	1 Bo	6	0.28	17	2	4	94	good
Johan Niewoudt	11 BO	10	0.36	11	6	4	90	average
Johan Niewoudt	12 GEEN KUNSMIS BO	20	0.32	12	8	12	80	good
Johan Niewoudt	13 KUNSMIS BO	10	0.24	16	4	6	90	good
Naas Brits	KUNSMIS A	20	0.16	15	10	10	80	good
Naas Brits	SONDER KUNSMIS D	22	0.16	24	12	10	78	good
Naas Brits	SONDER KUNSMIS G	22	0.24	24	12	10	78	good
Naas Brits	VERDIG	16	0.16	20	8	8	84	poor
Pietie Lombaard	1 Goed bo	18	0.64	6	10	8	82	good
Pietie Lombaard	1 Swak bo	18	0.40	6	14	4	82	poor
Pietie Lombaard	4 Bo Goed	8	0.20	12	4	4	92	good
Pietie Lombaard	4 Bo dood	8	0.20	21	4	4	92	poor
Roodt Kielbourne	GOED Bo	22	0.44	7	12	10	78	good
Roodt Kielbourne	SWAK Bo	20	0.68	13	12	8	80	poor
Tielan Niewoudt	7 Swak Bo	10	0.16	9	6	4	90	poor
Tielan Niewoudt	GEEN KUNSMIS Bo	10	0.32	27	6	4	90	good
Tielan Niewoudt	KUNSMIS Bo	10	1.84	24	6	4	90	good


Ca (ppm) vs pH
1200
1000
800
600
400
200
0
1
3
5
7
9
11
13
15
17
19
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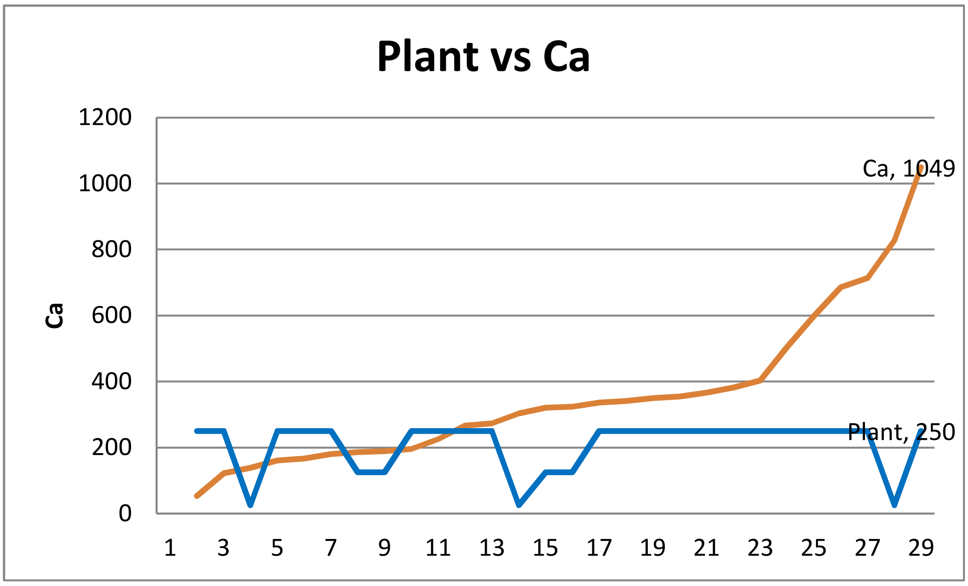
23
25
27
Ca
pH


Plant vs Ca
Ca
1200
1000
800
600
400
200
0
1
3
5
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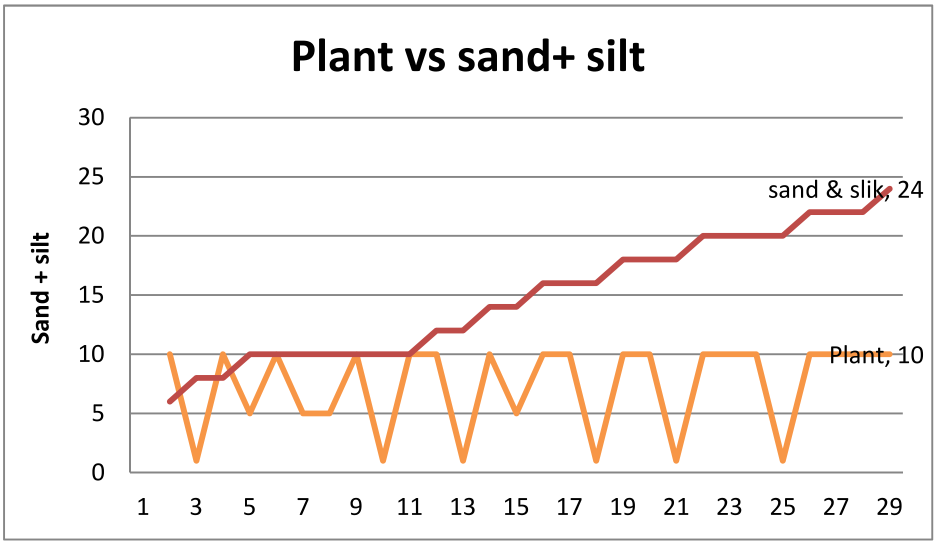
9
11
13
15
17
19
21
23
25
27
29
Ca, 1049
Plant, 250


Plant vs sand+ silt
Sand + silt
30
25
20
15
10
5
0
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7
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13
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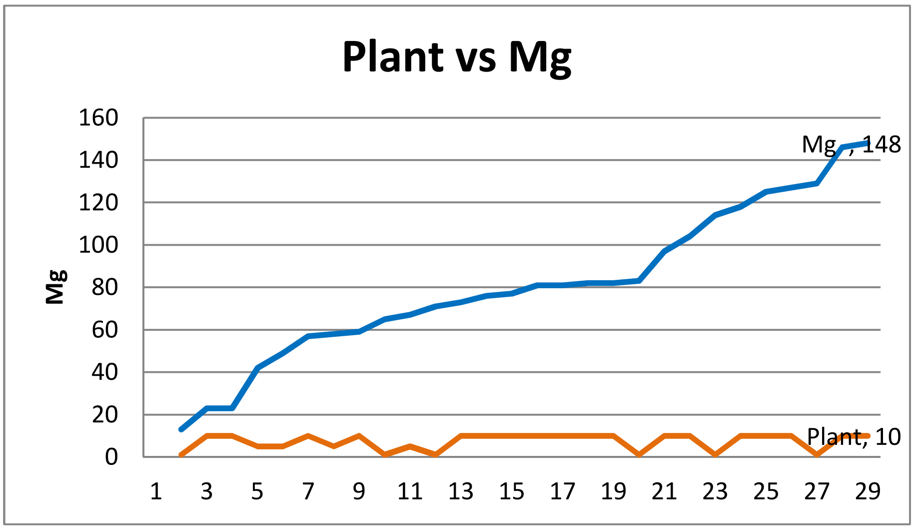
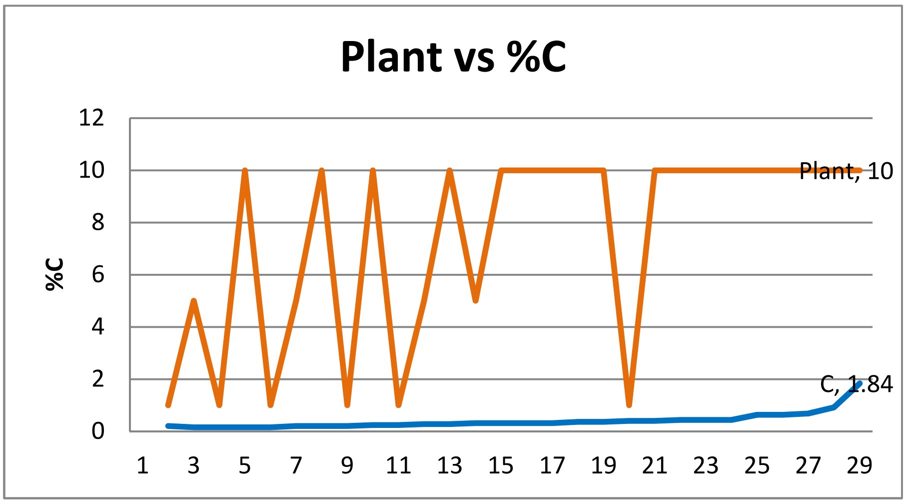
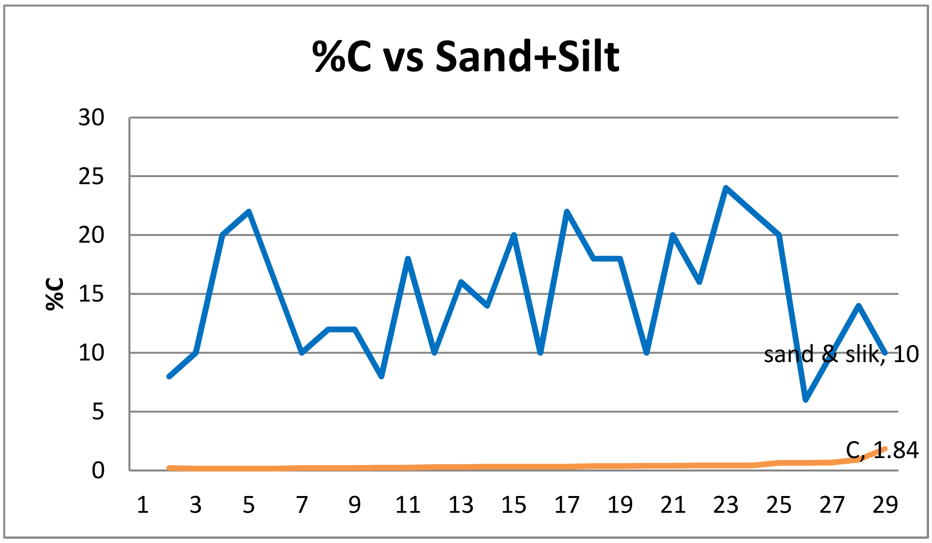
27
29
sand & slik, 24
Plant, 10


Plant vs Mg
Mg
160
140
120
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Mg , 148
Plant, 10


Plant vs %C
%C
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Plant, 10
C, 1.84


%C vs Sand+Silt
%C
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
sand & slik, 10
C, 1.84

Summary

- Despite to the severe drought of the 2015/2016 season, the root development was generally very good for most of the crops.
- As in the 2014 season, there was a correlation between texture and root development.
- There is a good correlation between poor root development and more sandy soils.
- When good root development occurs on sandy soils the Calcium is always higher than 350 mg/kg.
- A clear correlation between root development and Calcium in mg/kg occurs.
- Root development was always higher when efficient Calcium occurs in the soil.
- The only exception was on the pasture field. It can be explain due to compaction caused by livestock.
- Soil surface compaction or *plough pans* must be properly broken up before planting no till directly into old pasture fields.
- In general, the no-till system performed better in the drought conditions and allowed higher yields to realise due to the fact that moisture losses were reduced drastically.
- In some cases the non-uniformity of crops in the no-till system also led to yield losses, and therefore the conventional system did better.
- Where compaction problems were experienced, the lengthening of the planter tines solved the problem successfully.
- Root development and plant growth also increase with the increase in soil Carbon content.
- All the results of the plant population trials have not been quantified yet at this moment, but it appeared as if the yields on the drier soils with lower populations were significantly better than the higher populations.
- There was almost no difference between the maize planted with fertilizer and without fertilizer.
- There was also no clear trend in the soil chemical analysis as well.
- However the same samples must be taken on the same place every year. One year's data are simply not enough.

SGS

3. Assessment of cover crop adaptability and suitability

Work Package title	**Assessment of cover crop adaptability and suitability** **Crop and Livestock integration**
Work Package period	October 2015 to September 2016
Lead partner	ARC-API (Mr. Gerrie Trytsman)
Involved partners	Grain SA, Ottosdal no-till club, ARC-GCI
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 • Soil health monitoring with solvita test. (infiltration as a measure of soil health) • Crop livestock integration (part of arable rotation)
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	1. Land preparation (finding a suitable location, sourcing materials) 2. Purchase Materials & Equipment 3. Establishing and Planting of trials 4. Seasonal management and maintenance of trials 5. Monitoring and Sampling (including harvesting, biomass and yield determination, nutrient analysis) 6. Lab Analyses 7. Monthly meetings (project team) & Training 8. Annual reference group meeting (advisory committee) 9. Harvesting, biomass and yield determination, nutrient analysis 10. Annual report and admin (production & technical data) 11. 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.)

Table 3.1: A summary of progress made during 2015 / 2016

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). Drawing up a concept note for livestock integration Action plan that will include acquisition of seed, inoculum, stickers, implements, chemical inputs, monitoring and evaluation of trial, harvesting, collecting and interpretation of data. The action plan should clarify the roll of every party involved.	With the cooperation of the farmers a suitable site was identified. • Previously use as a no-till production field • Homogeneous (physically, chemically and biologically) A concept note was prepared and with the help of the participating farmer a suitable site was identified for livestock integration.
2. Purchase Materials & Equipment	Acquisition of seed, inoculum, stickers, implements, chemical inputs.	Warm season crops were delivered to farmers after purchasing it from Cover Crop Solutions. Additional seed for extended area (mixture) was

		made available to farmers.
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.	The screening trial was planted on the 20 January 2016. The livestock integration trial was planted on the 27 January 2016. 7-3-2016 plant winter annuals for livestock integration,
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	A field form was drawn up to collect valuable data with trial visits, which incudes. • Agronomic evaluation • Soil condition data • Nitrogen fixation • Other comments Photos and height (cm) measurements of the accessions were taken. Pest activities were monitor. Sunflower needed to be replanted. DM of crops were determine.
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 6. Root evaluation:	Harvesting of CC trial 13-4-2016. Soil samples for analyses were taken at the same treatments than the previous year. 1-6-2016 determine DM from the Livestock integration, summer annuals Livestock integration:20-6-2016 take samples at the winter crops to determine DM,
6. Lab Analyses	C:N content of plant material	Soil samples were send for the Haney analysis
7. Monthly meetings (project team) & Training	Partake in monthly forum meetings, discussing problems and possible solutions to that.	August open day CA workgroup meeting February Report back and planning meeting on 1 September 2016
8. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee; Discussion and evaluation of trials. Learning from previous mistakes.	Scheduled in fourth quarter.
9. Annual report	Written technical report covering trial	On-going process.

and admin (production & technical data)	procedures, results and progress.	Bi-annual technical report completed by end February 2016. Technical annual report at the end of September
10. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits	Enquiries around cover crops are expanding. 19th April 2016 Farmers day at Ottosdal. Attend farmer day at Migdol 20th April 2016. Writing of articles for SA Grain.

3.1. Establishment and status of Cover Crop screening trial

The screening trial was planted late due to the drought conditions in the North West Province. The farmer experienced problems with Soybean plantings and germination was less than satisfactory. Replanting Sunflower on these fields meant that the trial was planted late in January 2016. Data was gathered during April for the summer annuals. Winter annuals were harvested during June 2016. Data available from the previous season's plant available water (PAW) will also be presented in this report. This data forms part of the evaluation of the screening trial. NWK (Martiens du Plessis) determined the PAW and Mr Coert Coetzee (project farmer facilitator) harvested the cash crops of the different treatment.

Table 3.2: The effect of different rotational crops on PAW and maize yields

Crops planted in 2014 (previous season)	PAW (mm) measured after winter 2014	Maize yields (kg ha^{-1}) 2014-2015 season
Sunhemp *(Crotalaria juncea)*	22	649.97
Mixture summer *(Lab-lab, Sorghum, Sunhemp)*	26.4	389.98
Soybean (*Glycine max)*	19.3	1061.62
Millet or Babala (*Pennisetum glaucum)*	7.8	1429.94
Grain sorghum *(Sorghum bicolor)*	5.2	1018.29
Sunflower *(Helianthus annuus)*	22.4	498.31
Velvet bean *(Mucuna pruriens)*	51.6	844.97
Cowpeas (*Vigna unguiculata)*	18.4	844.97
Maize (*Zea mays)*	38.3	1321.61
Dolichos (*Lablab purpureus)*	17.6	1104.96
Vetch	0.4	628.31
Mixture Winter (B oats, Vetch, Radish)	0.04	389.98
Triticale	0.04	194.99
Radish	0.3	476.65
Rye	0	368.32
Oats	0	1083.29
Black oats	0.56	433.32
Correlation coefficient (r^2)	*0.33*	

It is clear from the r^2 that a slight positive relationship between the two variables exists for maize. *P glaucum* or commonly known as Babala produced the highest maize yield where maize on maize also showed promise. If root and leave diseases are not present, stacking of maize might be considered a viable option to build carbon rich soil. After only two years, however, this might be a premature conclusion but worth exploring. Also worth noting is the fact that Oats used all plant available water but still manages to produce a yield of 1083 kg/ha in a very dry year. One of the reasons for this phenomenon might be the higher infiltration rate after planting Oats.

Table 3.3: The effect of different rotational crops on PAW and Sunflower yields

Crops planted in 2014 (previous season)	PAW (mm) measured after winter 2014	Sunflower yields (kg ha^{-1}) 2014-2015 season
Sunhemp *(Crotalaria juncea)*	22	1583.27
Mixture summer *(Lab-lab, Sorghum, Sunhemp)*	26.4	1458.26
Soybean (*Glycine max)*	19.3	1499.94
Millet or Babala (*Pennisetum glaucum)*	7.8	1916.59
Grain sorghum *(Sorghum bicolor)*	5.2	1708.27
Sunflower *(Helianthus annuus)*	22.4	833.30
Velvet bean *(Mucuna pruriens)*	51.6	1416.61
Cowpeas (*Vigna unguiculata)*	18.4	1166.62
Maize (*Zea mays)*	38.3	1291.62
Dolichos (*Lablab purpureus)*	17.6	1666.6
Vetch	0.4	624.98
Winter Mixture (Black oats, Vetch, Radish)	0.04	999.96
Triticale	0.04	333.32
Radish	0.3	374.99
Rye	0	749.97
Oats	0	1541.61
Black oats	0.56	1083.29
Correlation coefficient (r^2)	*0.38205*	

It is clear from the r^2 that a slight positive relationship exists between the two variables for Sunflower. Again Babala is the crop that delivered the highest yield of Sunflower, followed by Sorghum in second place. Despite these crops having had a low PAW after harvest, (7.8mm for Babala and 5.2mm for Sorghum respectively), they had a positive effect on the yield of the following Sunflower crop.

Sunflower also seemed to do well if planted in succession to legumes such as *C. juncea, G. max, M. pruriens, L. purpureus* and *V. unguiculata.* From the cool season crops *A. sativa* and *A. strigosa* performed well. As already mentioned, being an extremely dry year, planting sunflower with low levels of moisture (PAW) at the start of a growing season, makes absolute sense.

Table 3.4: The effect of different rotational crops on PAW and Grain sorghum yields.

Crops planted in 2014 (previous season)	PAW (mm) measured after winter 2014	Grain sorghum yields (ton ha^{-1}) 2014-2015 season
Sunhemp *(Crotalaria juncea)*	22	1.9
Mixture summer *(Lab-lab, Sorghum, Sunhemp)*	26.4	2.1
Soybean (*Glycine max)*	19.3	2.0
Millet or Babala (*Pennisetum glaucum)*	7.8	1.7
Grain sorghum *(Sorghum bicolor)*	5.2	1.3
Sunflower *(Helianthus annuus)*	22.4	0.55
Velvet bean *(Mucuna pruriens)*	51.6	1.65
Cowpeas (*Vigna unguiculata)*	18.4	2.1
Maize (*Zea mays)*	38.3	0.2
Dolichos (*Lablab purpureus)*	17.6	0.95
Vetch	0.4	0.05
Winter Mixture (Black oats, Vetch, Radish)	0.04	0.5
Triticale	0.04	0.45
Radish	0.3	0.1
Rye	0	0.2
Oats	0	1.65
Black oats	0.56	0.9
Correlation coefficient (r^2)	*0.36659*	

It is clear from the r^2 that a slight positive relationship exists between the two variables for Grain sorghum. Grain sorghum seems to do well after legumes and mixtures with legumes in them. The cocktail containing Lablab and Sunhemp, and Cowpea as a pure stand produced the highest yield of 2.1 tha^{-1} for sorghum. Pure stand of Sunhemp and Soybean slightly behind with 1.9 and 2 tha^{-1} respectively. For the summer grasses again Babala should be mentioned with a yield of 1.7 tha^{-1}. For the cool season crops Oats again outperformed the other crops.

Table 3.5: The effect of different rotational crops on PAW and Soybean yields

Crops planted in 2014 (previous season)	PAW (mm) measured after winter 2014	Soybean yields (kg ha^{-1}) 2014-2015 season
Crotalaria juncea	22	791.64
Sunhemp *(Crotalaria juncea)*	26.4	916.63
Mixture summer *(Lab-lab, Sorghum, Sunhemp)*	19.3	291.66
Soybean (*Glycine max)*	7.8	708.31
Millet or Babala (*Pennisetum glaucum)*	5.2	624.98
Grain sorghum *(Sorghum bicolor)*	22.4	458.32
Sunflower *(Helianthus annuus)*	51.6	1208.29
Velvet bean *(Mucuna pruriens)*	18.4	541.65
Cowpeas (*Vigna unguiculata)*	38.3	708.31
Maize (*Zea mays)*	17.6	458.32
Dolichos (*Lablab purpureus)*	0.4	208.33
Mixture Winter (Black oats, Vetch, Radish)	0.04	1499.94

Triticale	0.04	416.65
Radish	0.3	125.00
Rye	0	333.32
Oats	0	283.32
Black oats	0.56	416.65
Correlation coefficient (r^2)	*0.43540*	

Soybean shows the highest positive correlation in relation to PAW of all the cash crops. However, the highest yield for Soybean was produced when planted after the winter mixture containing Black oats, Vetch and Radish, which resulted in almost no PAW. This result can be very significant because farmers expressed a concern with the low residues after producing Soybeans in rotation. Planting a short season cultivar that can be harvested early can present an opportunity for farmers to plant a cool season cover crop to boost residues and that can protect the soil from erosion, improve soil water use efficiency and induce positive effects on soil-borne diseases and fertility.

3.2. Crop livestock integration

Due to the drought and farmer commitments the 7ha area allocated to a crop-livestock integration trial was planted on the 27th January 2016. The small seed and large seed were pooled separately and thoroughly mixed as illustrated in the photo below.

Photo 3.1: Mixing the cover crop seed, Ottosdal

Small seed was planted first with an Amazone spreader as illustrated in the photo below.

Photo 3.2: Amazone spreader in action sowing cover crop seed

After using an Amazon spreader to sow the small seeded cover crops, a spike tooth harrow was used to cover the seed with soil as illustrated in the photo below.

Photo 3.3: Covering the seed using a spike tooth harrow

Large seeded cover crops were immediately planted into the small seeded crops with a no-till planter using maize plates as illustrated in Photo 3.4 below.

Photo 3.4: Planting large seed with a no-till planter

The results of the planting less than a month later can be seen in Photo 3.5 below taken on 15 February 2016.

Photo 3.5: Condition of cover crops on 15 February 2016

No one species can deliver all the advantages multiple cover crops deliver in combination. That's why most farmers who start with single species cover crops eventually move to mixes. The benefits of multi-specie cover crops are multiple: Some of the cover crops are nitrogen fixers, some are very good at scavenging leftover nitrogen in the soil, some have deep roots that extend benefits deeper into the soil profile, while others help to control specific weeds or attract beneficial insects.

The value of cover crops partially lies in the biomass produced above ground. The real benefit lies in the diversity of plant roots that create an underground habitat with a healthy balance of predator and prey organisms. That balance improves nutrient cycling and puts organic matter production on the fast track. A single cover crop is a good start, but multiple species deliver many more benefits.

Using one or two species is a step in the right direction. But there are more benefits from using several cover crops together. The benefits are exponential with the synergy created to feed the soil biology with a dozen species together. You can actually accelerate biological time in nutrient cycling.

First-time cover crop users tend to use only one or two species because they think that is the simplest. A multiple-species planting is actually easier and safer to manage than a single species cover crop. The more diversity you have, the more plant companionship exist above-ground and soil biology balance you have below-ground.

The benefit of mixtures comes through very clearly in a drought situation. While monocultures struggle, 6 to 8 species cocktail mixes flourish in dry times, inter alia working together to suppress weeds. Using mixtures that include both warm and cool season plants, and both grasses and broadleaf plants, is ideal. The following serves as a broad framework:

- Warm season grasses (maize, millet, sorghum);
- Warm season broad leafs (soybeans, cowpea, lablab, sunflowers);
- Cool season grasses (cereal rye, wheat, triticale, oats); and
- Cool season broad leafs (vetch, radish, turnips).

Having two or three representatives from each group would be ideal. But there's a practical side to consider. Seed availability, cost, seeding methods, ability to terminate the plants and other factors determine how many species you might use. Some studies suggest six to eight species from three of the groups would be ideal.

The message is not to be limited, but to be creative. To quote Einstein: “logic will take you from point A to B; imagination will take you anywhere”.

In Photo 3.6 below, 100% soil coverage with plant material was attained within a month of planting, with only a total of 21 mm of rain during the previous week. Growing conditions on this date was optimal. A total of 70 mm rainfall was received on this plot since planting.

Photo 3.6: Cover crop condition on 1st March 2016

A farmers day (green tour) was held at Ottosdal on 19th April and 59 farmers attended the event. Photo 3.7 below was taken during the event.

Photo 3.7: Cover crop middle April

Samples of the mixture was taken to determine yield. The average DM for the samples was a staggering 12 t ha^{-1}.

Late February a winter mixture was planted at Ottosdal with a small seed planter. Good rain fell and good stand culminated, as can be seen in photo 3.8 below.

Photo 3.8: Winter cover crop

The winter mixture was harvested on the 20/6/2016 to determine yield. Photo 3.9 below was taken at the same time as the sampling proses. The average DM yield for the winter cover crops was 10.24 t ha^{-1}.

Photo 3.9: Winter cover crop before harvest

3.3. Harvesting the Cover crop trial.

The cover crop trial at Humanskraal was harvested on the 13th and 14th of April 2016. Table 3.6 contains the DM data. It is clear from the data that crops do have a profound rotational effect on each other as far as yield goes. Conditional formatting was used to make the interpretation of the data easy for the reader. Dark green shades indicate the highest effect on yield for a specific treatment while the red shades indicate the lowest effect on yields. Totals and averages on the right hand side of the table reflects the yield of the different treatments on a specific crop planted during the 2015 season, while totals and averages at the bottom reflects the performance of a specific crop on all treatments during the 2016 season. For instance, during the 2016 season Sunhemp (SunH) did well on Guarbeans and Oats but failed to produce after Black Oats and Radish.

Mr. George Steyn (Humanskraal farmer co-worker) did an excellent job during the growing season and the trial for the second season looked amazing. His unselfish inputs and excellent collaboration is hereby acknowledged.

3.4. Infiltration rate measurements taken at the Humanskraal trial

Conservation practises done correctly will improve infiltration rate into the soil profile. These practises include high density grazing, minimal soil disturbance, crop diversity and permanent organic soil cover. To test the infiltration rate on different treatments at the Humanskraal trial site was taken. Clearly standing out from the data is the fact that severe or uncontrolled wheel traffic in no-till maize can cause compaction. Very good infiltration rates have an infiltration rate of under 3 minutes. From figure 3.1 crops such as Rye and Radish also seems to compact the soil to a certain extend.

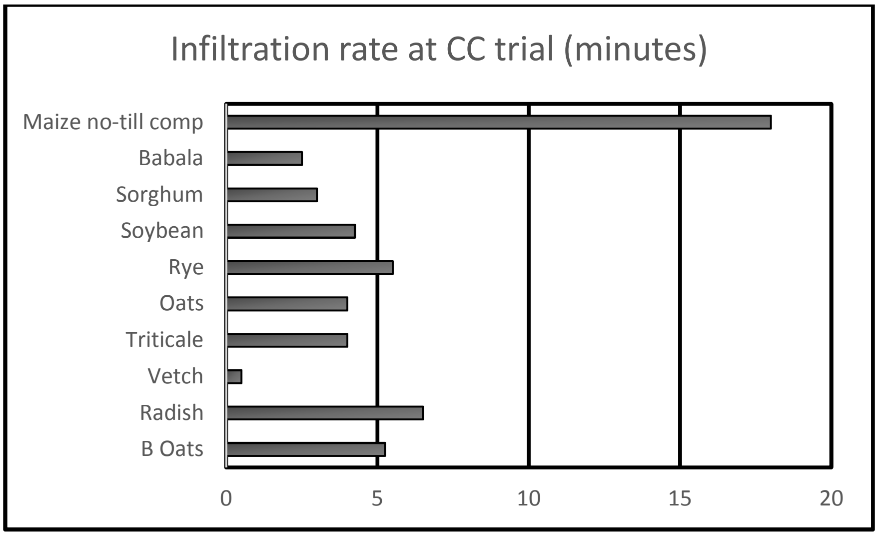


Figure 3.1: Infiltration rate for certain treatments

Table 3.6: DM data of cover crop trial 2016

	Crop 2016																		
Crop 2015	**SunH**	**MixS**	**Soy**	**Bab**	**Sor**	**SunF**	**Vel**	**Cow**	**Maize**	**Labl**	**Vet**	**MixW**	**Trit**	**Rad**	**Rye**	**Oats**	**BOats**	**Total**	**Ave**
Lablab	3,3	7,0	2,5	8,0	8,1	4,9	4,6	3,5	5,8	4,5	5,4	7,1	7,8	6,5	3,5	7,0	6,7	96,1	5,7
Velvet	3,7	3,7	2,1	4,7	8,9	4,5	2,7	3,2	6,0	4,5	4,8	8,5	6,2	5,3	3,7	5,5	7,4	85,4	5,0
Sorghum	3,6	4,5	4,1	9,5	6,9	5,3	3,7	2,9	8,7	3,1	7,0	11,9	5,7	7,8	5,8	4,6	8,7	103,9	6,1
Sunflower	3,7	3,1	3,1	6,5	7,6	5,5	3,7	5,2	6,2	4,6	5,1	8,8	7,4	7,1	4,3	5,8	7,1	94,3	5,6
Maize early	4,7	4,7	4,6	6,3	5,7	4,5	5,7	2,8	12,4	7,5	5,4	9,7	9,7	14,0	6,8	6,9	8,5	119,6	7,1
Babala	4,4	4,2	4,4	12,5	11,3	6,0	3,7	3,3	11,3	5,2	5,4	11,0	10,5	15,3	7,9	6,7	8,3	131,3	7,7
Cowpea	4,0	7,2	6,0	17,5	9,6	4,3	3,9	3,2	14,3	3,4	6,1	10,7	10,8	12,6	6,0	5,4	8,9	133,9	7,9
Sunhemp	3,8	1,7	3,9	7,6	8,3	2,9	4,3	3,6	8,2	3,3	5,7	6,0	10,5	10,3	6,2	7,3	8,2	102,0	6,0
Soybean	4,5	4,9	4,0	12,8	8,7	8,7	4,3	3,0	13,3	4,0	7,0	5,9	9,2	10,4	6,3	6,6	7,8	121,6	7,2
Mix Summer	5,2	6,8	3,5	13,9	8,1	6,4	3,6	5,3	7,2	4,0	6,3	11,4	10,7	11,2	7,1	7,0	8,2	125,8	7,4
Maize late	4,5	1,4	2,8	12,2	11,3	4,9	3,4	3,9	12,8	7,2	5,4	8,8	12,3	13,3	6,2	6,9	8,1	125,4	7,4
Guarbean	5,7	5,9	7,4	14,7	14,1	8,5	5,2	4,8	12,2	6,3	6,5	7,2	10,3	10,5	7,6	7,9	6,6	141,4	8,3
Oats	6,0	2,4	4,4	13,9	11,4	11,8	5,7	5,3	14,1	6,8	5,3	10,3	7,8	17,8	5,4	5,5	6,0	139,8	8,2
Vetch	4,9	3,7	2,7	11,0	7,8	3,9	6,0	3,3	10,8	5,6	7,3	8,7	7,9	7,5	7,0	4,8	4,8	107,7	6,3
B Oats	3,0	4,8	4,4	12,2	9,8	12,8	4,9	5,8	15,1	5,7	8,1	10,3	10,7	12,4	6,5	6,9	5,5	139,0	8,2
Rye	3,8	5,2	4,7	18,1	10,3	13,2	5,1	5,6	12,0	5,5	6,4	8,3	11,2	19,0	7,9	7,5	8,3	152,1	9,0
Radish	2,9	4,1	3,7	10,9	9,0	6,0	4,0	3,4	15,4	4,4	5,8	7,4	9,8	10,9	6,2	6,4	6,6	117,2	6,9
Triticale	4,4	3,3	5,2	10,3	10,6	9,8	4,9	4,7	13,7	4,5	8,6	7,0	11,4	16,0	6,7	6,5	6,7	134,2	7,9
Mix Winter	4,4	3,9	5,2	12,9	11,1	10,0	4,7	4,7	12,4	4,3	8,0	8,4	10,6	13,7	6,2	6,6	7,2	134,2	7,9
Total	80,2	82,6	78,4	215,6	178,7	133,7	83,9	77,3	211,9	94,5	119,7	167,3	180,7	221,6	117,3	121,9	139,9		
Ave	4,2	4,3	4,1	11,4	9,4	7,0	4,4	4,1	11,2	5,0	6,3	8,8	9,5	11,7	6,2	6,4	7,4		

3.5. Problems encountered with the project:

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

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

None

3.7. The estimated duration of the project until completion:

Winter cover crops had been ordered form Cover Crop Solutions to establish the winter annuals. Funding for the project has been extended for this financial year.

4. Weed survey of field trials: planning and analyses

Work Package title	**Weed survey of field trials: planning and analyses**
Work Package period	October 2015 to September 2016

Lead partner	ARC-GCI (Dr E Hugo)
Involved partners	Ottosdal No-till club members, SGS

Objectives	• To plan the on-farm maize weed survey trials • To analyse and report the results of the weed survey trials • Determine challenges in weed control of no-till practices

Justification	Knowledge of the long-term effect of tillage or reduced-tillage practices on weed diversity and species composition will provide information necessary for improving weed management in agro-ecosystems. The constant use of certain active ingredients of herbicides such as glyphosate in a monoculture-maize production system also raises a concern for development of resistant weed populations. Most research to date on weed control in reduced tillage practices have shown clearly that tillage has a profound effect on the species composition and subsequent shift in the weed spectrum. The absence of soil disturbance and presence of crop residue cover in CA systems will generally lead to an increase over seasons in organic matter content of the soil, soil moisture, temperature and microbial activity. These factors may have a direct or indirect effect on weed control efficacy, including weed species present, time of weed seed germination and emergence, weed-crop interference, competition between weed species, effective herbicide application and residual efficacy of herbicides as well as waiting period of herbicides on follow-up crops.

Description of work	**Planning of trials in collaboration with participating farmers. 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 report • Regular attendance of meetings

	• Reporting as required • Popular article once enough results have been acquired.

Risks	Adequate involvement and participation of farmers

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 <u>not</u> achieved** (in report period)
Field trial to evaluate delayed application of mesotrione containing tank mix	One field trial planted Application treatments: Pre-emergence, 1, 2, 3 and 6 weeks after planting Application scheduled for 4 weeks after application was omitted due to severe hail damage during this period Determine crop damage	No visual discolouration of crop was recorded for all treatments. Control of purple nutsedge was not effctive Trial was succesfully harvested and data were analysed.
Field trial to compare efficacy of different adjuvants	One field trial planted Treatments: 5 different adjuvants were added to tank mix, respectively Determine efficacy of different tank mixes	Effective control was recorded, except for purple nutsedge Trial was succesfully harvested and data were analysed.
Annual report and admin (production & technical data)	Written technical report covering trial procedures, results and progress.	On-going process. Bi-annual technical report completed by end February 2016. See annual report below.

4.1. Actions taken to date

The efficacy of herbicide spray programs on maize has been discussed at a meeting held between Ottosdal farmers practicing conservation agriculture (CA) in January 2015. Although glyphosate forms an integral part of the spray program in their CA systems, farmers agreed that other herbicides have to be phased in and applied at the correct time to minimize the development of possible glyphosate resistant weed species and to increase efficacy of weed control. Most spray programs applied by the farmers, therefore, include herbicides such as atrazine, terbuthylazine, mesotrione and chloroacetamides (acetochlor, s-metolachlor). Several farmers also obtained good weed control with an s-metolachlor/mesotrione mix (Camix, product from Syngenta SA) where it is applied at planting with a follow-up application app. 4 weeks after planting. The same program is also followed where mesotrione (Cantron, Product of Villa Crop Production), metolachlor (Metolachlor 800 EC, product of Villa Crop Protection) and atrazine/terbuthylazine (Supranex, product of ADAMA) are sprayed in a tank mix. The correct timing is essential for effective weed control for most of the products mentioned, but due to environmental conditions (soil too wet or too dry), applications have to be delayed sometimes. Post-emergence application with mesotrione is advised on the label for between 35 and 42 days after the pre-emergence application. The effect of mesotrione containing tank mixes on maize after the prescribed post-emergence application was evaluated to determine any crop damage and consequent yield loss. A field trial was planted on 23 November 2015 with the maize cultivar DKC80-30R at the ARC-Grain Crops Institute. The field trial was a randomized block design with four replicates with each plot measuring 5m x 10m. Application of the respective treatments were done using a tractor sprayer calibrated to deliver 110 L/ha. The tank mix containing mesotrione, atrazine/terbuthylazine and metolachlor was applied pre-emergence, 1, 2, 3, 4, and 6 weeks after planting, respectively. A control treatment receiving no herbicides was included to compare with the respective treatments. The dosage rates of the products were: 250 ml mesotrione, 1L metolachlor, and 600g atrazine/terbuthylazine. The pre-emergence application was done on 24 November 2015 and the relevant applications were done according to the subsequent weeks after planting at 1, 10 and 17 December 2015. A hail storm damaged maize leaves severely during the 4 weeks after application period, resulting in omitting this treatment. The 6 weeks after planting application was done on 4 January 2016. Visual evaluations were done weekly on a percentage scale compared to the control treatments to determine efficacy of weed control and crop damage.

Farmers are subjected to a variety of adjuvant products to be added to herbicide tank mixes to improve efficacy of post-emergence herbicides. The products and availability may, however, differ from one season to another. Weed control efficacy of several of these adjuvants was determined when applied to a tank mix containing mesotrione. A separate field trial was conducted where the same tank mix as mentioned above were used, with different adjuvants added to the tank mix, respectively. Adjuvants used included Tronic, Performer, Agral, Complement Super and Break thru. The field trial was a randomized block design with four replicates, planted on 16 November 2015 with maize cultivar DKC73-76R, each treatment plot measured 5m x 10m. Application of the respective treatments were done on 17 December 2015, using a tractor sprayer calibrated to deliver 110 L/ha. The adjuvants (6 treatments) were added to the tank mix (mesotrione/atrazine/terbuthylazine/metolachlor), respectively at the following dosage rates: 1) Performer 300ml/100L water, 2) Performer 500ml/110L water, 3) Agral 200ml/100L water, 4) Complement Super 100ml/ha, 5) Break thru 50ml/100L water and 6) Tronic 500ml/ha. Visual evaluations were done weekly on a percentage scale compared to the control treatments to determine efficacy and/or crop damage. Weeds were counted in the middle two rows of maize in each treatment plot, except for purple nutsedge that showed severe infestation levels and was recorded as a percentage coverage per plot.

4.2. Progress Made

All herbicide products were obtained by chemical representatives used by Ottosdal CA farmers. Two field trials were successfully planted and all treatments were applied successfully. Visual evaluations were done weekly to determine efficacy of tank mixes and to evaluate any crop damage. Both trials are being maintained until physiological maturity when it will be harvested to determine the effect on crop yield.

Both field trial was hand harvested on 31 May 2016 when maize was physiological matured with a moisture content of 12.5%. Plants and ears harvested were counted and threshed to determine ears per plant, mass per ear, total ear mass, weight of 1000 kernels yield (t ha^{-1}). All yield data were analysed using a One-Way ANOVA with treatments as a factor to determine significance between means at P= 0.05. (Genstat Release 18.1, VSN International, 2015)

4.3. Results achieved to date

Delayed mesotrione-mix application trial:

Maize seedlings showed no visual chlorosis / yellowing in any of the mesotrione-mix treatments. Effective weed control (>90%) was recorded in all treatments.

The application of the mesotrione-mix at different weeks after emergence had no significant effect on any of the yield parameters measured (Table 1). The lowest yield was recorded where the mesotrione-mix was applied only one week after emergence. Yield after application of the mesotrione-mix at 2, 3 and 6 weeks after application varied between 2.5 and 3.5 t ha^{-1}.

Maize yield was therefore not reduced after the application of the recommended mesotrione-mix and dosage rates up till six weeks after emergence during the 2015/2016 growing season.

Table 4.1. Effect of mesotirone-mix applied at different weeks after emergence (WAE) on maize yield parameters

Treatment	Ears $plant^{-1}$ (#)	Mass ear^{-1} (g)	1000 kernel mass (g)	Yield (t ha^{-1})
Control	1	98.72	592	2.49
WAE - 1	1	116.26	610	2.29
WAE - 2	1	100.98	608	2.56
WAE - 3	1	99.93	623	2.46
WAE – 4*	1	113.76	662	3.08
WAE - 6	1	117.64	662	3.51

*No mesotrione-mix application due to severe hail damage

Adjuvant trial:

Effective control (>90%) was recorded in all treatments, however, severe purple nutsedge infestation occurred throughout the trial and were separately rated. Late emergence of only morning glory and sweet signal grass was recorded at the tasselling stage of maize and the mean numbers are shown in Table 4.1. Purple nutsedge is difficult to control since very few active ingredients are registered for effective control; herbicides applied (mesotrione-mix) did, however, not control this weed since it is not on the list of weeds controlled of products used in tank mix.

Table 4.2. Mean numbers of morning glory and sweet signal grass, and the percentage cover of purple nutsedge recorded at the tasselling stage of maize.

Treatment	Tank mix	Adjuvant added	Morning glory (*Ipomoea purperea*) (#)	Sweet signal grass (*Brachiaria eruciformis*) (#)	Purple nutsedge infestation (*Cyperus rotundus*) (%)
1	250ml Cantron 1L Metolachlor 600g Supranex	Agral 200ml/100L	0	1	24
2	250ml Cantron 1L Metolachlor 600g Supranex	Complement Super 100ml/ha	5	3	23
3	250ml Cantron 1L Metolachlor 600g Supranex	Break thru 50ml/100L	0	0	5
4	250ml Cantron 1L Metolachlor 600g Supranex	Performer 300ml/100L	1	3	33
5	250ml Cantron 1L Metolachlor 600g Supranex	Performer 500ml/100L	2	2	24
6	250ml Cantron 1L Metolachlor 600g Supranex	Tronic 500ml/ha^2	1	0	54

Yield results:

Only mass per ear and total yield (t ha^{-1}) differed significantly between treatments. Mass per ear was higher in all the treatments compared to the control where no adjuvant was added. The highest yield was recorded for the Mesotrione-mix + Break thru treatment (Table 4.3).

Table 4.3. Effect of different adjuvant products in combination with mesotrione-mix on maize yield parameters.

Treatment	Ears $plant^{-1}$ (#)	Mass ear^{-1} (g)	1000 Kernel weight (g)	Yield (t ha^{-1})
Mesotrione-mis (no adjuvant)	1.2	115.6a	313.4	3.6ab
Mesotrion-mix + Agral	1.0	152.9b	353.5	3.9ab
Mesotrione-mix + Complement Super	1.2	157.3b	366.3	4.3bc
Mesotrione-mix + Break Thru	1.1	145.8b	331.5	5.0c
Mesotrione-mix + Performer (300 ml/100L)	1.0	139.7ab	323.3	3.3a
Mesotrione-mix + Performer (500ml/100L)	1.1	152.7b	334.5	3.7ab
Mesotrione-mix + Tronic	1.0	156.0b	344.5	3.5ab

*Numbers followed by the same letter(s) in a column do not differ significantly at P = 0.05.

4.4. Problems encountered and milestones not achieved

Delayed application of mesotrione trial: A severe hail storm was experienced during the 4 weeks after application treatment period and application was not done since maize leaves were severely shredded.

It should also be noted that although trials were irrigated when possible (due to strict irrigation schedule and demand), severe drought conditions prevailed during December 2015 and January 2016 that may have an effect on plant growth and yield.

5. Agronomic field trial planning and analyses

Work Package title	**Agronomic field trial planning and analyses**
Work Package period	October 2015 to September 2016
Lead partner	ARC-GCI (Dr. A. A. Nel)
Involved partners	Ottosdal No-till club members, SGS
Objectives	• To plan the various on-farm maize CA related field trials • To analyse and report the results of these 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. Other unkown variables are what cultivars are the best adapted for CA, should the Argentinian guidelines on row width and plant population density be followed and should planters be fitted with couters rather than tines? 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 of trials in collaboration with participating farmers. 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. Statistical analyses, interpretation, discussion and drawing of conclusions from the collected data. Presentation and reporting of the results to participants and MT as required.

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

Risks	Adequate involvement and participation of farmers

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 <u>not</u> achieved** (in report period)
Planning of trials	Field trial plans and data sheets were compiled.	After meeting with the No-till Club where the objectives were discussed, field trial plans and data sheets were compiled and handed to the Club.
Statistical analyses, interpretation, discussion and drawing of conclusions from the collected data.	Report on results	Due to the extreme drought of 2015/2016, some trials could only be planted in January which led to delayed harvesting and collection of results. Results will be presented in September to the Ottosdal No-till Club.
Presentation and reporting of the results to participants and MT as required.	Annual and biannual reports and presentation	Results of 2013/2014 and 2014/2015 seasons were presented to the No-till Club in November 2015. Annual and bi-annual reports were submitted as required. (2013/2014 to 2015/2016 report attached)

List of trial objectives for 2015/2016

Title	**Objective**
1. Plant population densities of crops in	To get an indication if the plant population

conservation agriculture	densities that are currently used, should be increased or decreased in conservation agriculture systems for maize, soybean sunflower and sorghum.
2. Crop rotation in conservation agriculture	To investigate the influence of six crops, when grown in rotation, on each other on a number of farms.
3. Local versus Argentinian row widths and plant population densities	To compare the yields of maize, soybean and sunflower grown in Argentinian row widths of 0.5 m and plant population densities, with local row widths (mostly 0.9 m) and population densities on a number of farms.
4. The use of tines versus coulters fitted planters on the performance of crops	To determine the influence of tine or coulter fitted on the planter, on the growth and yield of different crops on a number of farms and over seasons in 0.9 m rows
5. Cultivar evaluation in conservation agriculture	to get an indication of (a) the best performing cultivars of different crops at a relatively high plant population in 50 cm row widths, (b) the performance of these cultivars in the local system of 90 cm spaced rows and lower plant population densities.
6. A comparison of conventional and conservation agriculture (CA) cropping systems	To compare the yield and grain quality of crops in conventional and CA production systems with both 0.52 and 0.9 m spaced rows in the CA systems on farms where conventional practices are applied.

5.1. Actions taken to date

Field trials were described, planned according to the objectives and provided to the No-till club for execution. Results from 2013/2014, 2014/2015 and 2015/2016 were analysed and the results with conclusions were documented. The research objectives were about:

1. Crop rotation systems (all seasons)
2. Argentinian versus local row widths and populations (all seasons)
3. Tines versus coulter fitted on planter (all seasons)
4. Plant population densities (2013/2014 & 2015/2016)
5. Maize cultivar evaluation (all seasons)
6. Conventional crop systems vs CA crop systems (2015/2016)

5.2. Progress made

The following number of trials were planned, conducted and analysed in 2013/2014 to 2015/2016 for each objective:

Objective	**Number of trials**
Crop rotation systems	7
Argentinian versus local row widths and populations	18
Tines versus coulter fitted on planter	5
Plant population densities	13
Maize cultivar evaluation	9
Conventional crop systems vs CA crop systems	3
Optimum plant population densities	10

5.3. Results achieved to date

Crop rotation systems: The first season (2013/2014) served the purpose of establishing a "rotational effect" in the soil. In 2014/2015 and 2015/2016 results indicated that the yields of maize, sorghum and soybean are affected by a rotation x season interaction. A preceding crop that enhances the yield of a particular crop in one season, may suppress it in a second season.

Argentinian versus local row widths and populations: No maize yield difference was found in 53% of the trials, while 27% was in favour of the Argentinian system and 20% in favour of the local widths and populations.

Tines versus coulter fitted on planter: Yields were similar for treatments although a tine working depth of 240 mm instead of 150 mm resulted in an increased maize yield.

Conventional crop systems vs CA crop systems: No-till in combination with a high plant population density, had equal or superior yields compared to that of conventional tilled maize with traditional wide rows and plant population densities. The yield advantage was up to 2.2 t ha^{-1}.

Plant population densities: Most of the maize trials indicated an optimal no-till population density above 30 000 plants per ha. No-till sorghum and sunflower were unaffected by plant population density while the results suggested that the optimum density for no-till soybean was above 300 000 plants per ha.

5.4. Problems encountered and milestones <u>not</u> achieved

Drought affected results in 2014/2015. Extreme drought in 2015/2016 affected results and prevented the timely planting of trials.

5.5. Agronomy: Annual Progress Report - 2013 to 2016

1. Crop rotation systems

Introduction

It is well known that crop rotation can reduce the risk of diseases, pests and weeds, and enhances soil quality. When grown in rotation, crop yields are often higher than those of monoculture crops.

Crop rotation is one of the three principles of conservation agriculture. Limited research results regarding crop rotation in conventional tillage are available, while the influence of crop rotation in no-till on the performance of any of the crops currently grown in the Ottosdal area, is unknown. Preliminary results indicate that limited monoculture (a few years) with maize may be successful in conservation agriculture, however, the effect of long-term rotations is needed.

Aim

The aim is to investigate the influence of six crops on each other on a number of farms to find the best crop sequence.

Procedure

The six crops namely, cowpeas, forage sorghum, grain sorghum, maize, soybeans and sunflower were grown in the 2013/2014 season on three farms. The cycle length of the rotation systems is two years and a crop matrix is used for the trial layout. The matrix consists of strips of each crop next to each other (2013/2014). In 2014/2015 the strips were square on those of 2013/2014, resulting in six rotation plots for each crop. In 2015/2016, the layout of year 2013/2014 was repeated. Every crop is thus grown in monoculture and in rotation with each of the other crops. Crops were planted in 0.52 m wide rows, fertilised according to the potential of the soil using well-adapted cultivars of the various crops. Farms where trials were planted in 2014/2015 were Humanskraal, Noodshulp and Holfontein. Due to the extreme drought of 2015/2016, only one trial was planted at Humanskraal.

Row spacing for the maize cultivar and crop rotation trials were 0.52 m. Plant population densities were 4 m^{-2} for sunflower, 15 m^{-2} for grain sorghum, 30 m^{-2} for soybean and 23 m^{-2} for cowpeas per square metre respectively.

Results

The first season in crop rotation served to create a “rotational effect” in the soil. Yields recorded in two of the four trials planted in 2013/2014 are shown in Table 1.1. Yield results of the 2014/2015 and 2015/2016 seasons are shown in Table 1.2.

Table 5.1 Grain yield of the crops planted in the crop rotation trial in **2013/2014**

Farm	Maize (t ha^{-1})	Sorghum (t ha^{-1})	Soybean (t ha^{-1})	Sunflower (t ha^{-1})
Humanskraal	8.92	2.85	2.05	2.85
Noodshulp	6.08	3.73	2.67	2.92

2014/2015

The yield of both maize and grain sorghum was affected by the previous crop, although all yields were low. The yield of maize preceded by forage sorghum was 60% or 0.84 t ha^{-1} higher than the mean yield of maize preceded by cowpea, maize, soybean and sunflower. The grain yield of grain sorghum preceded by maize and soybean was 127% or 0.78 t ha^{-1} higher than that of grain sorghum preceded by sunflower. Compared with the other rotational crops, sunflower was the only crop that had a suppressive effect on the yield of both maize and grain sorghum. Due to a lack of replicates, no conclusion can be made about the soybean yield response.

2015/2016

Due to a lack of replication, no statistical analyses could be made on the 2015/2016 yield results and consequently also no reliable conclusions. Maize yields were surprisingly high despite a very late planting date (31 December 2015) with a mean of 4.55 t ha^{-1}. It appears that grain sorghum, as preceding crop, suppressed the yield of maize while sunflower improved it. Grain sorghum had a mean yield of 2.95 t ha^{-1} which appear to be improved with sunflower as preceding crop and suppressed by forage sorghum as preceding crop. Soybean, with a mean yield of only 0.91 t ha^{-1} appears to be improved by maize and supressed by sunflower as respective preceding crops.

It seems that the way crop yields were affected in 2015/2016 is different from the way they were affected in 2014/2015. This indicates that crop responses are subjected to a rotation x season interaction, a well-known phenomenon. Results from additional seasons are needed to draw reliable conclusions.

Table 1.2 Mean grain yields in t ha^{-1} for two seasons as affected by the preceding crop

Season	Preceding crop					
	Cowpea	Forage sorghum	Grain sorghum	Maize	Soybean	Sunflower
			Maize			
2014/2015	1.11^{B*}	2.23^{A}	1.72^{AB}	1.51^{B}	1.45^{B}	1.51^{B}
2015/2016	4.17	4.17	3.85	5.38	3.79	5.94
Mean	2.64	3.20	2.79	3.45	2.62	3.73
			Grain sorghum			
2014/2015	1.08^{AB}	1.08^{AB}	1.03^{AB}	1.24^{A}	1.53^{A}	0.61^{B}
2015/2016	3.20	2.76	2.60	3.22	2.62	3.27
Mean	2.14	1.92	1.82	2.23	2.08	1.94
			Soybean			
2014/2015	0.75	0.95	0.80	0.63	0.93	0.56
2015/2016	1.09	0.85	0.61	1.51	0.93	0.49
Mean	0.92	0.90	0.71	1.07	0.93	0.53

*Means followed by different letters in a row are significantly different at P = 0.05.

The crop rotation trial in 2015/2016 at Humanskraal with maize in the background, sunflower and grain sorghum next to it.

2. Comparison between local and Argentinian row widths and plant population densities

Introduction

Row widths currently used for all crops in the local conservation agriculture system are 0.75 and 0.91 m. However, the most frequently used width is 0.91 m. Maize plant population densities are normally lower than 24 000 ha^{-1}. Row widths of 0.52 m or less are used in Argentinian systems, with plant population densities for maize easily double the local recommendation. The only exception is soybean, where the Argentinian system is lower than the local one. It is unknown how the Argentinian row widths and plant population densities will perform in comparison with local systems.

Aim

The aim is to compare the yields of maize, soybean and sorghum grown in Argentinian crop row widths of 0.52 m, and plant population densities with local row widths and population densities on a number of farms.

Procedures

In 2014/2015 and 2015/2016, trials were done on six and three farms respectively using the Argentinian Pierobon planter (provided by Valtrac under the Grain SA x Argentina cooperation agreement) with row widths of 0.52 m representing the Argentinian system, while the planter of the farmer was used to plant according to his usual densities and row width of 0.75 or 0.91 m. The target plant populations are shown in Table 2.1.

The Argentinian Pierobon planter in action on the trials in Ottosdal 2014/2015.

Table 2.1 Plant population densities for crops in the Argentinian and local systems

Crop	System	
	Argentinian (plants ha^{-1})	Local (plants ha^{-1})
Maize	40 000	24 000 or less
Soybean	300 000	300 000
Sorghum	120 000	120 000
Sunflower	40 000	40 000

The Argentinian system consisted of a strip, or strips with six rows, or multiples of six rows, with the local practice next to it.

All inputs, such as fertiliser and cultivars were similar for both treatments. At harvesting, the yield of the treatments, and the final plant population densities were determined. An appropriate harvester table to harvest the Argentina maize trial was not available at harvest and the trials were harvested by hand. Where three or more replicates were present, yield data were subjected to analyses of variance. Five maize and one sunflower trial were done in 2014/2015 and three sunflower, one maize and one soybean trial in 2015/16.

Results

Maize yields for the various field trials are shown in Table 2.2. The analyses of variance showed that significant differences between the two systems occurred in only two trials. At Droëkraal however, fertiliser rates were different for the two systems. The yield difference is probably a fertiliser effect rather than a result of the different row widths and population densities.

Results of the combined data for 2013/2014, 2014/2015 and 2015/2016, excluding the unreliable yields from Droëkraal, are shown in Fig. 2.1. In 53% of the field trials, yields were equal for the two systems, in 27% the Argentinian systems resulted in higher yields, and in 20% of cases the local wider rows and lower plant densities had higher yields.

Table 2.2 Maize yield as affected by local and Argentinian production practices 2014/2015 and 2015/2016

Farm/Farmer	Yield (t ha^{-1})		Significance
	Local	Argentinian	
		2013/2014	
Dirk Laas	2.86	3.55	-
George Steyn	6.08	6.67	-
Hannes Otto	9.36	9.51	-
Phillip vd Berg	4.87	6.04	-
Phillip vd Berg	5.98	6.83	-
Tobie Martin	5.52	6.84	-
Nico de Bruyn	5.01	6.15	-
Koos Voorendyk	4.29	3.10	-
Koos Voorendyk	3.92	3.12	-
Uys Schickerling	6.41	5.41	-
Hannes Steyn	4.06	4.46	-
Jaco Pienaar	5.36	5.56	-
		2014/2015	
Humanskraal	1.49	1.01	*
Langskuur	2.5	2.51	ns
Doornpoort	3.49	3.81	ns
Korannafontein	2.90	3.01	ns
Droëkraal	3.02	2.29	*#
		2015/2016	
Humanskraal	3.59	3.96	ns

- Not replicated; * Significant at P = 0.05; # different fertiliser rates applied.

Sunflower had equal plant population densities for the 0.52 and 0.91 cm rows. One field trial was done in 2013/2014 and three in 2015/2016. The recorded yields are shown in Table 2.3. Higher yields were constantly recorded for the narrower 0.52 m row width than for the 0.91 m width although not statistically different at the 5% probability level. However, when analysed over all trials, the yield advantage for the 0.52 m Argentinian row width was a significant 0.130 t ha^{-1} (Fig. 2.2).

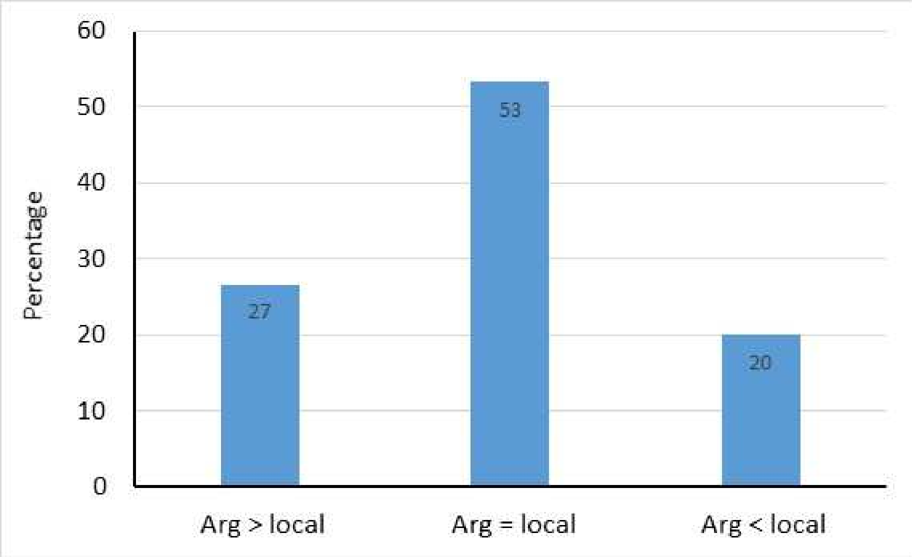


Fig. 2.1 Yield comparison of maize grown according to local and Argentinian row widths and plant population densities. Combined results for 2013/2014 and 2014/2015

Table 2.3 Sunflower yield (t ha^{-1}) as affected by local (0.91 m) and Argentinian (0.52 m) row-widths in 2013/2014 and 2015/2016

Farm	Row width (m)		Significance
	0.91	0.52	
	2013/2014		
L du Plessis	2.04	2.41	ns
	2015/2016		
H Otto (1)	1.64	1.73	ns
H Otto (2)	1.55	1.60	ns
H Otto (3)	1.94	2.06	ns

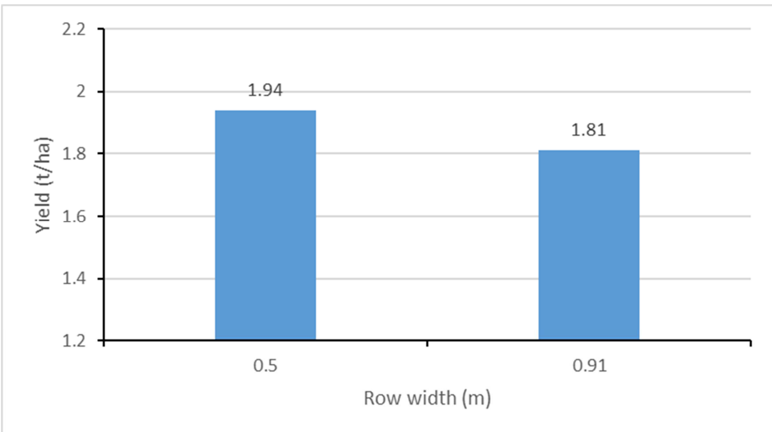


Fig. 2.2 Mean sunflower yield as affected by Argentinian (0.52 m) and local (0.91 m) row widths in four trials.

Row widths of 0.52 m and 0.76 m was compared in 2013/2014 and 2015/2016 on soybean at Humanskraal. The yield for the 0.52 and 0.76 m rows was 2.64 and 2.43 t ha^{-1} in 2013/2014, and 0.85 and 1.05 t ha^{-1} respectively in 2015/2016.

Row widths of 0.52 m and 0.76 m was also compared in 2013/2014 on sorghum at Humanskraal. The yield for the 0.52 and 0.91 m rows was 6.57 and 6.45 t ha^{-1} respectively.

Sunflower row widths of 0.91 and 0.52 m in 2015/2016.

3. The use of tines versus coulters on planters on the performance of crops

Introduction

Different planter options are available, with either a coulter or a tine fitted to the fertiliser unit. Coulters usually disturb the soil less than tines, which is an advantage. Deeper placement of fertiliser, and a larger or deeper seedbed can be created with tines to benefit seed emergence and seedling growth. It is unclear whether coulters or tines are best suited for crop growth and yield in local conditions.

Aim

To determine the influence of tines and coulters on the growth and yield of different crops on a number of farms.

Procedures

Trials were done in 2013/2014, 2014/2015 and 2015/2016 on the farm Humanskraal. Strips of maize were planted with coulters and adjacent to it, with tines fitted to the Jumil JM2670-SH-EX planter as treatments in 0.52 m rows. In 2013/2014 the treatments were replicated but not in 2014/2015 and 2015/2016. Accordingly, statistical analyses were not possible on the latter two trials.

Three tine configurations were also compared in two replicated field trials in 2014/2015.

- Long tine, working depth 240 mm
- Short tine, working depth 150 mm
- Diamond point depth 150 mm

Results

Maize planted with tines and coulters in 2013/2014, 2014/2015 and 2015.2016 had about similar yields, as the difference was 5% or less. Mean measured yields were respectively 8.69, 0.57 and 4.72 t ha^{-1} for the three consecutive seasons.

The effect of tine type and working depth on the yield of maize is shown in Fig. 3.1. The yield of maize, planted with a tine with a working depth of 240 mm, was 18% higher than the mean yield obtained with the short and diamond type tines.

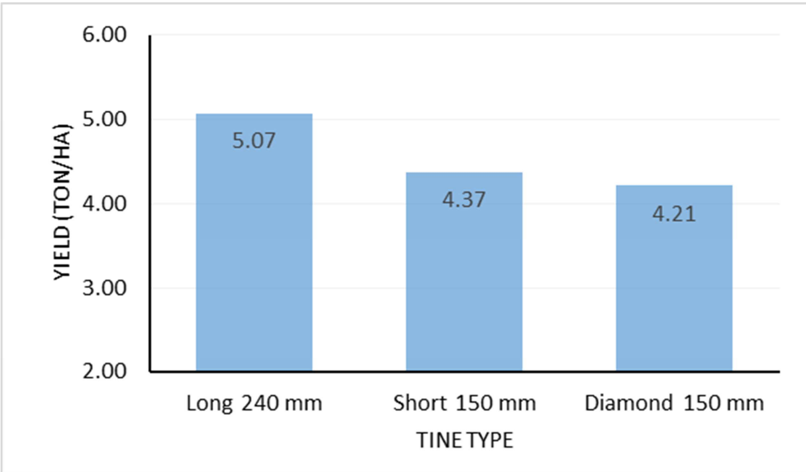


Fig. 3.1 The effect of tine type and working depth on the yield of maize in 2014/2015.

4. Cultivar evaluation in conservation agriculture systems

Introduction

Cultivar selection is an important aspect in the optimisation of maize production, which is controlled by the farmer. Currently, national cultivar trials are not done in no-till as part of conservation agricultural systems. It is thus unknown how cultivars will perform in no-till, under both the local and altered plant population densities and row widths of CA.

Aim

The aim is to identify the best performing maize cultivars at a relatively high plant population for this region.

Procedures

Four cultivar trials were done, each on a different farm in 2014/2015 and one trial in 2015/2016. Various available cultivars were included which also differed among farms. The trial layout consisted of six rows of the chosen cultivars at 0.52 m row widths. A control cultivar was included between every two adjacent cultivars tested. The cultivars included are shown with the results in Fig. 5 to 8

Plots of 62.4 m^2 were harvested by hand and the grain threshed for yield determination. Cultivar yields were normalised through the following steps: The mean yield of all control strips was calculated as Yc. A factor was calculated for each control strip as Yc divided by the yield of the control strip. Individual measured cultivar yields were then adjusted by multiplying it with 0.66 times the control strip factor next to it plus 0.33 times the control strip factor, which are one cultivar strip away from it.

Results

The adjusted cultivar yield results of the 2014/2015 and 2015/2016 trials are shown in Fig. 4.1 to 4.5.

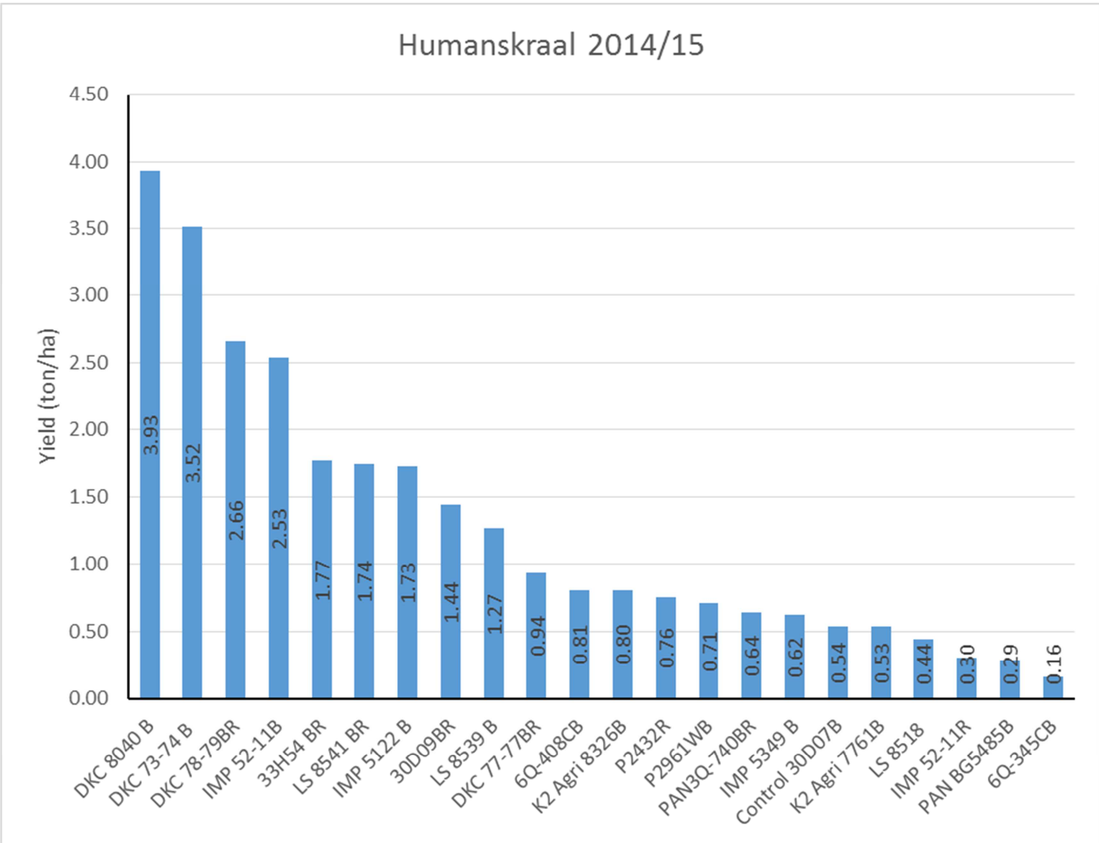


Fig. 4.1. Adjusted cultivar yields at Humanskraal (rainfall = 394).

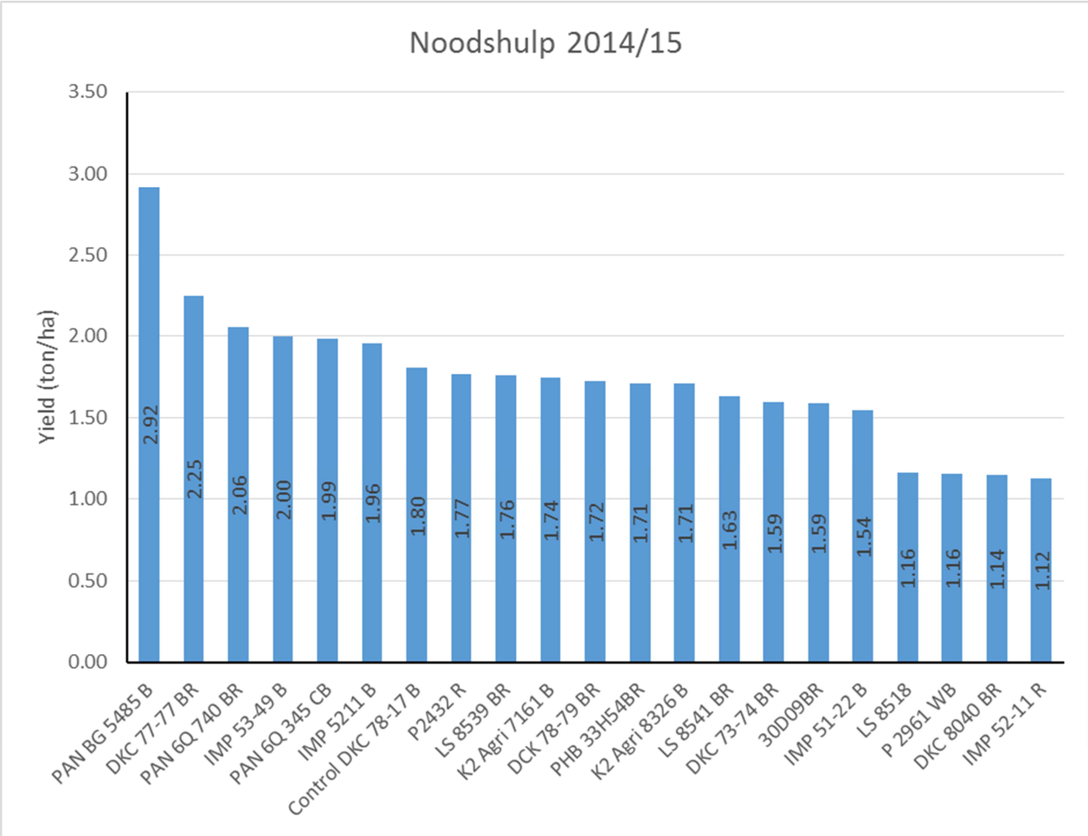


Fig. 4.2. Adjusted cultivar yields at Noodshulp (rainfall = 423 mm).

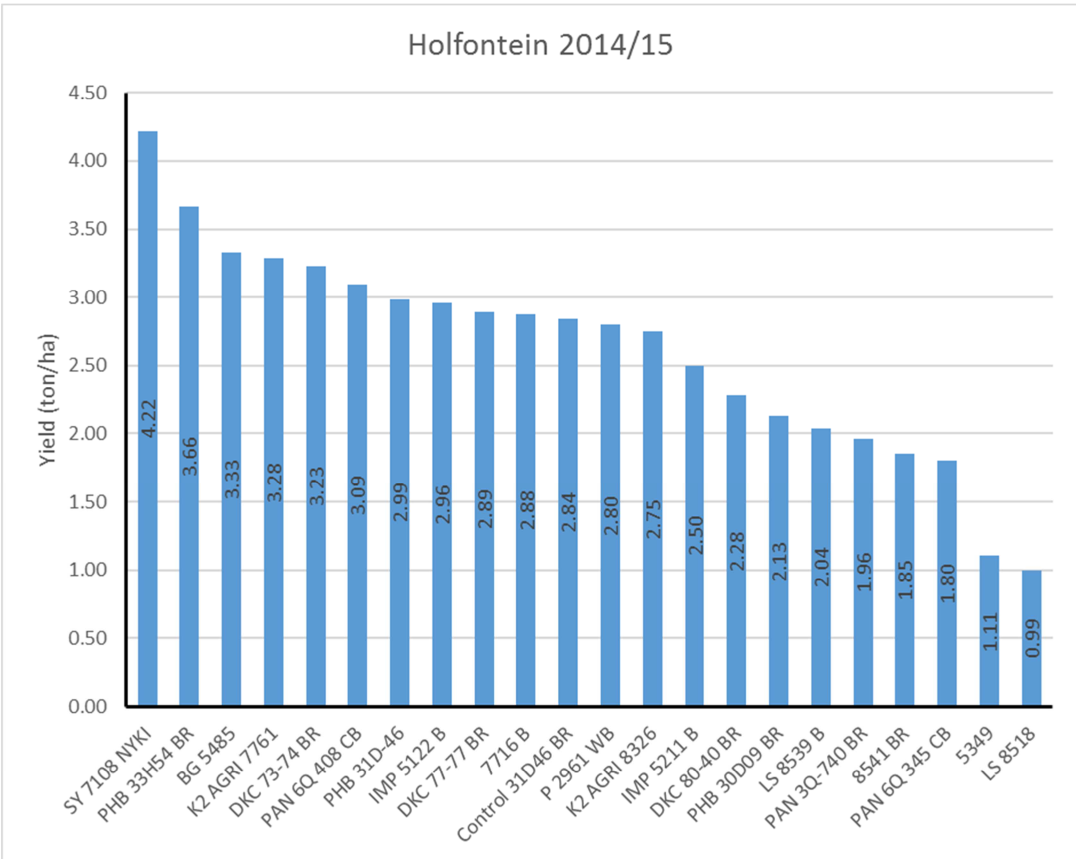


Fig. 4.3. Adjusted cultivar yields at Holfontein (rainfall = 431 mm).

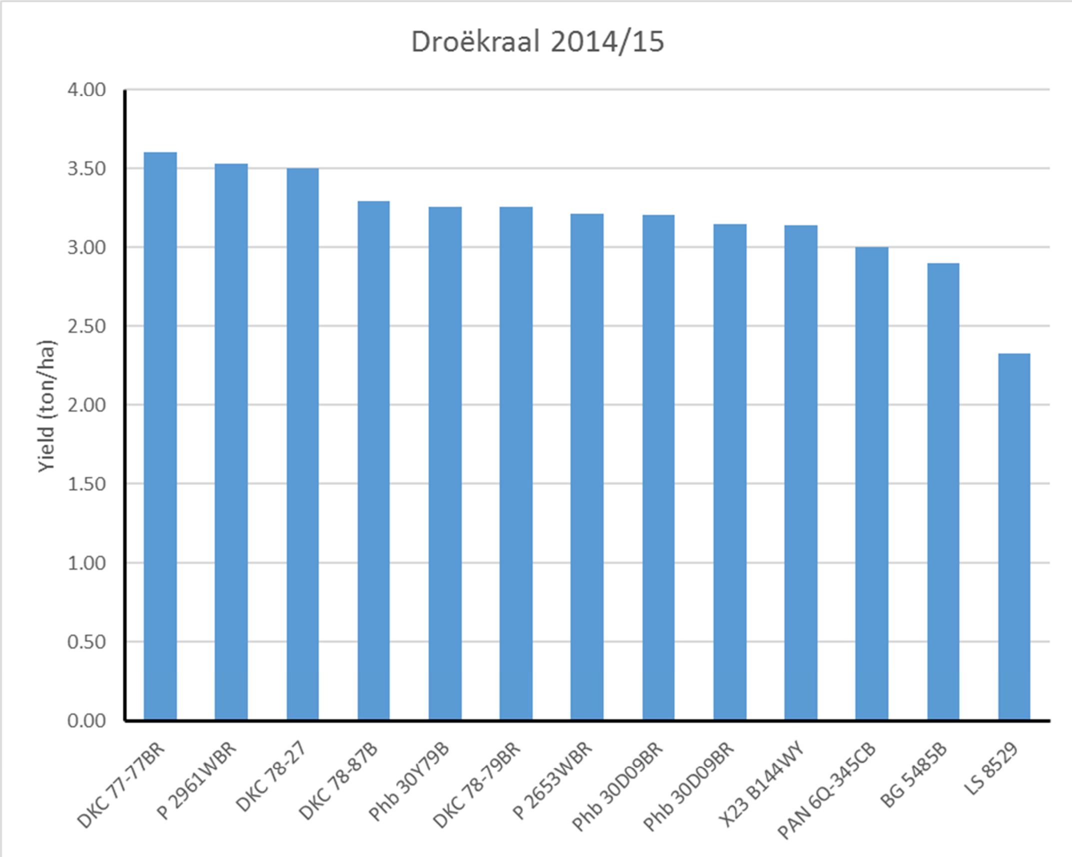


Fig. 4.4. Maize cultivar yields at Droëkraal (rainfall = 454 mm).

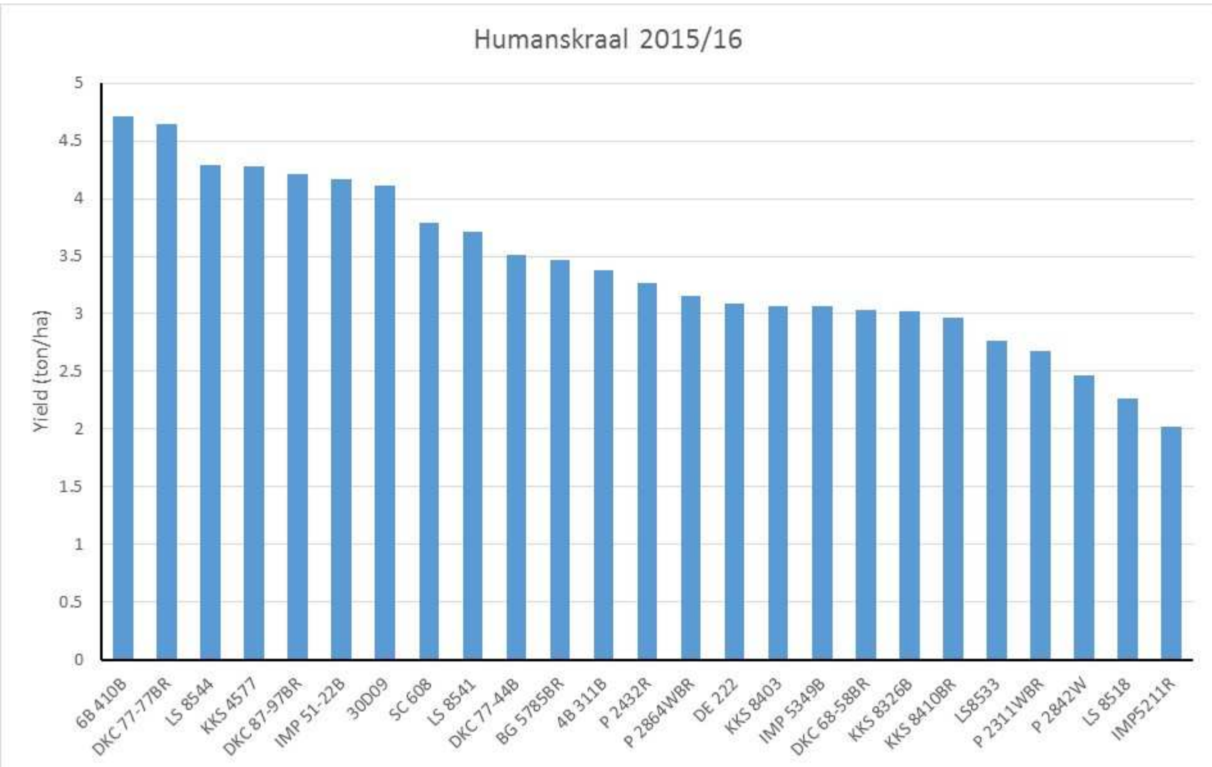


Fig. 4.5. Maize cultivar yields at Humanskraal.

5. A comparison of conventional and conservation agriculture (CA) cropping systems

Introduction

It is now well known that crop production under conventional soil tillage accelerates soil erosion cause a decline in soil quality and crop productivity. Conventional crop systems are consequently not sustainable and the only alternative is to change to conservation agriculture cropping systems with its principles of no-tillage, a surface mulch and crop rotation.

Due to a local lack of scientifically based results the need exists to collect results on the success (or not) of CA crop systems in comparison in comparison with conventionally produced crops in field trials. The results of such a comparison will confirm if the sustainability maize production has improved due to a change to CA. The economy of these crop systems can be compare and these field trials can be used to promote CA among farmers, as well as research and training platforms for students.

Aim

To compare the yield of crops in conventional and CA production systems with both 0.52 and 0.91 m spaced rows in the CA systems.

Procedures

One or more field trials in which commercially available equipment will be used on farms of participating farmers. The current conventional system used on the farm will be the control which will be compared with no-till. The test crop and rotation system will also be chosen by the participating farmer. Different possible treatments or systems exists.

Possible Treatments

1. **Plow**: conventional mouldboard ploughing 20 – 30 cm deep.
2. **Rip-on-row**: As applied in the area or on the particular farm.
3. **No-till with 0.52 m spaced rows**: no-till with a surface mulch and chemical weed control with the Argentinian recommended plant population densities.
4. **No-till with 0.91 m spaced rows**: no-till with a surface mulch and chemical weed control with locally recommended plant population densities.

Treatments 1 and 2 represent conventional systems while 3 and 4 represent CA systems.

Layout

The treatments can be assigned to strips on a selected land. The width of a treatment should equal at least one width of the widest used implement, usually the herbicide sprayer that is used. For results to be scientifically comparable, at least three replications of each treatment should be present. All replicates can be on a particular land or, one complete replicate, which consist of all the treatments, can be on one land while the others are on other land or even different farms. All aspects such as fertilisation, cultivar used, herbicide, depth of ploughing etc. should be applied in exactly the same way on all replicates.

The 2015/2016 participating farmers, the conventional and CA systems applied are shown in Table 5.1.

Table 5.1 Participating farmer, description of the tillage system applied and number of seasons of no-till

Participating farmer/farm	Tillage system and row width (m)	Crop	Population density (m^{-2})	Number of no-till years
Jaco Bamberger	**1.** Moulboard ploug, 2.3 m	Maize	2.26	-
	2. Rip-on-row 45 cm deep, 2.3 m		2.26	-
	3. No-till, 0.52 m		4.00	First
	4. No-till, 0.91 m		2.42	First
Niël Rossouw	**1**. Strip till 20 cm deep 1.5 m	Maize	1.78	-
	2. No-till 0.91 m		2.20	First
	3. No-till 0.52 m		4.20	First
Pieter van Vuuren	**1.** Rip-on-row 40 cm deep, 2.3 m	Maize	1.31	-
	2. Rip-on every second row 1.15 m		2.61	-
	3. No-till, 0.91 m		1.76	First
	4. No-till 0.52 m		3.00	First

Results

Results of the various trials are shown in Fig 5.1 to 5.3. On the farm of Jaco Bamberger, the Argentinian no-till system of 0.52 m spaced rows with a planting population of 4.0 plants m^{-2} outperformed the no-till 0.91 m row spacing and the two wide row tilled system with 0.96 t ha^{-1}. On the farm of Niël Rossouw, the mean yield of the two no-till systems was 85% or 2.22 t ha^{-1} than the yield of the strip-till system.

The no-till 0.52 m spacing with 3 plants m^{-2} density had the highest yield of all systems on the farm of Pieter van Vuuren including the 0.91 m no-till system. Rip-on-row with a 2.3 m row spacing had the lowest yield of all systems even where it was combined with a no-till row between the tilled rows.

The systems were not replicated in these trials and scientifically based conclusions cannot be made. However, the results give strong evidence in favour of the no-till, 0.52 m spaced rows with a high plant density over that of the conventionally tilled, wide rowed low population density systems. Compared to results from elsewhere in the world, these results are also remarkable as most no-till yields are higher than that of the conventional systems from the first season of no-till. Results from more seasons are needed for confirmation of the findings.

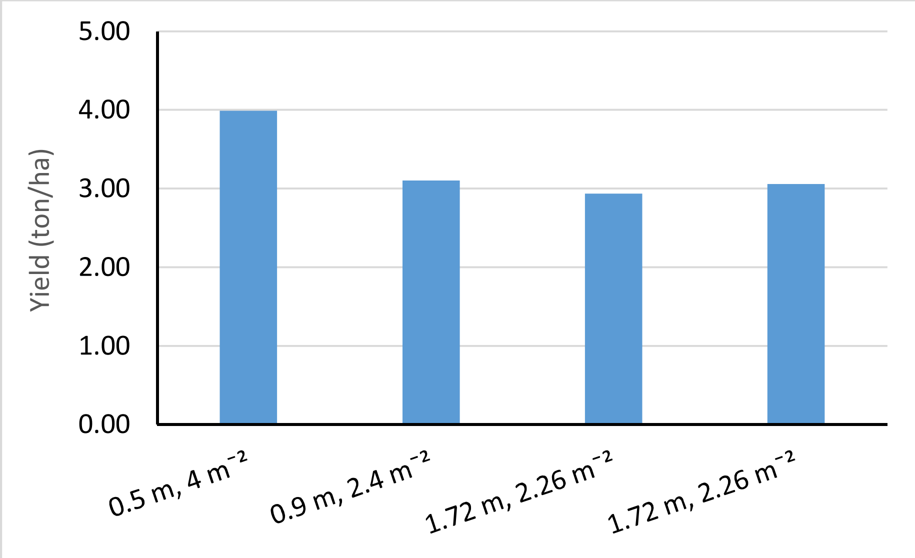


Fig 5.1 The yield of maize as affected by tillage, row width and population density (no-till, 0.52 spaced rows, 4.2 plants m^{-2}; no-till, 0.91 spaced rows, 2.2 plants m^{-2}; strip-till, 1.5 m spaced rows, 1.78 plants m^{-2}) on the farm of Jaco Bamberger in 2015/2016.

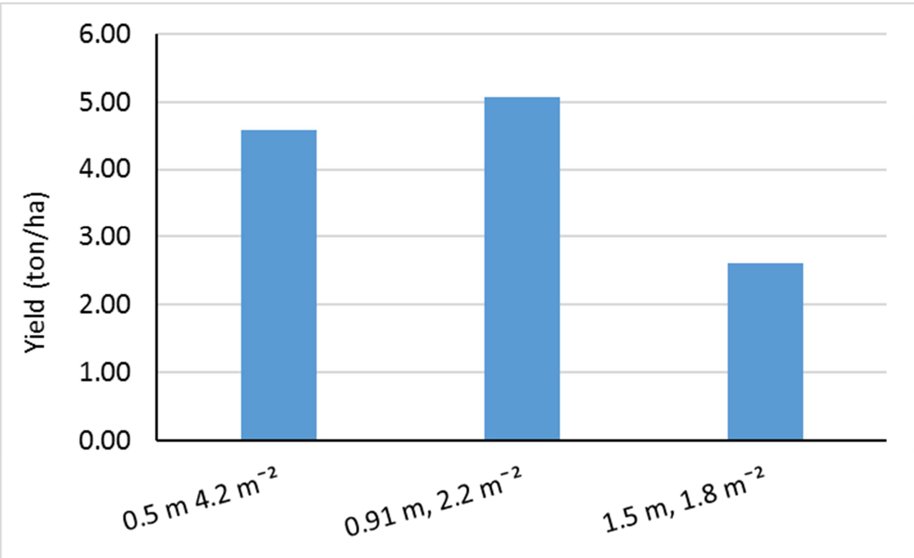


Fig 5.2 The yield of maize as affected by tillage, row width and population density (no-till, 0.52 spaced rows, 4.2 plants m-2; no-till, 0.91 spaced rows, 2.2 plants m-2; strip-till, 1.5 m spaced rows, 1.78 plants m-2) on the farm of Niël Rossouw in 2015/2016.

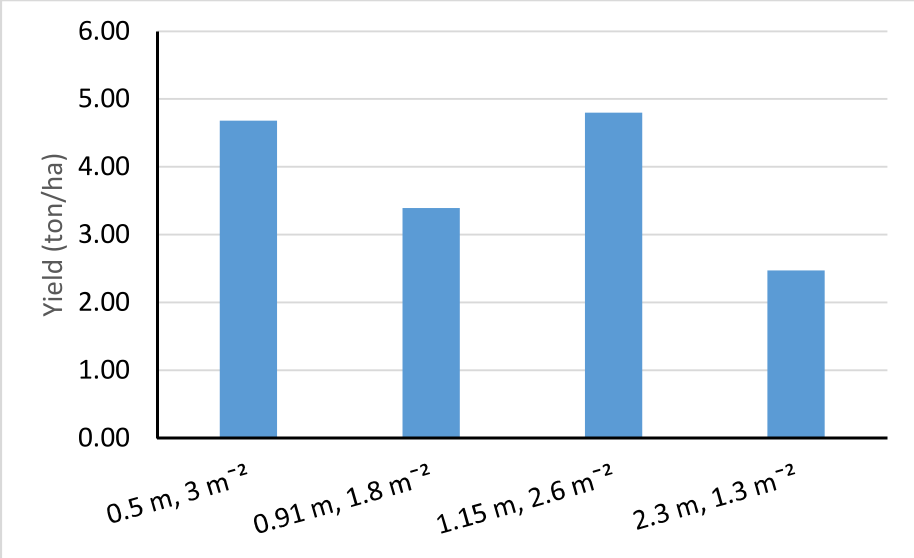


Fig 5.3 The yield of maize as affected by tillage, row width and population density (no-till, 0.52 spaced rows, 3.0 plants m-2; no-till, 0.91 spaced rows, 1.76 plants m-2; rip-on-every-second-row, 1.15 m spaced, 2.61 plants m-2; rip-on-row, 2.3 m spaced, 1.3 plants m-2 on the farm of Pieter van Vuuren in 2015/2016.

6. Optimum plant population of crops in conservation agriculture

Introduction

The plant population of crops remains an important aspect in optimising grain production. Theoretically, plant population determines the rate of soil moisture usage. If the plant population is relatively high and rainfall below normal, the risk of drought damage increases. If the plant population is too low, the available rainfall is under utilised. Accordingly, plant population should match the yield potential created by the rainfall. Rainfall varies from season to season and each season requires its own optimal plant population. Due to the unpredictability of rainfall, a suitable plant population for the long term yield potential should be used.

Depending on the yield potential, populations of 1.4 to 2.4 plants m^{-2} are currently used for maize, 3.0 to 4.0 plants m^{-2} for sunflower and 30.0 plants m^{-2} for soybeans. These populations have been determined through research and experience with conventional plough based crop systems. It is unknown if these populations should be adjusted for conservation agriculture systems.

Aim

The aim of this study is to get an indication if the variations in plant populations currently used, should be increased or decreased for conservation agriculture systems for maize, soybean sunflower and sorghum.

Procedures

Six no-till field trials with maize and one each with soybean and sorghum were done on three farms in 2013/2014. Two trials were done with sunflower in 2013/2014 and 2015/2016 respectively. Plant population densities varied from 1.5 to 4 m^{-2} in the various field trials for maize, from 15.5 to 30 m^{-2} for soybean, 6 to 12 m^{-2} for sorghum, and 3.5 to 5 m^{-2} for sunflower with row widths of either 0.76 or 0.91 m. Yields were measured on plots of 60 m^2. Quadratic curves ($Y = a + bX - cX^2$) were fitted to yield data from each trial to determine if yield were related to plant population density.

Results and Discussion

Maize responded well to plant population density in all six trials (Fig.s 6.1 to 6.6). With the exception of one trial, all response curves indicate that the optimum plant population density was above 3.0 m^{-2} in the 2013/2014 season. The optimum for one trial appear to be between 2.5 and 3.0 plants m^{-2}. The yield response varied from about 0.04 t ha^{-1} to 0.13 t ha^{-1} for a change of 0.1 plant m^{-2}.

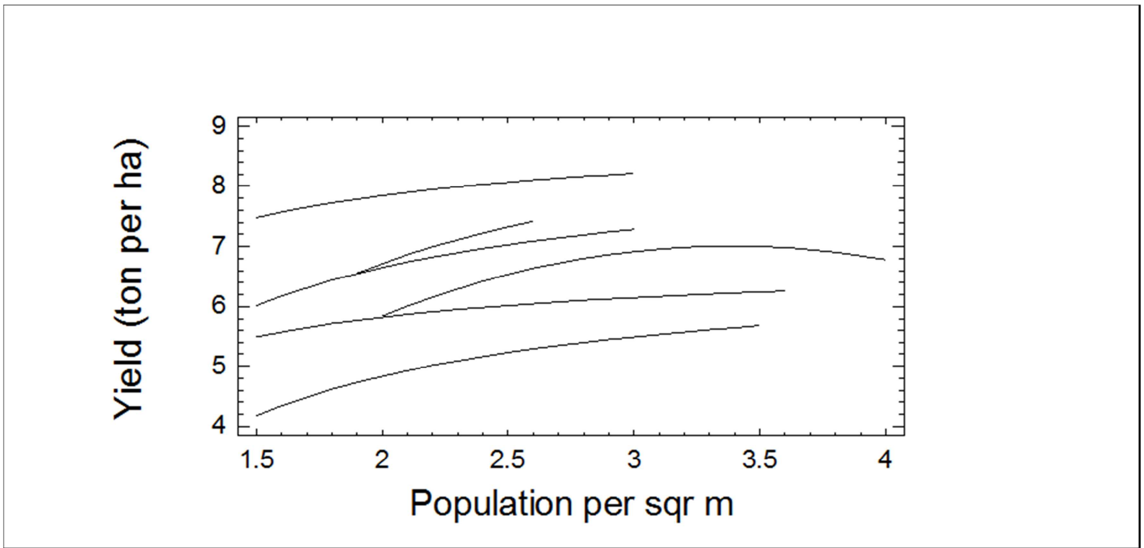


Fig. 6.1 No-till maize yield as related to plant population density in six field trials done in 2013/2014 with 0.76 and 0.91 m row widths.

Sunflower showed no response to plant population density in any of the two trials done. The response of the sunflower done in 2013/14 is shown in Fig. 6.2. Sorghum yield also showed no relation with plant population density as can be seen in Fig. 6.3 respectively. Soybean on the other hand, responded to density with an optimum higher than 300 000 plants per ha^{-1}. The response rate was approximately 3 kg ha^{-1} per 0.1 plants m^{-2}.

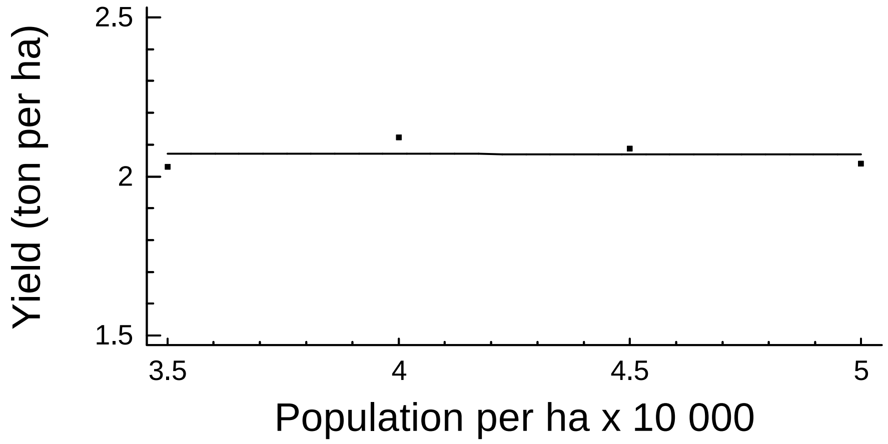


Fig. 6.2 Sunflower yield as related to plant population density in 2013/2014 with 0.76 and 0.91 m row widths.

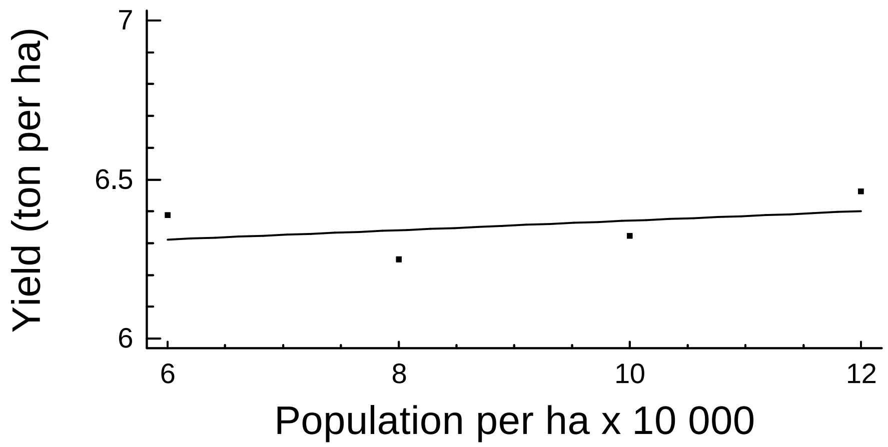


Fig. 6.3 Sorghum yield as related to plant population density.

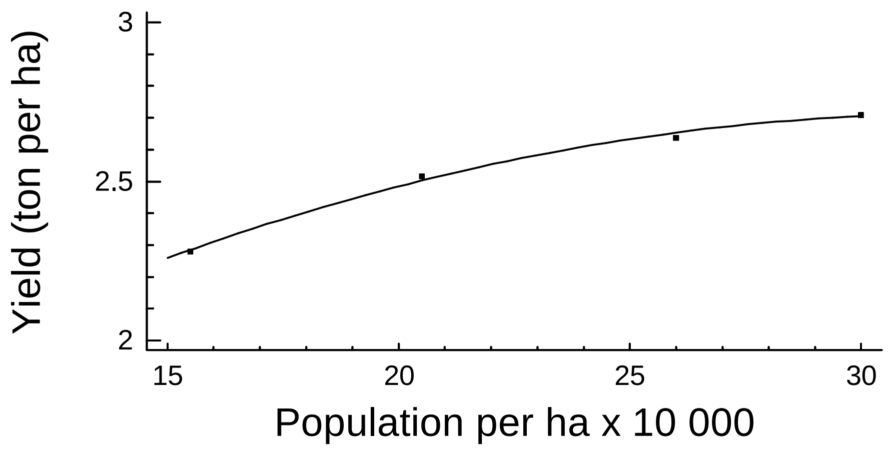


Fig. 6.4 Soybean yield as related to plant population density.

CONCLUSIONS

The 2013/2014 will be remembered for ample well distributed rain resulting in exceptionally high yields on some farms. In contrast, 2014/2015 and especially 2015/2016 will be remembered for drought and late plantings. Despite low yields in the latter two seasons, significant results were collected from which some conclusions could be made.

Results from the crop rotation trial indicate that the yields of maize, sorghum and soybean are affected by a rotation x season interaction. A preceding crop that enhances the yield of a particular crop in one season, may suppress it in a second season. Results from more seasons and replications are thus needed to determine which preceding crops have the highest probability for enhancing yields on which following crops.

Comparing the Argentinian practices, of narrow row widths and high plant population densities, with local wider rows and lower plant populations on the yield of maize, had a mixed outcome. In 53% of trials, yields of the two systems were similar while 27% favoured the Argentinian practices, while 20% favoured local practice. The yield of the 0.52 m row width sunflowers was constantly higher than the yield of 0.91 m row widths with a mean yield advantage of 0.13 t ha^{-1}. Soybean gave inconclusive results while the yield difference between the row widths for sorghum different with less than 2%.

The use of either tines or coulters, over three seasons had no effect on yields, while tines with a working depth of 240 mm, resulted in higher maize yields than tines with a working depth of 150 mm with normal or diamond fitted points.

Several maize cultivars were evaluated for yield. In 2013/2014 and 2014/2015, yield ranks of cultivars varied between localities, indicating the presence of a cultivar x locality interaction.

No-till in combination with a high plant population density, had equal or superior maize yields to that of conventional tillage with traditional wide rows and plant population densities. The yield advantage was up to 2.2 t ha^{-1}.

The optimal maize plant population density is above 3.0 plants m^{-2} as determined in 2013/2014. Sunflower and sorghum showed no response to plant population density. Soybean responded to density with an optimum higher than 30.0 plants m^{-2}.

6. 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 facilitator (Ottosdal No-till Club)
Involved partners	ARC-GCI, ARC-API, Grain SA

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 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. Lab Analyses 6. Monthly meetings (project team) 7. Annual reference group meeting (advisory committee) 8. Annual report and admin 9. 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

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY (September 2016)

Activities	**Deliverables**	**Progress and Results achieved**
1. Land preparation (10 visits)	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	Assisted to prepare land on 18 trials at 9 farmers' fields
2. Planting (10 visits)	Prepare planter for planting Move planter between farmers for timely planting Make sure farmers plant according to standard treatment specifications	Assisted to establish trials on 18 trials at 9 farmers' fields See list of trials in **Table 6.1** below.
3. Seasonal management (30 visits)	Assist farmers in weeding and pest/disease management	Completed seasonal activities for 2015-2016
4. Monitoring and Sampling	Assist farmers to complete field forms Assist to collect soil samples	Completed seasonal activities for 2015-2016

(Done with activity 3 above)	Monitor the farmer-led actions	
5. Lab Analyses	Assist with soil sampling	NA
6. Monthly meetings (project team) & Training (9 meetings)	Participate in monthly forum meetings, discussing problems and possible solutions to that.	Participated in 2 project meetings
7. Annual reference group meeting (advisory committee) (1 meeting)	Report progress and findings to advisory committee; Discussion and evaluation of data. Learning from each other.	Participate in meeting on 1 September 2016.
8. Annual report and admin (2 days)	Written report covering trial implementation, results and progress.	Participated in writing of annual report
9. Participate in Awareness events (2 days)	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits	CA conference in Ottosdal was cancelled. Participated in a green tour on 19 April.

Table 6.1: List of location and type of trials established in Ottosdal area, 2015/16 season

Trial Number:	**1**	**2**	**3**	**4**	**5**	**6**
Farmer co-worker:	**Plant pop (own planter)**	**Crop Rotation**	**Local vs Argentina**	**Tine vs Disc**	**Cultivars**	**Convens vs 90cm vs 50cm**
Hannes Otto	Sunflower		Maize			
			Sunflower			
George Steyn		√	Maize	√	√	
		+ Cover crops	Soya			
Philip v.d Berg		√ Weak				
Dirk Laas	Sunflower	v				
	Maize	Late planting			√	
Niel Rossouw						√

Piet v Vuuren						√
Jaco Bamberger						√
Koos Bezuidenhout	Sunflower Maize				√	
Tobie Martin						Striptill vs No-Till
Total Farmers	**5**	**3**	**2**	**1**	**3**	**4**

7. Summary of expenses on August 2016

Project Description	Total Actual YTD Aug16*	Total Budget YTD Sept16	Available to use
Ottosdal NW WP2 - Soil	72 156	88 300	16 144
Ottosdal NW WP3 - Cover crops	43 627	130 200	86 573
Ottosdal NW WP4 - Weeds	-	27 400	27 400
Ottosdal NW WP5 - Agronomy	-	56 960	56 960
Ottosdal NW WP6 - Grain SA	85 350	121 000	35 650
Ottosdal NW WP7 - Farmer facilitation	105 007	104 562	-445
Total	**306 139**	**528 422**	**222 283**

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