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 2016 TO SEPTEMBER 2017

Compiled by:
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September 2017

GRAIN SA
GRAAN SA

The Maize Trust

Ottosdal No-till Club

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1. Coordination and management

Work Package title	**Coordination and management**
Work Package period	October 2016 to September 2017

Lead partner	Ottosdal No-till Club (Mr Hannes Otto) 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 ***30 August 2017***. **Activity 4: Organise and Coordinate annual awareness event(s)** **Progress and Results achieved:** The annual Ottosdal CA conference was successfully held on 6 and 7 March 2017. Around 300 people attended the event. **Activity 5: Reporting.** All partners participates in the preparation of a six-monthly 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 has been done according to the The Maize Trust / CA-FIP guidelines. Work package managers were responsible for collating information and making a single work page report. The lead applicant has been 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 has been completed in September 2017.

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 2016 to September 2017

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: Attended the Grain SA CA working group meeting on the 22 February 2017; Presented a lecture on the observations in CA at the Ottosdal No Till Conference – 7 March 2017.
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 2017 -
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 on 27 February 2017 Conference held on the 6 -7 March 2017.

Summary of soil investigations on different farms done in 2016-2017 – individual reports will be made available from Grain SA or the Ottosdal No-till Club

Activities	**Deliverables or Milestones**	**Progress and Results achieved;** and/or **Problems and Milestones not achieved**
Owner: Piet van Vuuren Soil Investigations & Profile pits Area: Ottosdal	Final report in Aug with soil analysis.	Different root development was investigate between rows and also the differences between no till and rip
Owner: George Steyn Soil Investigations & Profile pits Farm: Humanskraal Area: Ottosdal	Final report in Aug with soil analysis.	Different root and cob development was investigate on 40 000 and 20 000 population
Owner: Hannes Otto Soil Investigations & Profile pits Farm: Droekraal Area: Ottosdal	Final report in Aug with soil analysis.	
Owner: Gert van Rensburg Soil Investigations & Profile pits Farm: Soetendal Area: Scheizer Reneke		
Owner: Tielman Niewoudt Soil Investigations & Profile pits Farm: Kameelpan Area: Scheizer Reneke	Final report in Aug with soil analysis.	Also high sandy soils in the Schweizer region but planted with a coulter.
Owner:Pieter Breedt Soil Investigations & Profile pits Farm: Area: Rostrataville	Final report in Aug with soil analysis.	*The trail was to look at the root development on different soil types.

3. Assessment of cover crop adaptability and suitability

3.1. WORK PACKAGE

Work Package title	**Assessment of cover crop adaptability and suitability** **Crop and Livestock integration**

Work Package period	October 2016 to September 2017
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 • Planting of cocktails that can be used as livestock feed or soil primers • Planting of cash crops on primed soil • Monitor and determine crop yield on mixtures • Established new cocktails from seed companies • Establish intercropping trial on sunflowers

Description of work	**On-farm, farmer-led screening trials; crop livestock integration; double cropping with Sunflower; cooperation with seed company and the priming of tried soils. Building a sustainable farming system for the North West province**

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.)

3.2. DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

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 with the farmer co-workers, a suitable site was identified for a new regenerative agriculture trial. • Previously used as a no-till production field but abandoned due to low productivity • 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 and soil restoration through multi-specie cover crop systems. Sunflower intercropping was done on field that was no sprayed with Clearfield products
2. Purchase Materials & Equipment	Acquisition of seed, inoculum, stickers, implements, chemical inputs.	Warm season cover crop seed was delivered to farmers after purchasing it from Barenbrug. Additional seed for extended area (mixture) was made available to farmers. Winter annual seed was delivered early February for screening trial and extended areas. Seed for the sunflower trial was also purchase for planting. Three additional farmers received seed to plant summer annuals (5ha). Rhizobium was supplied with the seed.
3. Establishing	Drawing up a field plan.	The screening trial was planted

and Planting of trials	Establish screening trial December. Established trial according to the field plan. Extended summer annuals area for soil priming and livestock integration was planted. Sunflower trial design was drawn up and trial was established early February. Extended winter plantings and screening trial established 28/2/17.	early December. December planting of cash crops in regenerative trial also took place and seed from seed companies was planted in 1ha plots. The livestock integration and regenerative trial was planted on the 9/12/17. Sunflower trial planted on 2/2/17.
4. Seasonal management and maintenance of trials	Regular visits to the trial site for inspection of weeds and insect damage and control if needed. 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.	Discussed trials with farmers and deliver seed. 17/1/17 - Visited sunflower farmer and discussed possible use of CC for residue management. 2/2/17 - Planted sunflower trial Photos was taken with every visit of the trials. Trials were harvested and DM determined
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:	The amount of trials has tripled, including monitoring. PPRI personnel were tasked to do soil health measurements at the screening trial. Height and biomass were determined All trials were harvested and data gathered. Interpretation and statistical analyses needs to be performed.
6. Lab Analyses	C:N content of plant material.	Will be forthcoming.
7. Monthly meetings (project team) & Training	Partake in monthly forum meetings, discussing problems and possible solutions to that.	13-14/10/17 - Meeting at Ottosdal steering com. 3-4/1/17 - Video CA of farmers Attend meeting and visit farmers on the 12/1/17. CA Conference 6&7 March. CA working group meeting February (presentation). Presenting at a report back meeting. Planning meeting scheduled for September 26
8. Annual	Report progress and findings to	Was held on 30 Aug 2017.

reference group meeting (advisory committee)	advisory committee. Discussion and evaluation of trials. Learning from previous mistakes.	Due to a symposium opportunity a WUE article was written and will be presented in September.
9. Annual report and admin (production & technical data)	Written technical report covering trial procedures, results and progress.	On-going process. Annual technical report completed by 3/17. Technical report submitted in September 2017 (see below)
10. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits	Enquiries around CC are expanding. Contribute to the video "Shepherds of the soil" Wrote articles (2) July Grain SA magazine Article in "landbouweekblab. Article on WUE "SOILBORNE PLANT DISEASES SYMPOSIUM" Partake in farmer's day event by manning a discussion point of CC Report back to farmer's end August

3.3 JUSTIFICATION

In the six-monthly report (March 2017) an effort was made to emphasize the critical role of organic material in soil forming processes. The impact on the physical, chemical and biological soil environment is discussed and the roll that active carbon (labile) or freshly added cover crop residues play were highlighted. Building stabile soil aggregates improve not only porosity but also contribute to a healthy root system. In the June 2017 Grain SA magazine two articles were published that included a theoretical role of cover crops on fertilizing cash crops as well as an in depth case study of the regenerative potential in degraded soil at Ottosdal. The positive impact on water use efficiency was demonstrated in 2016 when on average treatments in the cover crop screening trial produced in excess of 5 t/ha of maize under drought condition with a mere 350mm of effective rainfall during the growing season. Most farmers could manage about 1,5 t/ha under no-till conditions. The availability of soil moisture is seen as the most limiting factor of crop production in North West.

3.4 RESULTS ACHIEVED

Al the trials were harvested and dry Matter (DM) for the different treatments were calculated.

1. Screening trial
2. Infiltration trial
3. Seed company collaboration trial
4. Regenerative trial
5. Sunflower intercropping trial

A short summary of the results of the screening trial is presented for the 2016-17 season.

3.4.1 Maize early planting (on various cover crop treatments)

Plate 3.1: Maize early planting

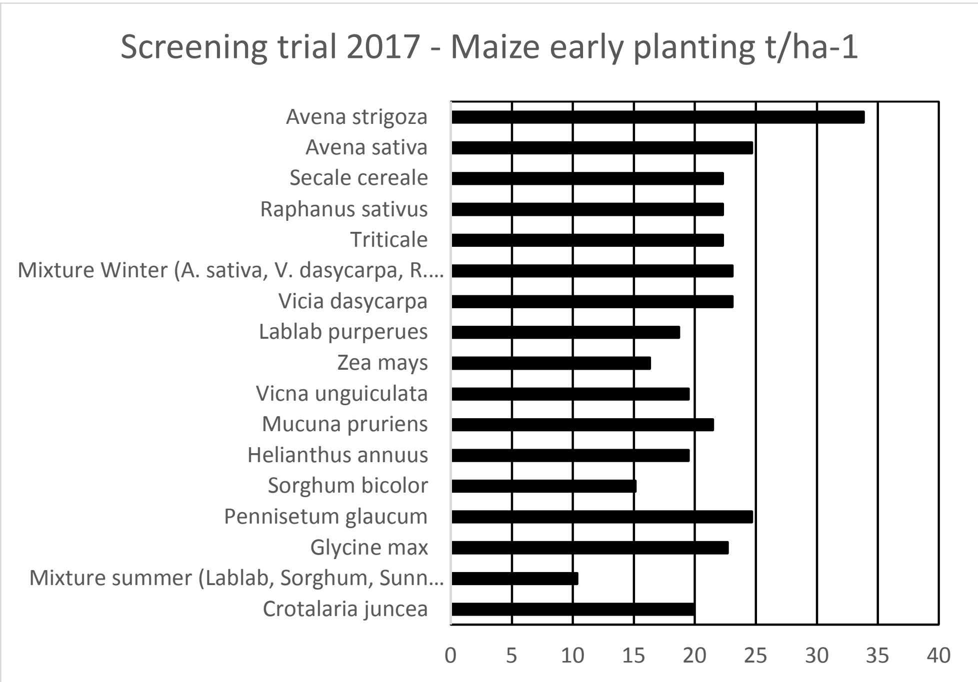


Figure 3.1: Early planted maize biomass performance on different treatments

Discussion: Biomass production trends seem to be higher on winter cover crops. This is unexpected because plant available moisture in this crops are usually close to zero.

3.4.2 Maize late planting

Plate 3.2: Maize late planting

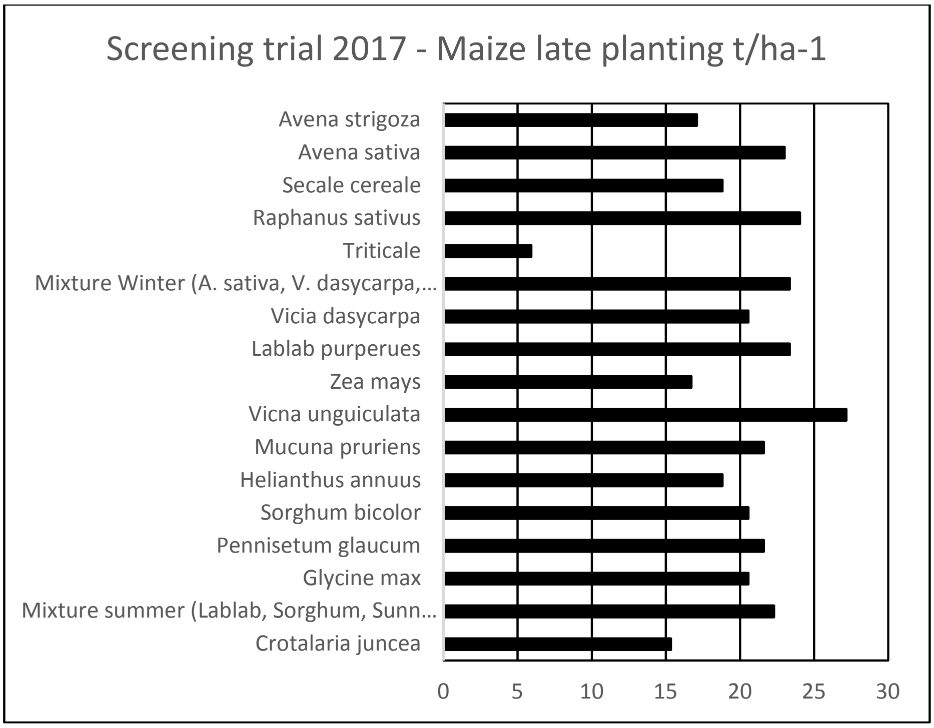


Figure 3.2: Late planted maize biomass performance on different treatments

Discussion: Triticale geminate from seed and interfered with the maize development. Taken into account that the harvesting index for maize is around 50% high yield realized.

3.4.3 Sunflower early planting

Plate 3.3: Sunflower early planting

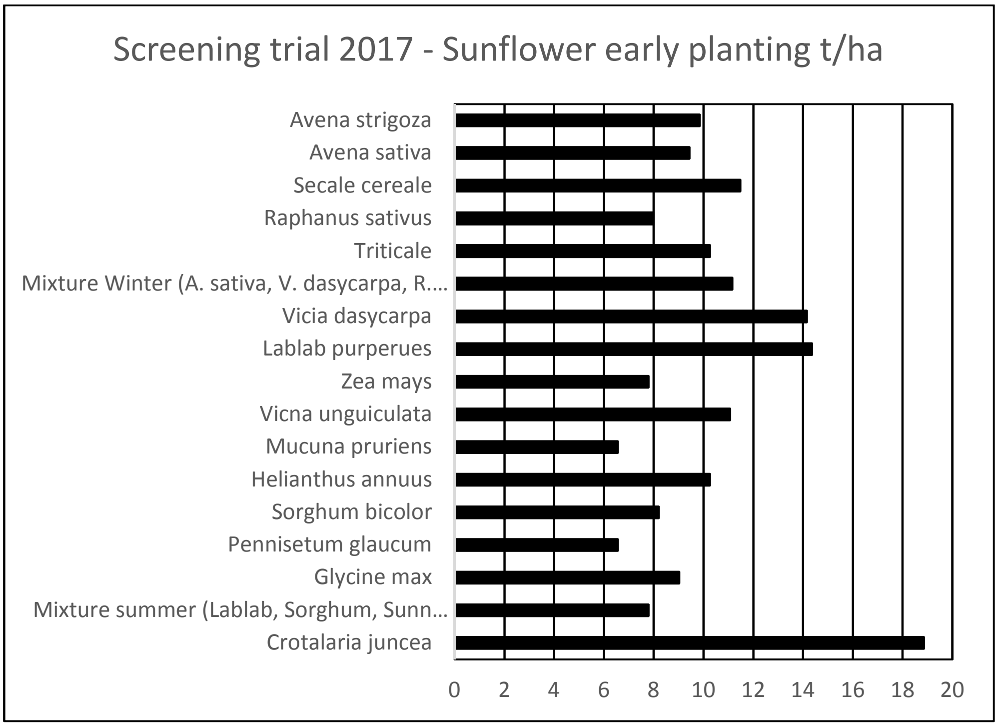


Figure 3.3: Early planted sunflower biomass performance on different treatments

Discussion: Early plantings seems to do well after legumes such as Lablab, Vetch and Crotalaria.

3.4.4 Sunflower late planting

Plate 3.4: Sunflower late planting

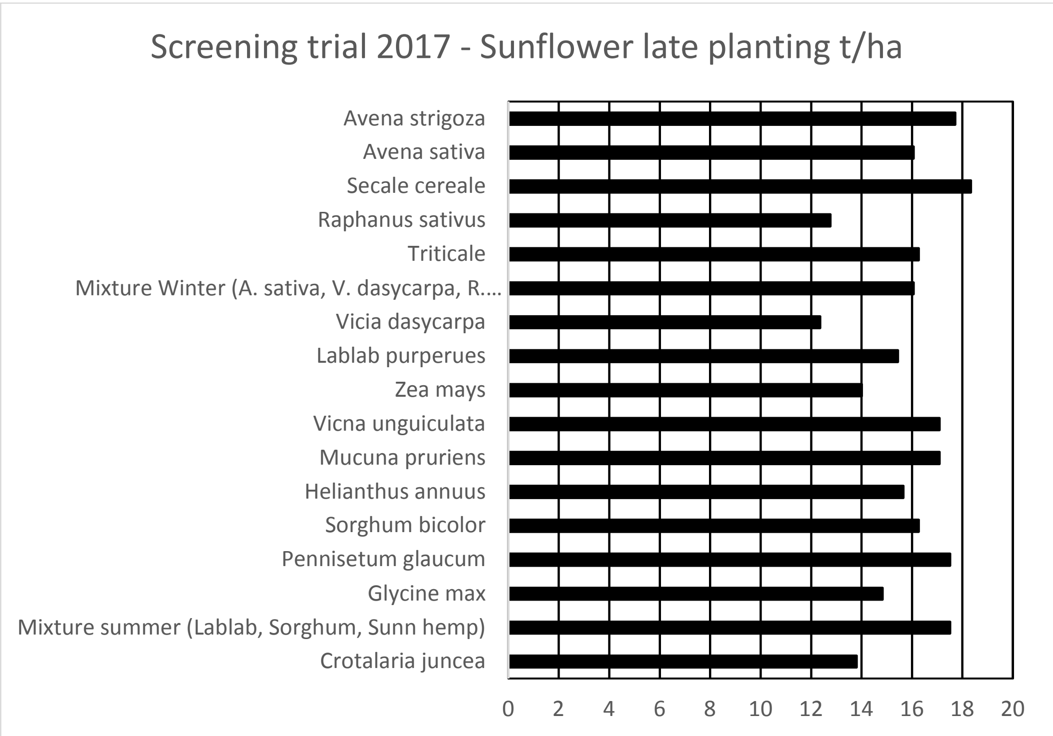


Figure 3.4: Late planted sunflowers biomass performance on different treatments

Discussion: Later planting of sunflower overall look better than early planting. Seems that moisture to secure a good stand is important for good germination of the crop. Less pest and diseases was also notice.

3.4.5 Soybean planting

Plate 3.5: Soybeans

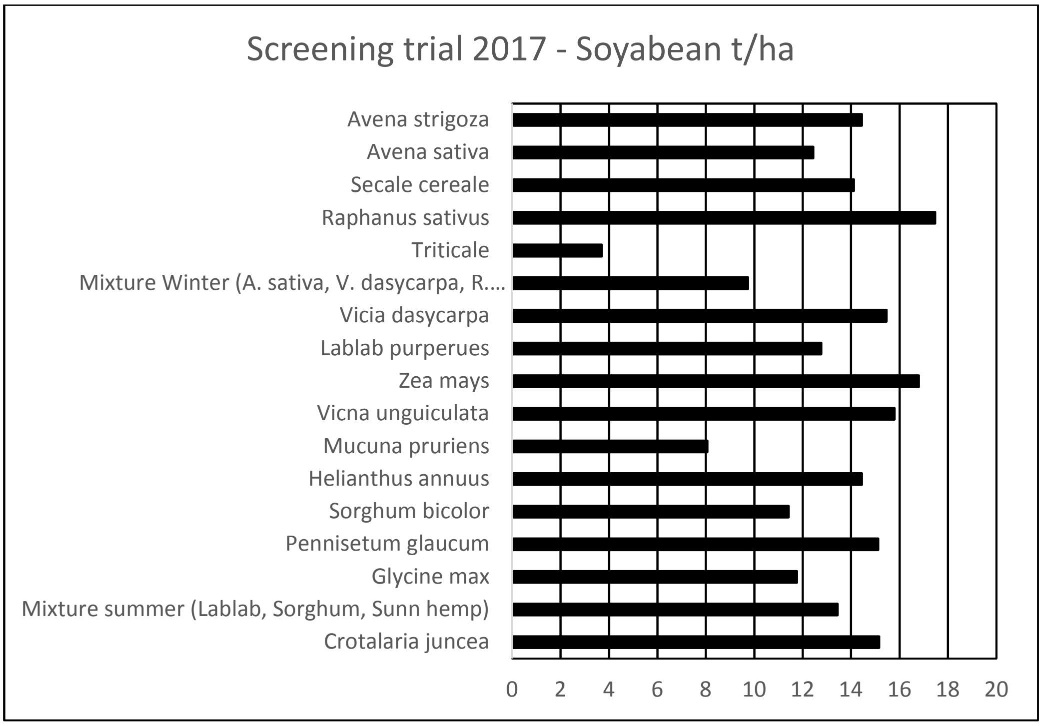


Figure 3.5: Soybean biomass performance on different treatments

Discussion: Biomass production for Soybeans seems to perform well after maize and babala, while high production also realized in rotation with legume crops such as cowpeas and grazing vetch.

3.4.6 Grain sorghum

Plate 3.6: Grain sorghum

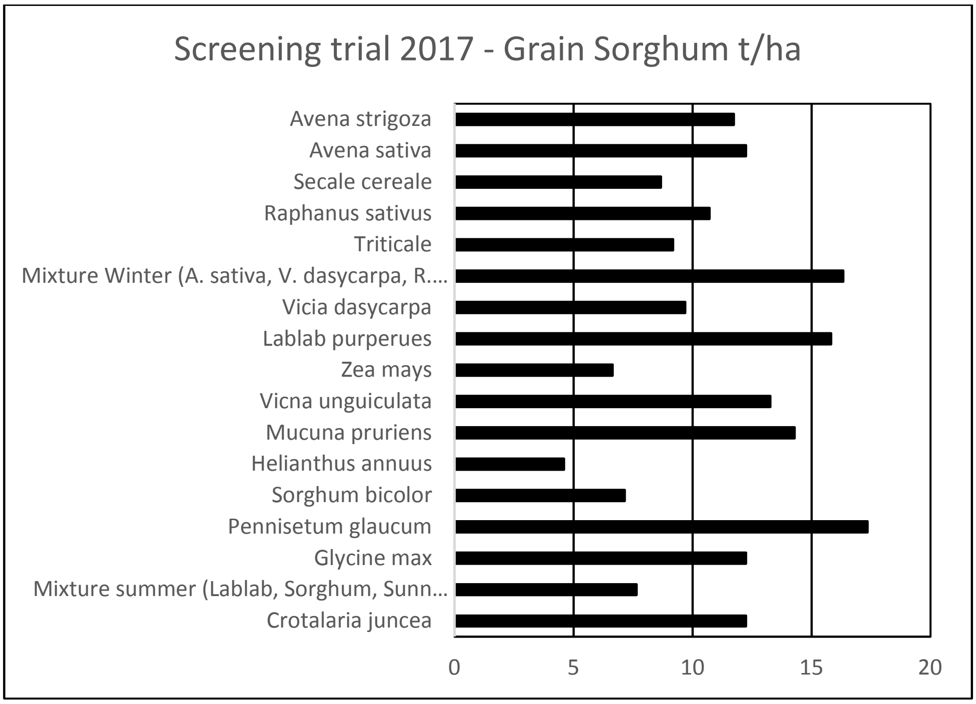


Figure 3.6: Grain sorghum biomass performance on different treatments

Discussion: Grain sorghums biomass is high after babala, legumes (cowpea, Velvetbean and lablab) and winter mixture.

3.4.6.1 Grain production summary from cash crops

Table 3.1: Yield production of cash crops on screening trial at Ottosdal, 2016/2017 season

Treatments	Grain Sorghum	S/flower early	S/flower late	Maize early	Maize late	Soya beans
Crotalaria juncea	3,13	2,32	2,48	7,7	9,73	2,74
Mixture summer	3,07	1,91	2,98	8,7	10,57	2,5
Glycine max	2,39	2,38	2,91	7,48	9,89	2,44
Pennisetum glaucum	3,2	1,58	2,48	7,26	9,3	3
Sorghum bicolor	2,78	2,63	2,51	7,78	7,69	2,61
Helianthus annuus	2,52	1,79	2,66	7,95	9,28	2,21
Mucuna pruriens	3,15	2	2,79	8,98	10,65	2,61
Vicna unguiculata	2,57	2,69	2,3	6,35	8,83	2,8
Zea mays	2,92	2,15	2,89	6,26	7,31	2,64
Lablab purperues	2,87	2,68	2,33	8,93	10,52	2,85
Vicia dasycarpa	1,99	2,73	2,62	6,15	10,08	2,41
Mixture Winter	2,33	2,52	2,83	8,53	8,86	2,27
Triticale	2,36	2,35	2,86	7,74	6,12	0,37
Raphanus sativus	1,78	2,6	2,48	8,87	8,3	2,33
Secale cereale	2,29	1,89	2,41	9,53	8,98	2,37
Avena sativa	3,32	1,55	2,99	7,45	8,37	2,29
Avena strigoza	2,92	2,14	2,62	8,96	6,81	2,37

Discussion: Piet Kriel, technical assistant and farmer facilitator of the Ottosdal CA FIP project, harvested the different treatments containing cash crops for us. Later plantings of maize and sunflower seems to outperform the earlier plantings. Recharge of soil moisture in the top soil layer is of great importance for establishing a good vibrant seedling. Farmers will benefit by incorporating response farming principals into their decision making process.

Soybeans seems to do well if good rain occurs during the season. Rotation with babala had the highest yields of the treatments. This also seems to be the case at Accent near Verde.

Grain sorghums as a whole was disappointing and yield are not impressive. In drought years it outperforms Soybeans.

3.4.7 Cowpea

Plate 3.7: Cowpea

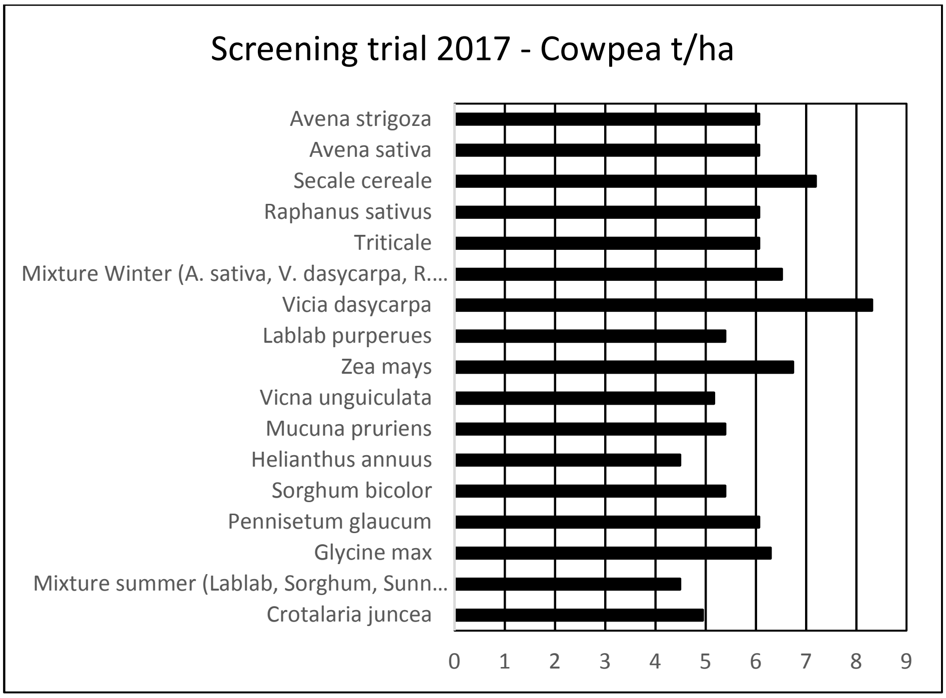


Figure 3.7: Cowpea biomass DM on different treatments

Discussion: Cowpea yield on winter cover crops tends to be higher than on the summer annuals. As mentioned before, this seems strange given the low moisture contend after winter cover crops as measured by NWK the previous season. This is difficult to explain, but it could be the presence of live roots during the winter that increased the microbial communities and populations, which after rewetting (rain), the winter C3 crops was decomposed (mineralised) quickly releasing nutrients to the Cowpeas. Rainfall was also used more effectively with probably no run-off from those fields.

3.4.8 Lablab

Plate 3.8: Lablab

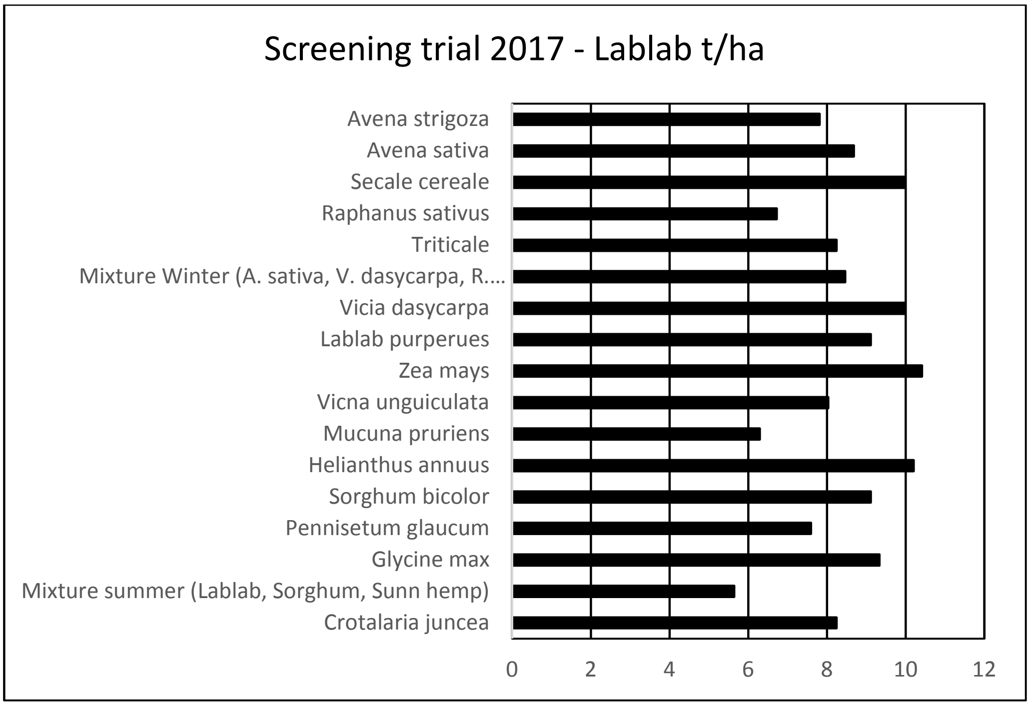


Figure10: Lablab biomass DM on different treatments

Discussion: Lablab yielded on al treatments satisfactory. This was after spray drift from herbicide nearly killed the crop early in the season. The recovery was remarkable. This legume has the ability to produce more than 200 kg of organic N in biomass.

3.4.9 Velvetbean

Plate 3.9: Velvetbean

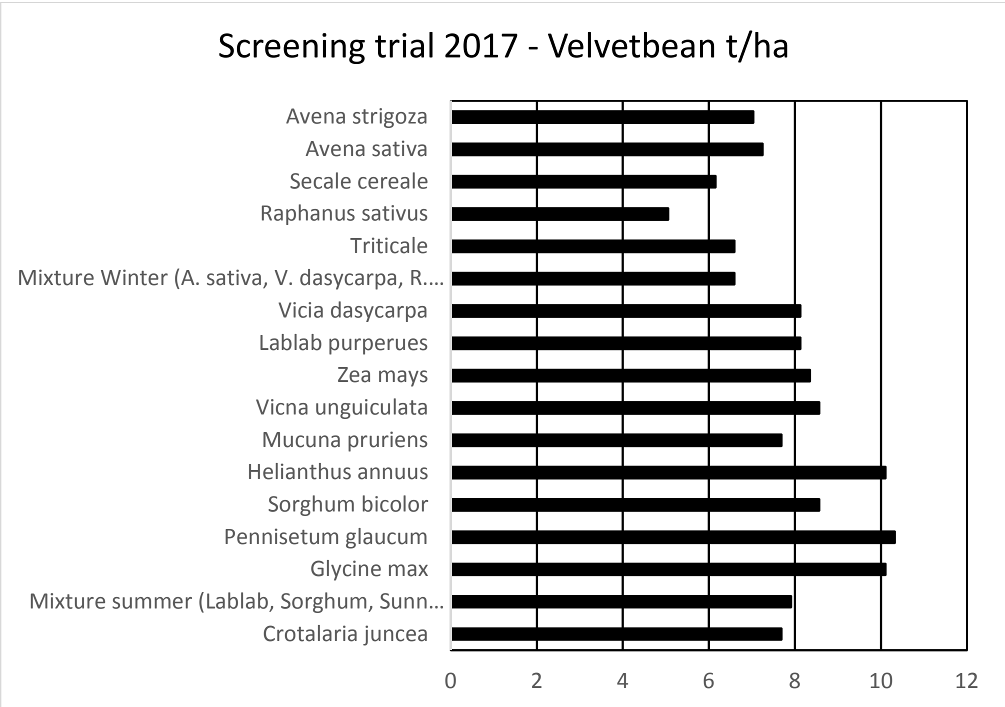


Figure 3.9: Velvetbean biomass DM on different treatments

Discussion: Like Lablab, this is a crop that has the ability to produce biomass in excess of 10 t/ha. Different to cowpeas, there is a definite trend of producing more biomass after summer annuals.

3.4.10 Sunnhemp

Plate 3.10: Sunnhemp

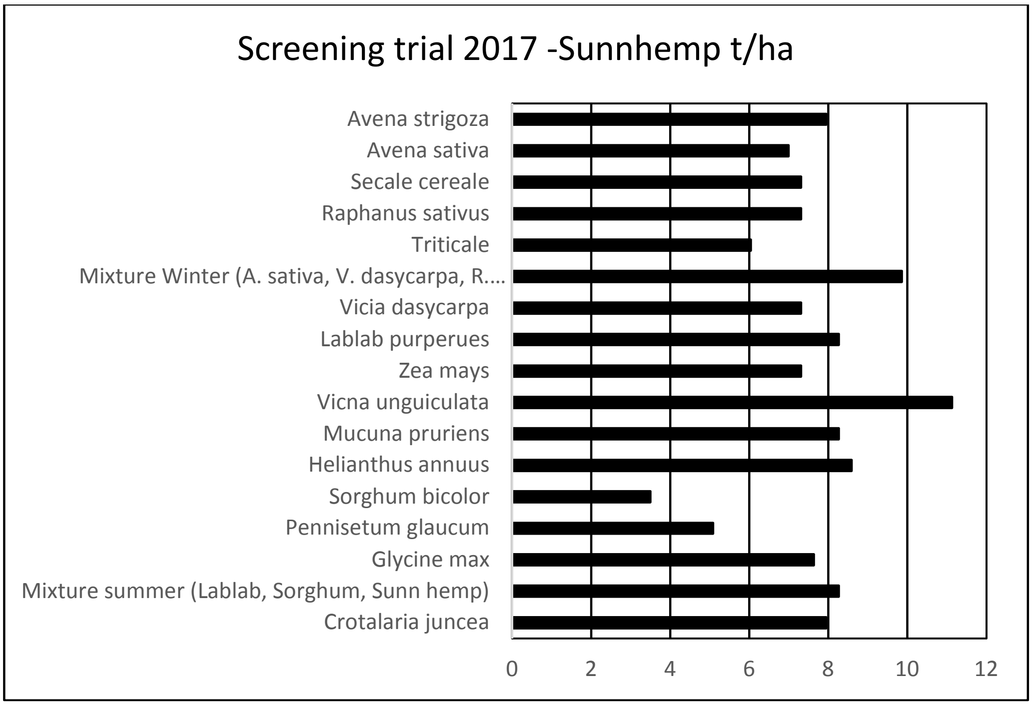


Figure 3.10: Sunnhemp biomass DM on different treatments

Discussion: This crop has small leaves and a woody stem. Leaves decompose quickly but stems will leave a good cover. This is a crop that is not suitable for grazing, except for the cultivar Tropic Sun, which seems to handle grazing well. It does not produce that well after sorghum and babala.

3.4.11 Guarbean

Plate 3.11: Gaurbean

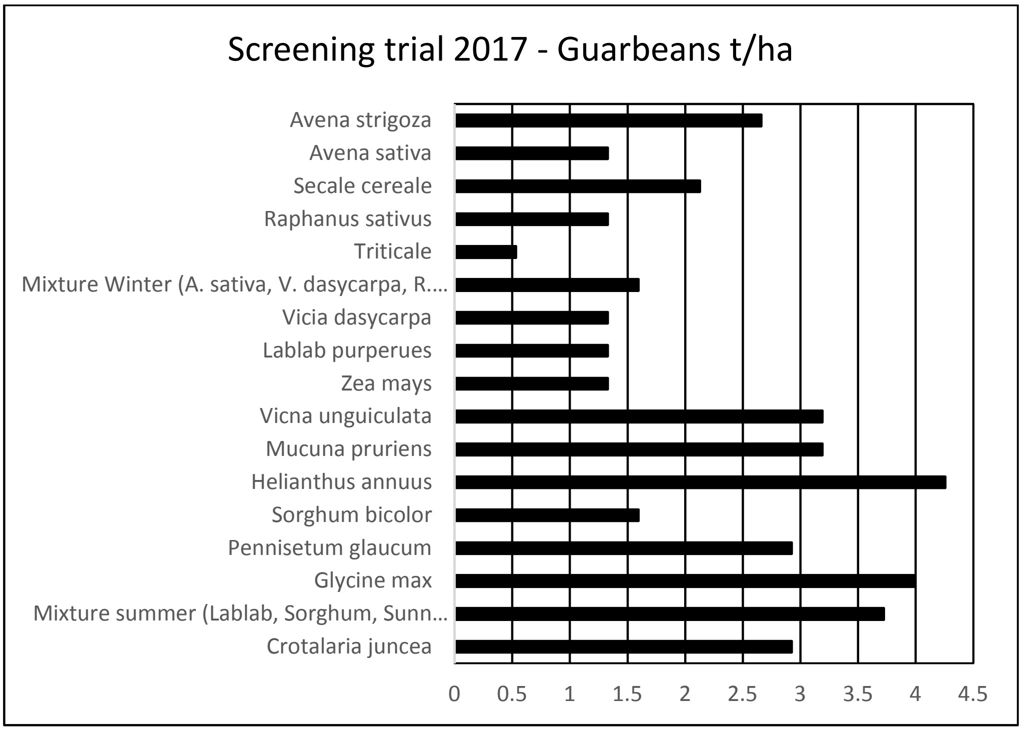


Figure 3.11: Gaurbean biomass DM on different treatments

Discussion: This is a crop that is used in the mining business (fracking) as a glue. It did not do well at all and seems to do better after summer annuals. It might be a crop to consider planting as an intercrop with sunflower.

3.4.12 Babala

Plate 3.12: Babala

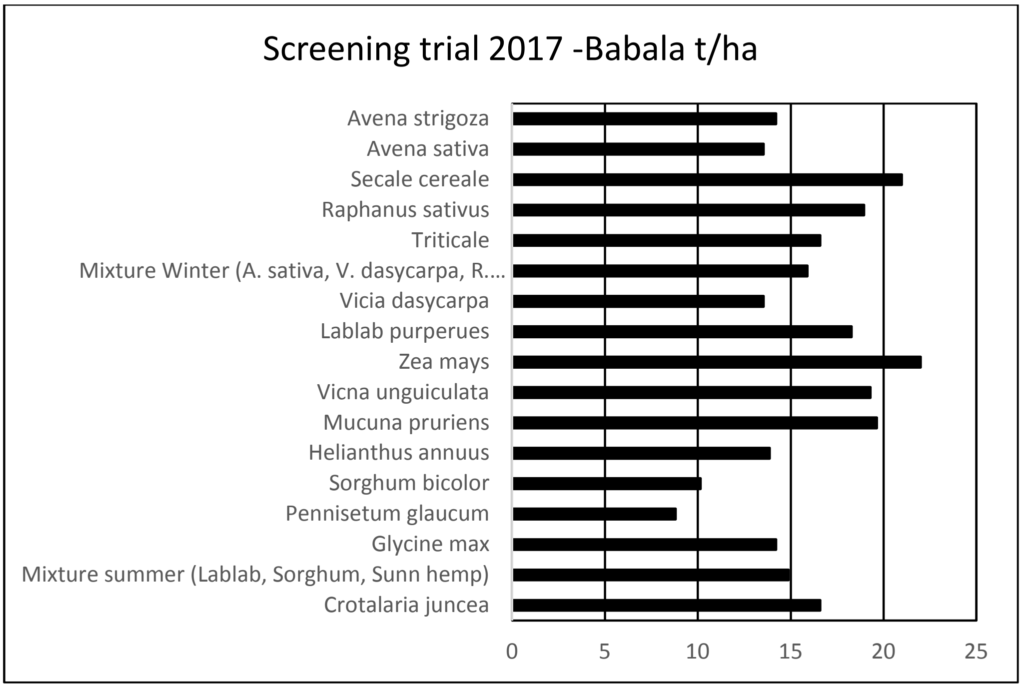


Figure 3.12: Babala biomass DM on different treatments

Discussion: This is an ancient crop that has not been tampered by too much through breeding. It produced a lot of biomass with a high content of lignin. It covers the soil well and produce good grazing material. Animals will consume the leaves but the stems will remain.

3.4.13 Summer mix

Plate 3.13: Summer mixture

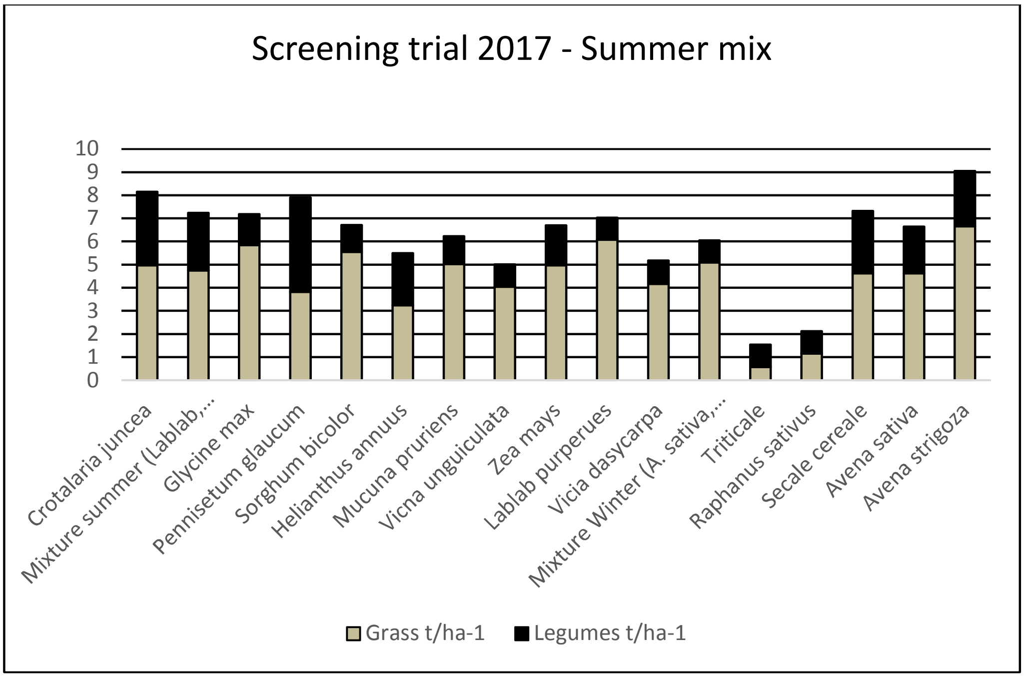


Figure 3.13: Summer mixture biomass DM on different treatments

Discussion: This system is not always easy to establish. It provides the farmer with biodiversity and protects the soil surface well. It produced high amounts of biomass. The inclusion of the winter crops rye and radish had a negative influence on production.

3.4.14 Triticale

Plate 3.14: Triticale

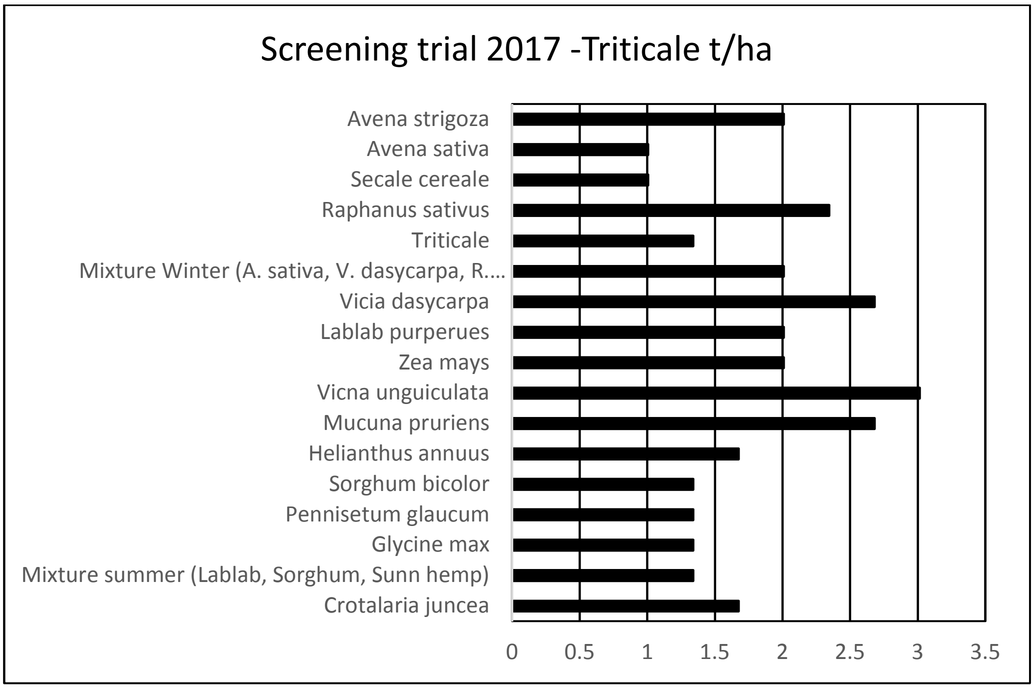


Figure 3.14: Triticale biomass DM on different treatments

Discussion: The winter annuals were planted late, because of the unavailability of a suitable planter (the borrowed planter was sold by the owner). Triticale at harvesting was not looking good. As an annual grass it seems to do well on treatments of crops that can biologically fix N or scavenge N after planting.

3.4.15 Winter mix (A*. sativa, V. dasycarpa, R. sativum*)

Plate 3.15: Winter mixture

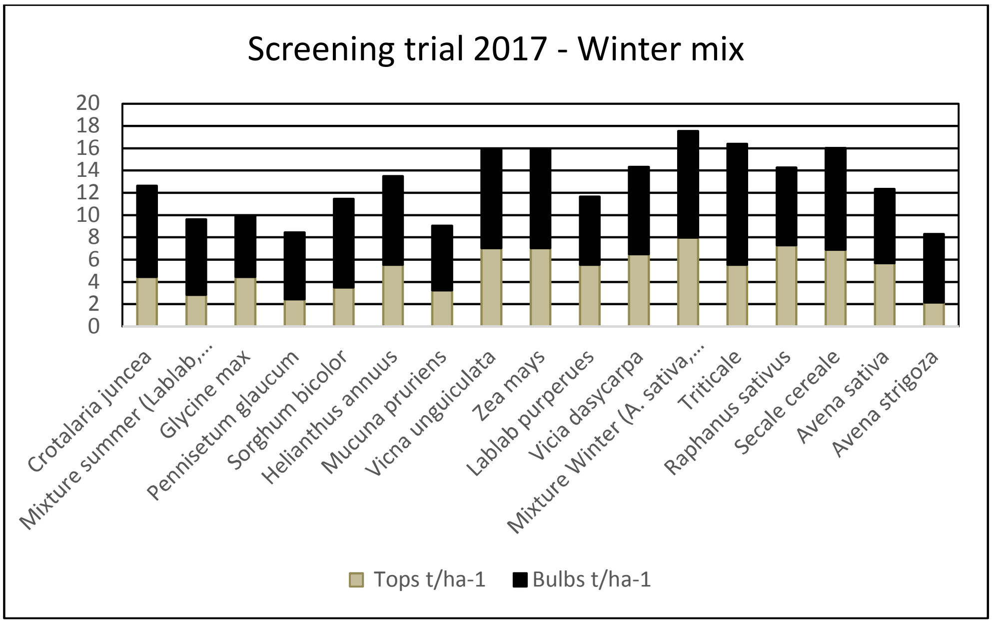


Figure 3.15: Winter mixture biomass DM on different treatments

Discussion: This system produced exceptionally well. Radish contributed a lot of biomass. Soil fungi numbers declined in the presents of radish due to the fumigation effect. It is good for compacted soil due to a taproot system. It scavenge N that can be lost due to leaching and volatilization.

3.4.16 Radish

Plate 3.16: Radish

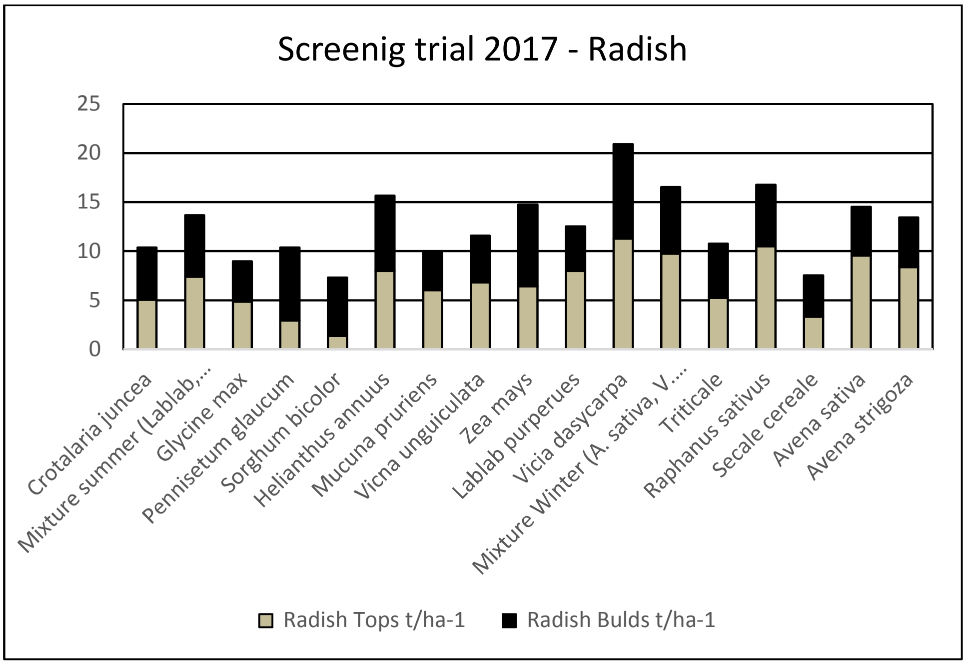


Figure 3.16: Radish biomass DM on different treatments

Discussion: As already mentioned, it is not the best crop when considering soil fungi propagation. It produced large root channels (holes) in the soil that will improve infiltration (prevent runoff) when decomposing. The taproot system can alleviate compaction and scavenge for N very effectively. It has a good grazing potential when integration is envisage.

3.4.17 Rye

Plate 3.17: Rye

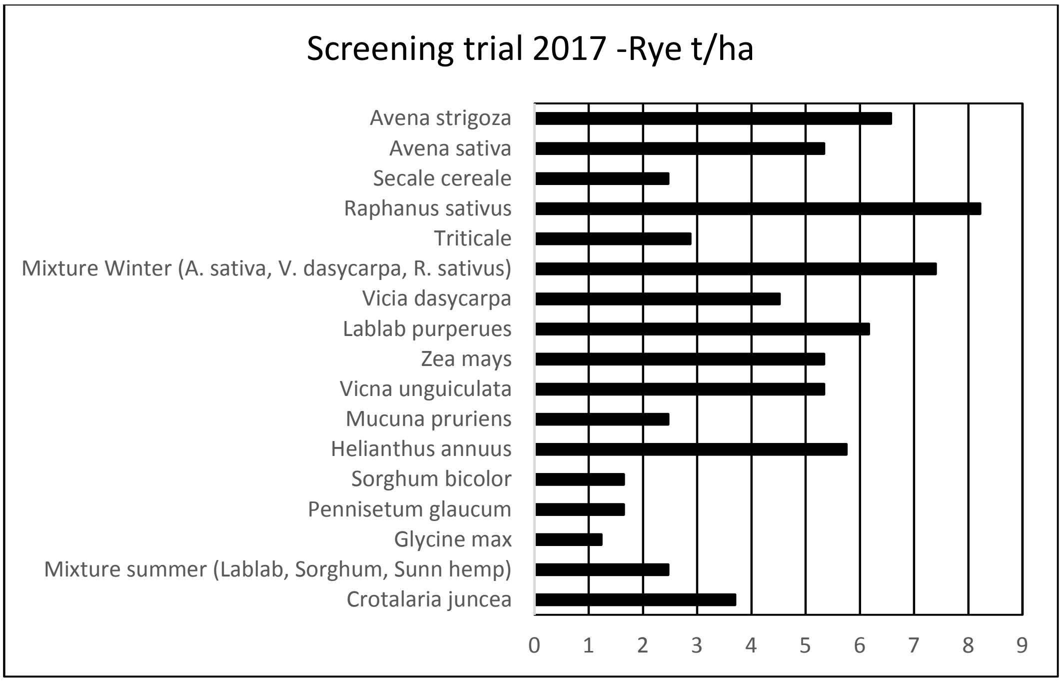


Figure 3.19: Rye biomass DM on different treatments

Discussion: Water harvesting after winter cover crops do have a positive effect on yield. Water that is stored during the early rains positively influenced the corp. It produced well and can contribute to the protection of the soil surface. It has the highest C:N ratio of the winter CCs and can immobilize N at the start of the growing season. It can also be grazed by animals.

3.4.18 Oats

Plate 3.18: Oats

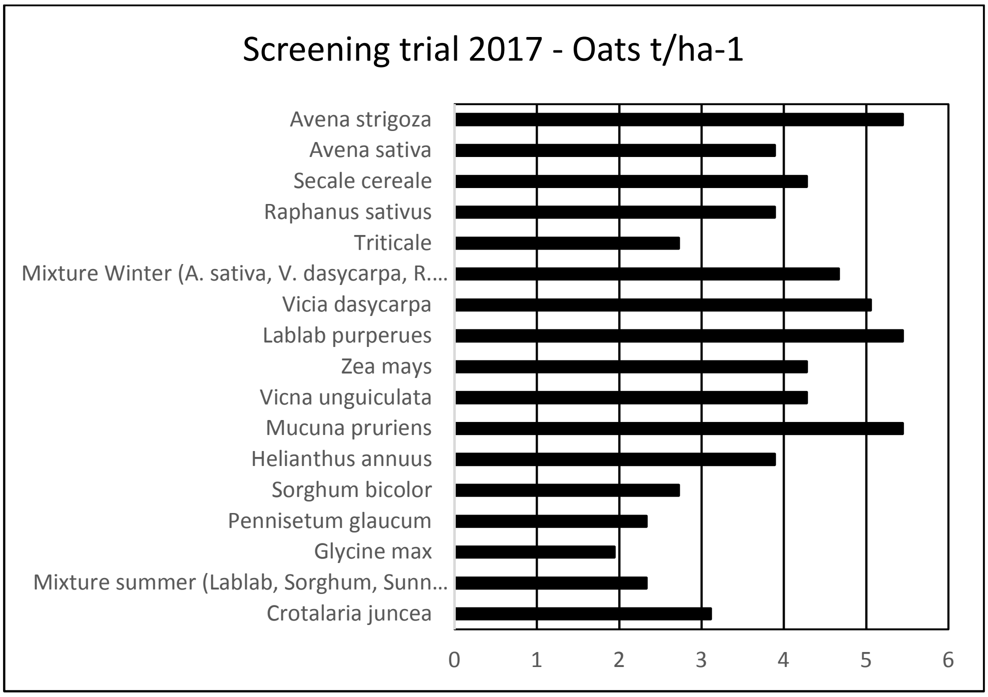


Figure 3.18: Oats biomass DM on different treatments

Discussion: Oats is highly palatable and can induce good animal gains. This is a crop that will not disappoint the producer. It does well in mixtures with radish (>0.5 kg/ha) and hairy vetch. It produced well on stored moisture. It does well after legume crops such as soy beans when planted after the main crop is harvested and moisture is expected. Seed is fairly cheap.

3.4.19 Hairy vetch

Plate 3.19: Hairy vetch

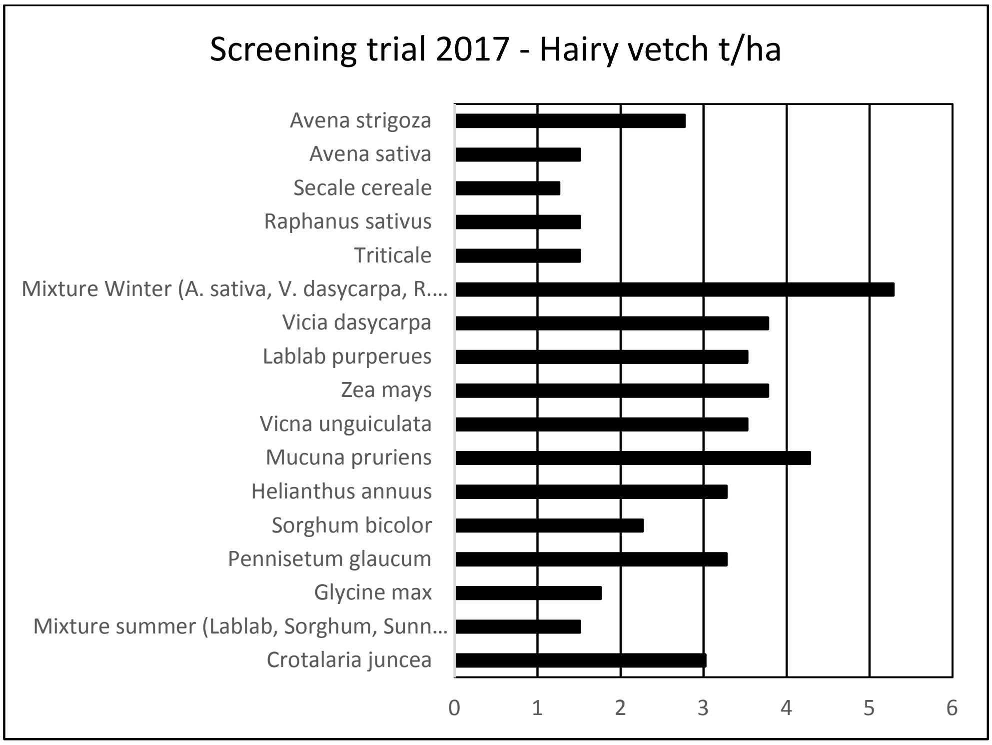


Figure 3.19: Hairy vetch biomass DM on different treatments

Discussion: This is a winter annual legume with less dormant seed than grazing vetch. It produces well after summer annuals and is less dependent on stored moisture. It contributes substantial N to the system through BNF. It is not very palatable, but will contribute to the protein needs of grazing animals. It has the ability to regrow from seed.

3.1.20 Black oats

Plate 3.20: Black oats

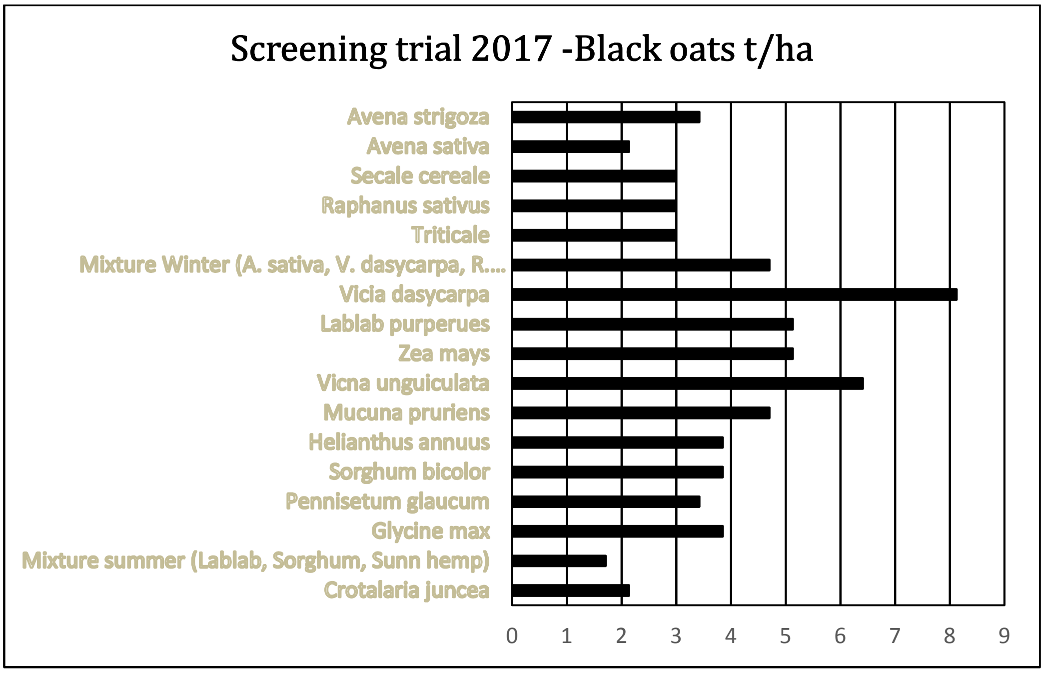


Figure 3.20: Black oats biomass DM on different treatments

Discussion: Black oats compares well with rye. It produced well and will not disappoint. It can be planted in a mixture or as a pure stand. It is less palatable than Oats but is the preferred crop for many farmers. Produces well after crops that contributed organic N through BNF.

3.5 INFILTRATION TESTS

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

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

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

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

Figure 3.21. Infiltration test being performed

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

Conservation practices that lead to poor infiltration include:

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

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

Long-term solutions for maintaining or improving infiltration include practices that increase soil organic matter and aggregation, and reduce soil disturbance and compaction. High residue crops, such as sorghum and small grains, perennial sod, and cover crops protect the soil surface from erosion and increase soil organic matter when reduced tillage methods that maintain surface cover are used to plant the following crop. Application of animal manure also helps to increase soil organic matter. Increased organic matter results in increased aggregation and improved soil structure leading to improved infiltration rates. Reduced tillage, reduced soil disturbance, and reducing the number of trips across a field necessary to produce a crop help leave continuous pore spaces intact and minimize the opportunity for soil compaction.

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

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

3.5.1 Measuring infiltration

The following material is needed to measure infiltration as shown in Figure 3.21:

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

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

Line ring with plastic wrap:

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

Add water:

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

Remove wrap and record time:

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

An infiltration rate of 28 mm under 3 minutes (180 seconds) will be regarded as rapid infiltration. In a CA system the infiltration rate will be influenced by compaction, texture, aggregate stability and moisture content of the soil. Figure 3.22 shows the infiltration rates taken on the various treatments in the screening trial at Ottosdal on 5 to 7 April 2017.

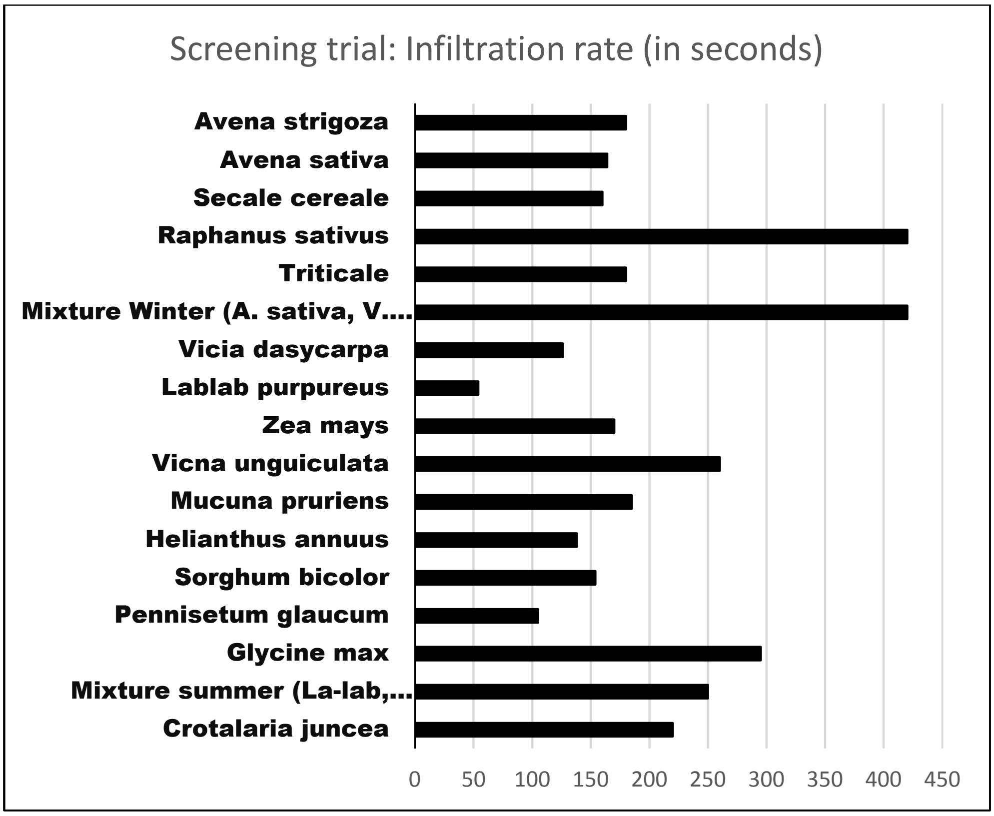


Figure 3.22: Infiltration time in seconds for different treatments at Ottosdal, April 2017

Discussion: Low values (in seconds) for crops such as Babala and Lablab indicate high infiltration rates and a positive influence of these crops on soil aggregation.

3.6 COLLABORATION TRIAL WITH SEED COMPANIES

Seed companies were asked to put together a mixture of cover crops that can cover the soil fast, produce lot of biomass and be suitable to supply livestock with palatable grazing.

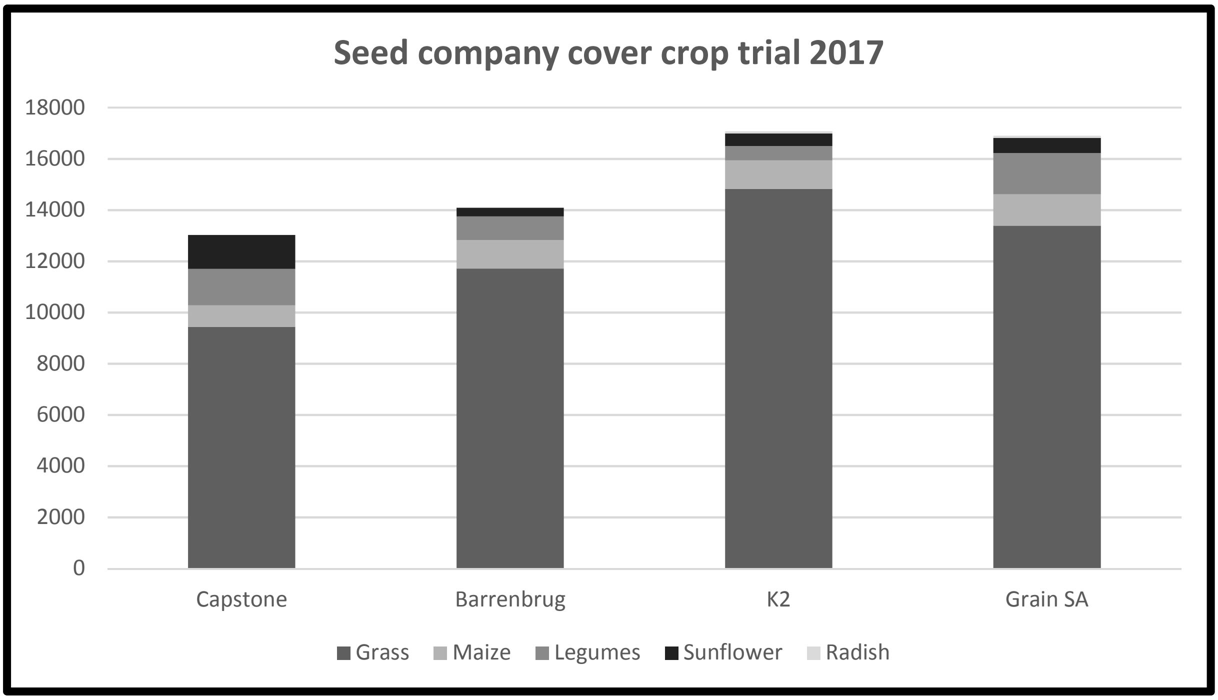


Figure 3.23: Dry matter production for different functional groups in different cover crop mixtures

Discussion: From Figure 3.23 it is clear that different functional groups were used in cover crop mixtures. Grasses such as babala and sorghums were well represented and contributed most biomass to the total production. This scenario is seen as highly suitable for the Ottosdal area. Grasses protects the soil surface and contribute to infiltration due to surface roughness that is created. The Grain SA mixture had the highest biomass production of legumes providing more nitrogen. A more complete report for the seed companies will be provided.

3.7 REGENERATIVE TRIAL

Our approach to rehabilitate or regenerate a degraded field on the farm Humanslaagte (Ottosdal) was to use CA principles, aiming to leverage the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density. In this sense, regenerative CA improves soil health, primarily through the practices that increase soil organic matter. This not only aids in increasing soil biota diversity and health, but increases biodiversity both above and below the soil surface, while increasing both water holding capacity and sequestering carbon at greater depths. As reported previously, a summer and winter mixture were planted during the previous season, wherafter the different cash crops were planted. Three cash crops were planted the past season and were harvested. Good yields materialized as can be seen in Figure 3.24.

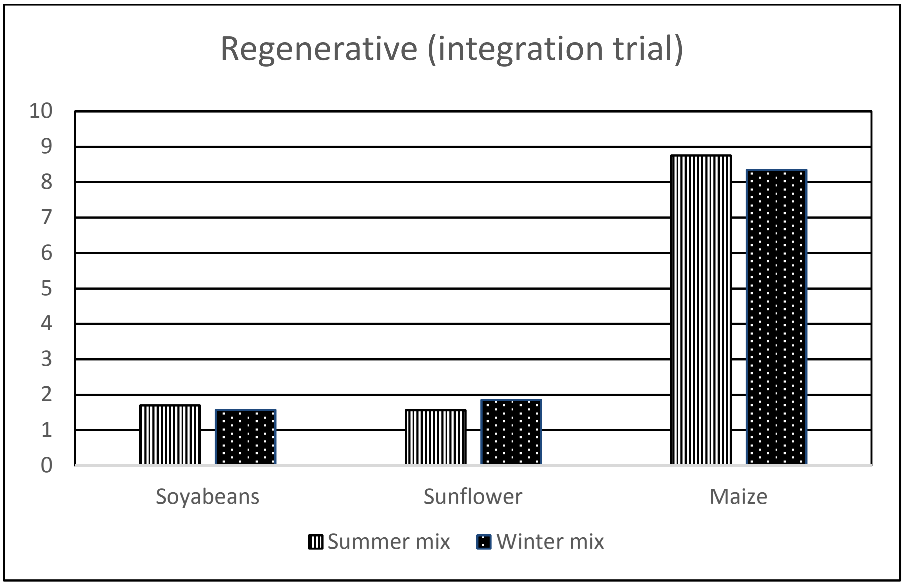


Figure 3.24: Grain yield for different treatments

Discussion: Maize and Soybeans did better after the summer annual cover crop mixture, while the sunflower performed better after the winter mixture.

3.8 SUNFLOWER INTERCROP TRIAL

Spray drift from herbicide killed the entire trial

3.9 PROBLEMS ENCOUNTERED

Good cooperation from all the different role players. As far as the cover crops, it is envisage that integration with livestock will now be priority.

2.10. MILESTONES NOT ACHIEVED

None

4. Weed survey of field trials: planning and analyses

Work Package title	**Weed survey of field trials: planning and analyses**
Work Package period	October 2016 to March 2017

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 not achieved** (in report period)
Attendance of meetings, planning, analyses and reporting	This work package and milestones were based on requests from farmers during the season	No requests and consultations were made during the season. Dr Elbe Hugo has left the services of the ARC and joined Syngenta. This work package is hereby terminated and remaining funds will not bre used.

5. Agronomic field trial planning and analyses

5.1. WORK PACKAGE

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

Work Package period	October 2016 to September 2017
Lead partner	Independent agronomist - Dr. A. A. Nel
Involved partners	Ottosdal No-till club members, Grain SA, 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

5.2. 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	Al results received from the No-till club were added to previous results, all data were analysed, conclusions drawn and documented (see addendum).
Presentation and reporting of the results to participants and MT as required.	Annual and biannual reports and presentation	Results of 2015/16 were presented to the No-Till Club on 13 October 2016. An article "Bewaringslandbou vereis 'n hoër mieliestand" was published in the March 2017 issue of SAGrain. A meeting with the No-till Club, was held on 27 February 2017. Future presentations, trial visit and other organisational matters were discussed and planned. A 16-page booklet on the trial results was compiled and printed as conference handout. Results of all trials were presented at the 2017 conference as well as a talk on crop rotation during the trial visit. Progress on the trial work was reported at the conservation agriculture working group on 22 February. A six monthly progress report on the trial planning and analyses was compiled and submitted to the project leader. An article written by Marleen Smith for Landbouweekblad on the results of the Ottosdal No-till Club after the No-Till conference was proof read and some details were corrected. An article "Gewasrotasies se kritiese rol in bewaringslandbou vir Noordwes deur die Ottosdal Geenbewerkingsklub ondersoek" was published in

		SA Grain (May 2017). Results of the 2016/2017 season were presented at a meeting of the No-till club on 30 August 2017.

5.3. SUMMARY OF AGRONOMY WORK PACKAGE FOR 2016/17

Actions taken to date

Agronomic field trials were described and planned according to the objectives decided on by club members during the planning meeting of 13 October 2016. The trial plans were provided to the No-till club for execution. Results from the 2016/17 were added to results of previous seasons, analysed and conclusions made and documented. The research objectives were:

1. Crop rotation systems (all seasons)
2. Argentinian versus local row widths and populations (all seasons)
3. Tines versus coulter fitted on planter (2013/2014 & 2015/2016)
4. Plant population densities (2013/2014, 2015/2016 & 2016/17)
5. Maize cultivar evaluation (all seasons)
6. Conventional crop systems vs CA crop systems (2015/2016 & 2016/2017)

Results were presented at meetings and published popular articles.

Progress made

The following number of trials were planned, conducted from 2013/2014 to 2016/2017 and the results analysed for each objective:

Objective	Number of trials
Crop rotation systems	5 (farm x season combinations)
Argentinian versus local row widths and populations	24 (three crops)
Tines versus coulter fitted on planter	5 (three seasons)
Plant population densities	13 (four crops)
Maize cultivar evaluation	10 (four seasons)
Conventional crop systems vs CA crop systems	6 (two seasons)

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. Early indications suggest that the usual rotation effect from one crop on anther might be different for tilled and no-till soils. Results from a longer period of time is needed before sound conclusions can be reached.

Argentinian versus local row widths and populations: Narrow 0.52 m spaced rows with increased plant population densities was compared to the local width of 0.76 to 0.91 m spaced rows and lower plant densities for maize. With the exception of three trials, the yield of maize was similar or higher in the Argentinian system compared to that of the local system in the remaining 16 trials. Over all trials the yield advantage of the narrow rows was 0.55 t ha^{-1}. In the case of sunflower, 0.52 m spaced rows had an average yield advantage of 0.16 t ha^{-1} over the 0.91 spaced rows at similar plant densities.

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 a maize yield increase.

Conventional crop systems vs CA crop systems: Six trials were done on three farms during two seasons. The performance of no-till maize grown in 0.52 m rows at 40 000 ha^{-1} and in 0.91 m rows with densities between 18 000 and 28 000 plants ha^{-1} were compared to the perfomance of maize grown in the tillage system which is applied on the farm and plant densities equal to or below 24 000 ha^{-1}. Tillage systems varied from mouldbord ploughing to deep ripping. Taking into account that these trials were done as first or second year no-till on these farms when relatively lower no-till can be expected, the results of the no-till systems is encouraging. Especially that of the no-till, 0.52 m spaced rows with a high plant density, which had similar or higher yields than that of the tilled systems. However, results from more seasons are needed to confirm these results.

Plant population densities: The aim of this study is to get an indication of the optimum plant population density for maize, soybean sunflower and sorghum in conservation agriculture systems. Three of the maize response curves of the 0.9 m spaced rows indicate that the optimum plant population density is between 30 000 and 38 000 ha^{-1} while the third curve is inconclusive. Two of the 0.76 m row spaced trials suggest an optimum plant density of between 23 000 and 30 000 ha^{-1}. Sunflower and sorghum yields showed no significant response to a range of "normal" plant population densities while the optimum for soybean appear to be above 300 000 plants ha^{-1}.

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

No serious problems were encountered and all milestones were reached.

5.4. DETAILED RESULTS FOR 2013/2014 TO 2015/2016

Trial 1: Suitable crop rotation systems for CA

Introduction

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

Crop rotation is one of the three principles of CA. Limited research results regarding crop rotation in conventional tillage are available, while the influence of crop rotation in CA 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 CA, however, the long-term effect of crop rotation is unknown and need clarification.

Aim

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

Procedure

The six crops namely, cowpeas, forage sorghum, grain sorghum, maize, soybeans and sunflower were grown during 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 planted square on those of 2013/2014, resulting in five rotation plots and one monoculture plot for each crop. In 2015/2016, the layout of year 2013/2014 was repeated and in 2016/2017 the 2014/2015 layout was repeated.

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. Since the extreme drought of 2015/2016, the trial continued only at Humanskraal. Plant population densities were 40 000 ha^{-1} for maize and sunflower, 150 000 ha^{-1} for grain sorghum, 300 000 ha^{-1} for soybean and 230 000 ha^{-1} for cowpeas respectively.

Results

The first season in crop rotation served only to create a "rotational effect" in the soil. Yields recorded in two of the three trials planted in 2013/2014 are shown in Table 5.1. Yield results of the 2014/2015 and 2015/2016 seasons are shown in Table 5.2.

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

Yield of crops in 2014/2015

The yield of both maize and grain sorghum was significantly 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.

Mean crop yields 2014/2015 to 2016/2017

Due to a lack of replication, no annual statistical analyses could be made since 2015/2016. The overall mean maize yield for the three seasons 2014/2015 to 2016/206 was 5.02 t ha^{-1}. The mean yield of maize following sunflower and maize (monoculture) was respectively 11 and 7% higher than the overall mean yield, while the maize yield following soybean, cowpeas, fodder sorghum and grain sorghum were between 2 and 5 % lower.

The three-year mean yield of grain sorghum following cowpeas, maize and sunflower was 8, 11 and 1% higher than the overall grain sorghum yield of 2.37 t ha^{-1}. Yields following soybean, fodder sorghum and grain sorghum (monoculture) were 2, 1 and 15% lower than the overall mean.

Soybean yields were strongly affected by crop rotation. The three year mean yield was 22, 19 and 3% higher than the overall mean of 1.29 t ha^{-1} following soybean (monoculture), cowpeas and maize respectively. However, mean yields were 4, 19 and 24% lower than the overall mean following grain sorghum, fodder sorghum and sunflower respectively.

Three-year mean sunflower yields were 11, and 8 % higher than the overall mean yield of 1.86 t ha^{-1} after fodder sorghum and maize respectively. Yields were 10, 5, 4 and 1% lower after grain sorghum, soybean, cowpeas and sunflower (monoculture) respectively.

Table 5.2 Mean grain yields in t ha^{-1} from 2014/2015 to 2016/2017 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
2016/2017	8.93	7.86	9.24	9.18	8.96	9.29
Mean	4.74	4.75	4.94	5.37	4.73	5.58
			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
2016/2017	2.81	3.39	3.17	2.39	3.28	3.46
Mean	2.56	2.34	2.01	2.64	2.32	2.39
			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
2016/2017	2.75	2.91	1.32	2.30	1.89	1.86
Mean	1.58	1.05	1.24	1.33	1.54	0.98
			Sunflower			
2014/2015	1.61	2.23	3.35	2.02	1.28	2.00
2015/2016	1.57	0.99	1.00	1.10	1.98	1.96
2016/2017	2.20	2.14	1.84	1.92	2.27	2.05
Mean	1.79	2.06	1.68	2.00	1.79	1.84

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

Soil cover

The soil cover left by the 2015/2016 crop after planting of the 2016/2017 crop (28 November 206) at Humanskraal, is shown in Table 5.3. Fodder sorghum, grain sorghum and maize on the other hand, left a high amount of residue which can be expected to be highly effective in protecting the soil surface.

Discussion and conclusions

The 2013/2014 and 2016/17 seasons will be remembered for ample well distributed rain resulting in exceptionally high yields. In contrast, 2014/2015 and especially 2015/2016 will be remembered for drought and late plantings.

Table 5.3 The soil cover left by the preceding 2015/2016 crop after planting of the 2016/2017 crop at Humanskraal,

Crop 2015/2016	Crop 2016/2017				
	Maize	Grain sorghum	Soybean	Sunflower	Mean
Soybean	42	18	16	22	25
Cowpea	27	27	28	40	31
Fodder sorghum	98	90	90	82	90
Grain Sorghum	82	82	64	64	73
Sunflower	26	24	28	26	26
Maize	96	70	90	76	83

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. What is surprising over the three seasons, is how well maize performed after maize with yield rankings of second and third (twice) and sunflower with yield rankings of first (twice) and third. Maize yield ranking after the two legumes varied from third to last. The opposite is expected as the yield enhancing effect of legumes on maize as follow up crop is well known. The possibility exists that the well-known rotational effect found on tilled soil, change or is absent in undisturbed soil conditions.

Sorghum performed well when it followed maize and cowpeas while sorghum in monoculture performed poorly. Soybean performed well when preceded by cowpeas, maize and in monoculture and it performed poorly when preceded by fodder sorghum and sunflower. Sunflower yields were improved by fodder sorghum and maize and suppressed by grain sorghum and soybean crops.

It is possible that the relatively lower yields of crops following sorghum may be, in part, due to lowered plant population densities. Sorghum usually left a high amount of residue and stubble which also intercepts wind-blown residue from other crops like maize which hampers the planting and crop establishment.

Results from several more seasons needed to determine which preceding crops have the highest probability for enhancing yields on which following crops. Cowpea, soybean en sunflower were at or below the 30% threshold set for conservation agriculture.

Trial 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 0.76 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 at 40 000 ha^{-1} for maize, almost double the local used density. Similar densities are used for other crops except for soybean, where the Argentinian recommend 250 000 ha^{-1} compared to the local 300 000 ha^{-1}. 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, sorghum and sunflower grown in Argentinian crop row widths of 0.52 m, and plant population densities with locally used row widths and population densities.

Procedures

From 2014/2015 to 2016/2017, 19 trials were done on several farms using an 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 0.76 or 0.91 m. The target plant populations are shown in Table 5.4.

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

Table 5.4 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. Nineteen maize, two soybean, one sorghum and four sunflower trials were done from 2013/14 to 2016/17.

Results

Maize

Results of the combined data from 19 trials, done on various farms, from 2013/2014 to 2016/2017, are shown in Figure 5.1. An analysis of variance showed that the yield of maize is significantly affected by the row width plant population systems ($P = 0.02$). The mean yield of the Argentinian system was 0.55 t ha^{-1} higher than the yield of the local row width and plant populations. However, in three instances, the opposite was true where the yield of the local system was between 0.38 and 1 t ha^{-1} higher than the yield of the Argentinian system. The mean increase for trials in favour of the Argentinian system was 0.8 t ha^{-1} with a range from 0.03 to 2.86 t ha^{-1}.

Soybean

Two field trials with soybean were done from 2013/2014 to 2016/2017 where the row widths of 0.52 and 0.76 m were compared at Humanskraal. In both cases the yield of the 0.76 m width was higher (mean of 0.2 t ha^{-1}) than the yield of the 0.5 m rows.

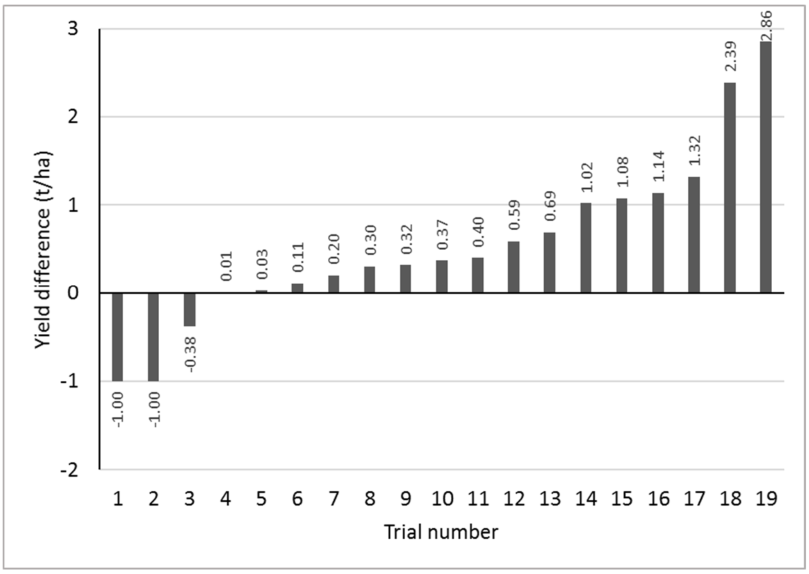


Fig. 5.1 The yield difference of maize in Argentinian (0.52 m) and local (0.91 m) row widths and plant population densities of 19 field trials done from 2013/2014 to 2016/17. Positive values represent cases where the yield of the Argentinian system was higher than that of the local system and the other way around.

Sorghum

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.

Sunflower

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. Higher yields were constantly found for the narrower 0.52 m row width than for the 0.91 m width (Figure 5.2). Analysed over all trials, the yield advantage for the 0.52 m Argentinian row width over that of the local width, was a significant 0.16 t ha^{-1}.

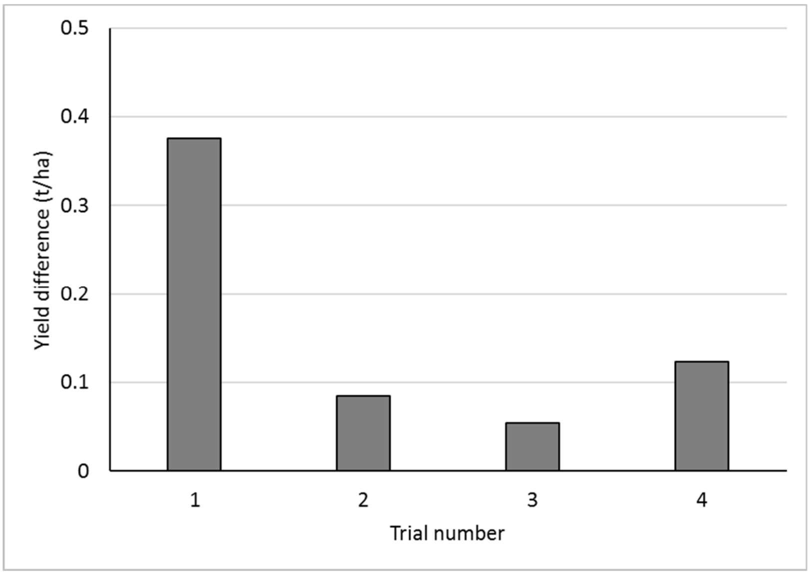


Fig. 5.2 The yield difference between Argentinian (0.52 m) and local (0.91 m) row widths in four field trials done with sunflower at 40 000 plants ha^{-1} done in 2013/2014 and 2015/2016. All four cases indicate that the yield of the Argentinian system was higher than that of the local system.

Discussion and conclusions

Taking an overall look at maize it is clear that most of the time a similar or higher yield can be expected from the narrow 0.52 m row with a high plant population Argentinian system, than with the local 0.76 to 0.91 m rows with lower plant population densities, even during seasons with drought. It should be kept in mind that three cases exist where the local system had higher yields than the Argentinian system. The cause should be investigated to determine under which conditions higher yields with the local system can be expected.

Trial 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 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 yield of maize.

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 a 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. 5.3. 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.

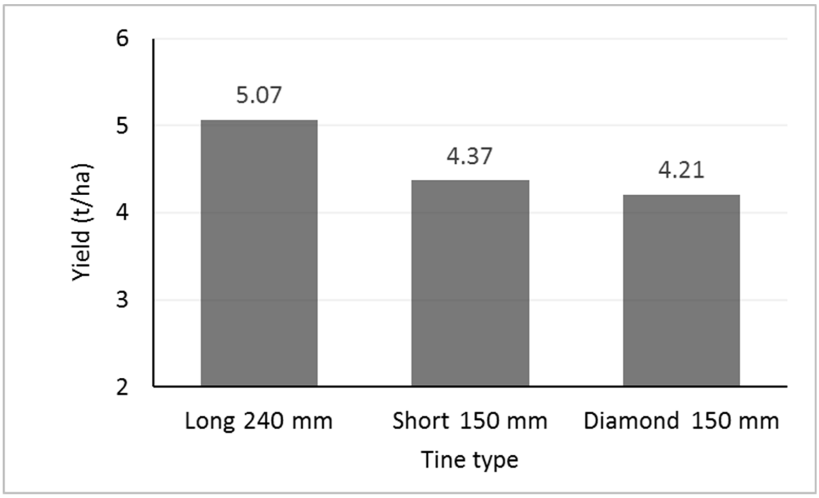


Fig. 5.3 The effect of tine type and working depth on the yield of maize in 2014/2015.

Discussion and conclusions

After three years of investigation no evidence could be found that either tines or coulters cause higher grain yields. However, soil texture was not taken into account in these trials. Farmers are of the opinion that tines are best suited for sandy soils or soils that has recently been converted to no-till, while coulters are better suited for loamy and clay soil. Deeper working depths (240 vs 150 mm) of tines caused a higher yield. The optimum depth of disturbance of the soil will depend on several soil parameters such as texture, structure extend of compaction etc. which usually have a large spatial variation. Further investigation into this matter is needed to link optimum depth of disturbance to these soil parameters. An economical analyses will most probably show that coulter planters is more profitable due to less diesel used.

Trial 4: Cultivar evaluation in conservation agriculture systems

Introduction

Cultivar selection is an important aspect in the optimisation of maize production, which the farmer can control. Currently, national cultivar trials are not done in no-till or in any conservation agricultural system. It is thus unknown how cultivars will perform in no-till, under high (50 000 plants ha^{-1}) population densities and row widths of 0.52 m.

Aim

The aim is to compare the yields of maize cultivars at 50 000 plants ha^{-1} in 0.51 m spaced rows.

Procedures

A cultivar trial was done in 2016/2017 on the farm Humanskraal. Twenty-eight cultivars, supplied by seven seed companies were included. The trial layout consisted of 12 rows of the chosen cultivars at 0.52 m row widths. A control cultivar was included between every two adjacent cultivars tested.

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.

Seed prices of all cultivars for the 2017/2018 season were collected. The net return taking the seed prices of the various cultivars into account were also calculated at a seeding rate of 40 000 ha^{-1} and a grain price of R1 800 t^{-1}.

Results

The adjusted cultivar yields grouped according to supplier company are shown in Fig. 5.4. Net returns are shown in Fig. 5.5.

Discussion and conclusions

Well performing (0.75 t above the average yield) cultivars in the past season were DKC 77-77BR, SC 608, PAN 5A-182 and PAN 6R-710BR.

New cultivars are introduced every season, replacing older ones. The weather also varies from season to season which impact on the relative performance of cultivars. Cultivar evaluation is thus a continuous process. It is also make sense to consult the results of several cultivar trials before a selection is made.

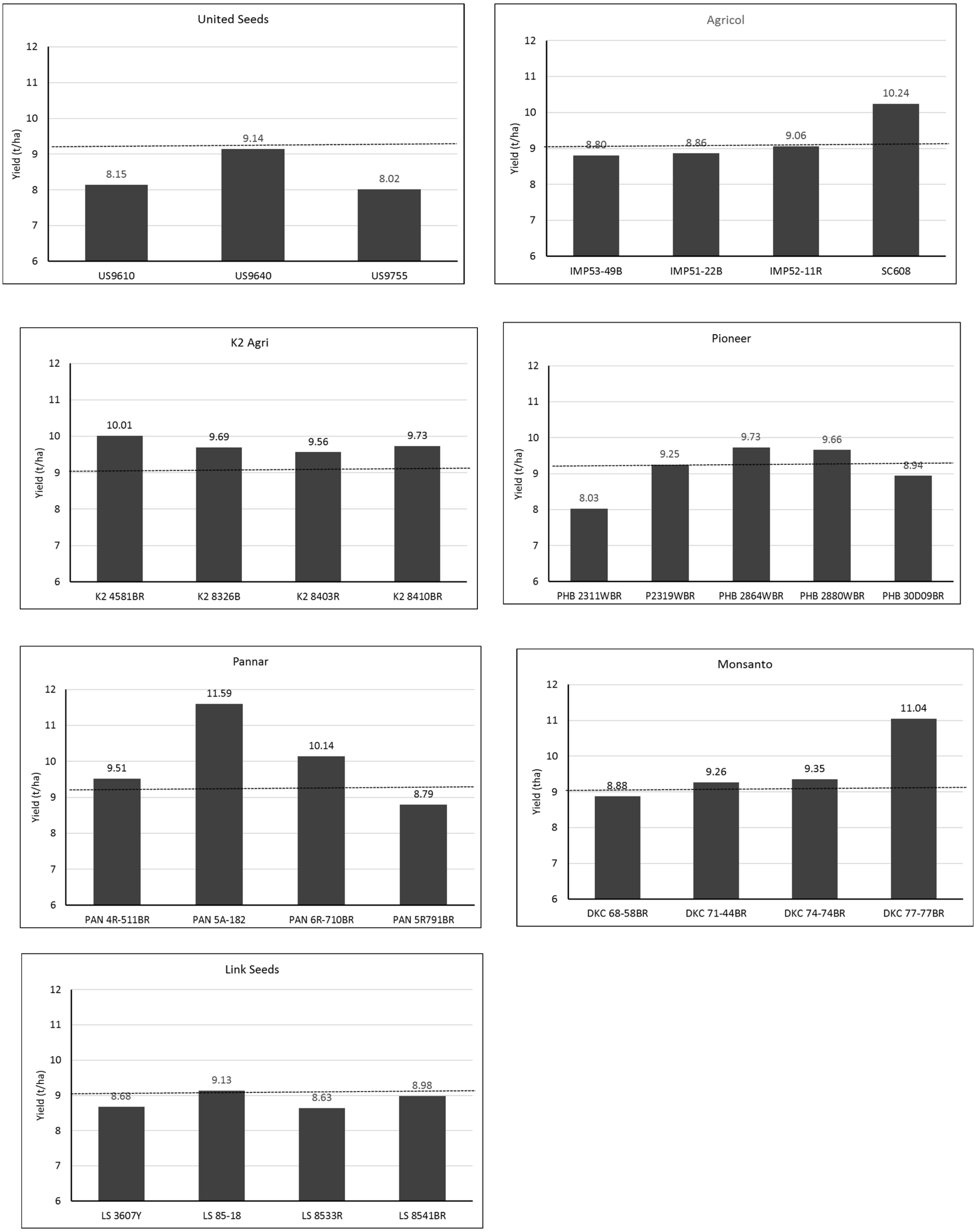


Fig. 5.4 Adjusted grain yields of cultivars at Humanskraal 2016/2017. The mean adjusted yield of all cultivars are indicated by the horizontal line.

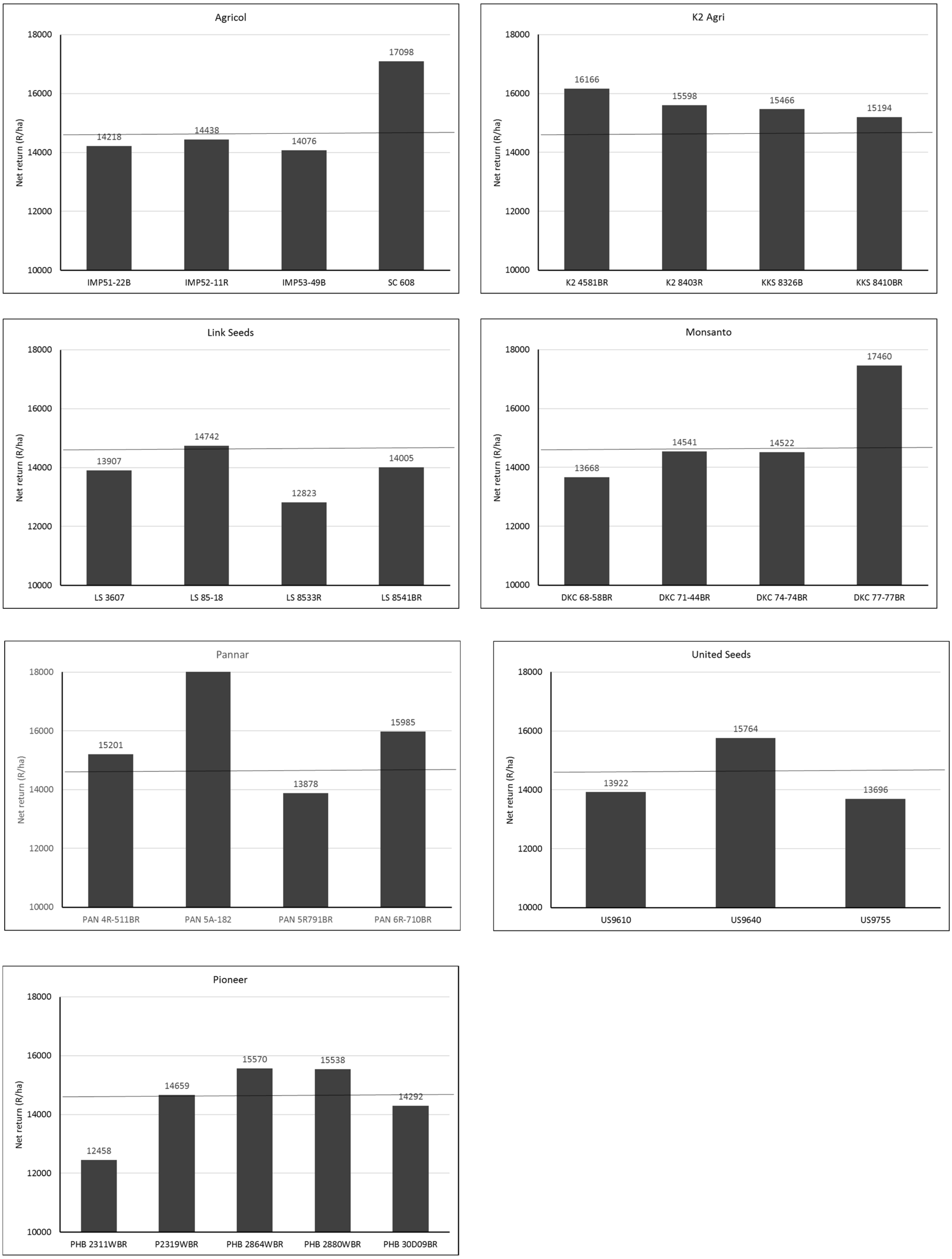


Fig. 5.5 The net return for cultivars calculated from the adjusted grain yields and seed price at a grain price of R1 800 t^{-1} at Humanskraal 2016/2017. The mean net return of all cultivars, is indicated by the horizontal line.

Trial 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 causing 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 of crop residue and crop rotation.

Due to a local lack of scientifically based results the need exists to collect results on the success of CA crop systems 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.

Aim

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

Procedures

Annual field trials were done on farms in which commercially available equipment are used. The current conventional system used on the farm was the control which was compared with one or two row widths in no-till.

Treatments were assigned to strips on a selected land. The participating farmers in 2015/2016 and 2016/2017, the conventional and CA systems applied are shown in Table 5.5. In all instances, no-till consisted of no primary tillage such as ripping or ploughing but, shallow tillage with disk was done to eradicate weeds between harvesting of 2014/2015 crop and planting of the 2015/2016 maize.

Results

Results of the various trials are shown in Fig 5.6 to 5.8. On the farm of Jaco Bamberger, the Argentinian no-till system of 0.52 m spaced rows with a planting population of 40 000 plants ha^{-1} outperformed all the other systems with 0.98 t ha^{-1} in 2015/2016. The rest of the systems had similar yields. In 2016/2017, the no-till systems had higher yields than the tilled systems with the 0.52 m spaced rows and 40 000 plants ha^{-1} again in the top position.

The rank of yields among the systems changed over the two seasons on the farm of Niël Rossouw with no clear advantage of no-till over strip-till. Results from more seasons is needed to determine if any pattern exist.

Table 5.5 Participating farmer, description of the tillage system applied and number of seasons of no-till 2015/2016 and 2016/2017

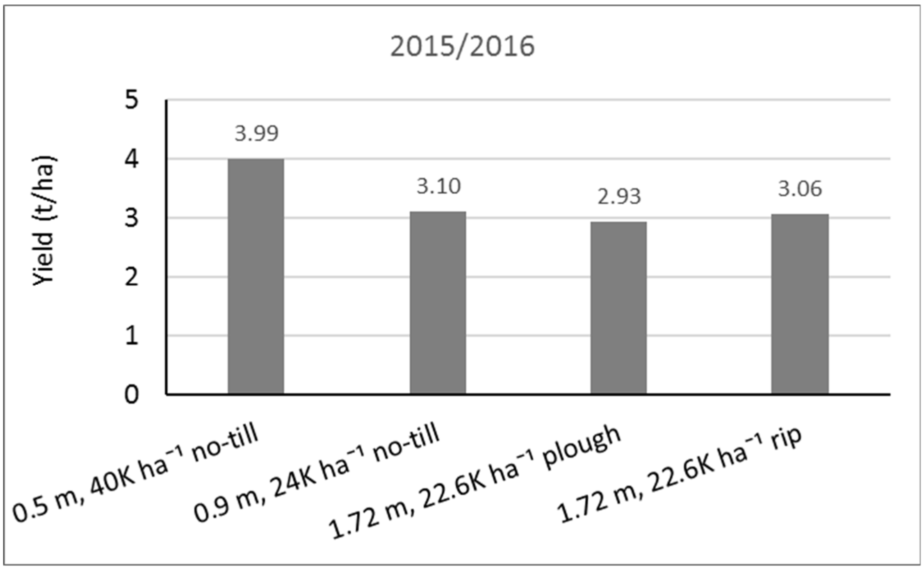
Participating farmer/farm	Tillage system and row width (m)	Population density (x1000 ha^{-2})
	2015/2016	
Jaco Bamberger	**1.** Moulboard ploug, 2.3 m	22.6
	2. Rip-on-row 45 cm deep, 2.3 m	22.6
	3. No-till, 0.52 m	40.0
	4. No-till, 0.91 m	24.2
Niël Rossouw	**1**. Strip till 20 cm deep 1.5 m	17.8
	2. No-till 0.91 m	22.0
	3. No-till 0.52 m	42.0
Pieter van Vuuren	**1.** Rip-on-row 40 cm deep, 2.3 m	13.1
	2. Rip-on every second row 1.15 m	26.1
	3. No-till, 0.91 m	17.6
	4. No-till 0.52 m	30.0
	2016/2017	
Jaco Bamberger	**1.** Moulboard ploug, 1.5 m	24.2
	2. Rip-on-row 45 cm deep, 1.5 m	33.4
	3. No-till, 0.52 m	40.0
	4. No-till, 0.91 m	27.5
Niël Rossouw	**1**. Strip till 20 cm deep 1.5 m	21.8
	2. No-till 0.91 m	21.0
	3. No-till 0.52 m	40.0
Pieter van Vuuren	**1.** Rip-on-row 40 cm deep, 1.87* m	20.0
	2. No-till, 0.91 m	24.2
	3. No-till 0.52 m	40.0

* 2 x 2.3 m + 1 m spacing

On the farm of Pieter van Vuuren rip-on-row with a 2.3 m row spacing had the lowest yield of all systems in both seasons even where it was combined with a no-till row between the tilled rows.

Discussion and conclusions

The systems were not replicated in these trials and clear statistically based conclusions cannot be made. Taking into account that these trials were done as the first or second year of no-till on these farms, relatively lower no-till yields were expected. However, the results of the no-till systems is encouraging, especially those of the no-till, 0.52 m spaced rows with a high plant density, which had similar or higher yields than that of the tilled systems. However, results from more seasons are needed for confirmation of the findings.



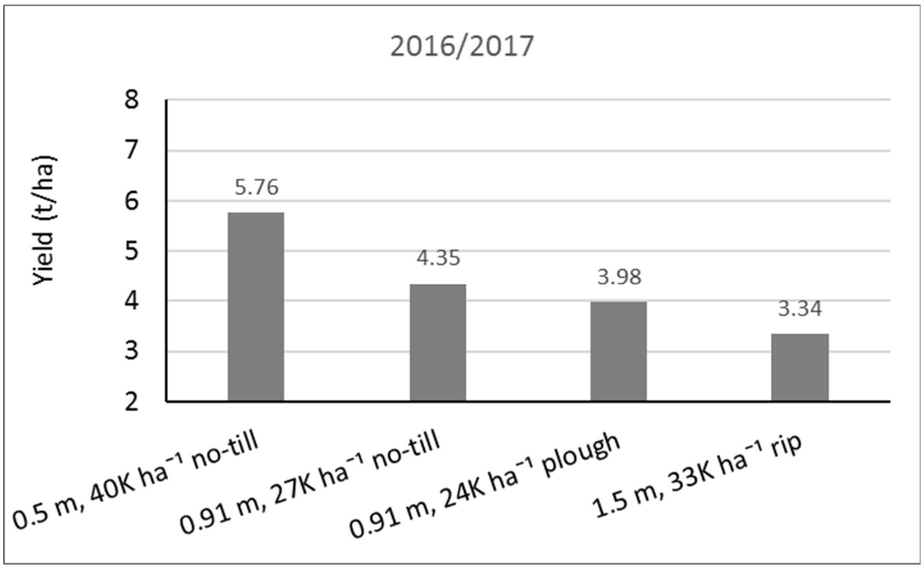
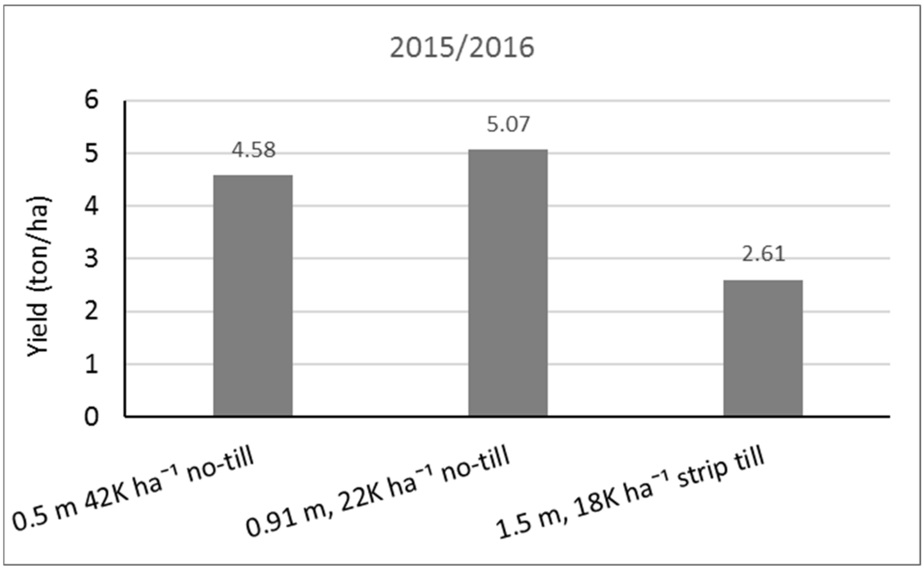


Fig 5.6 The yield of maize as affected by tillage, row width and population density on the farm of Jaco Bamberger in 2015/2016 and 2016/2017.



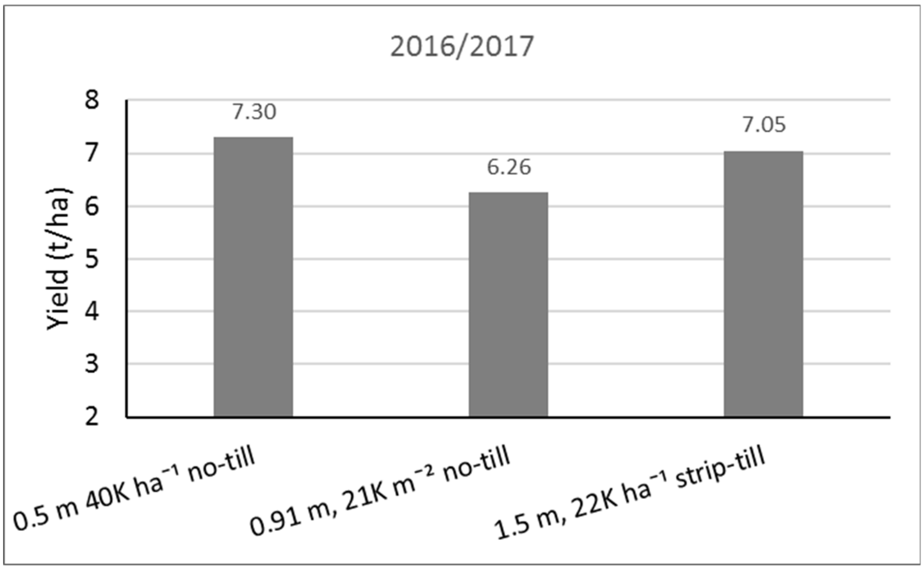
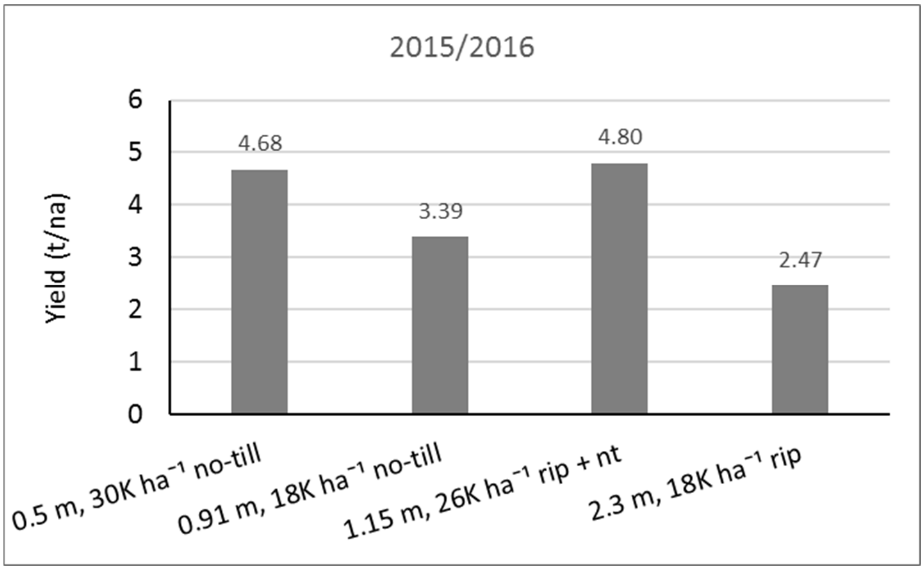


Fig 5.7 The yield of maize as affected by tillage, row width and population density on the farm of Niël Rossouw in 2015/2016 and 2016/2017.



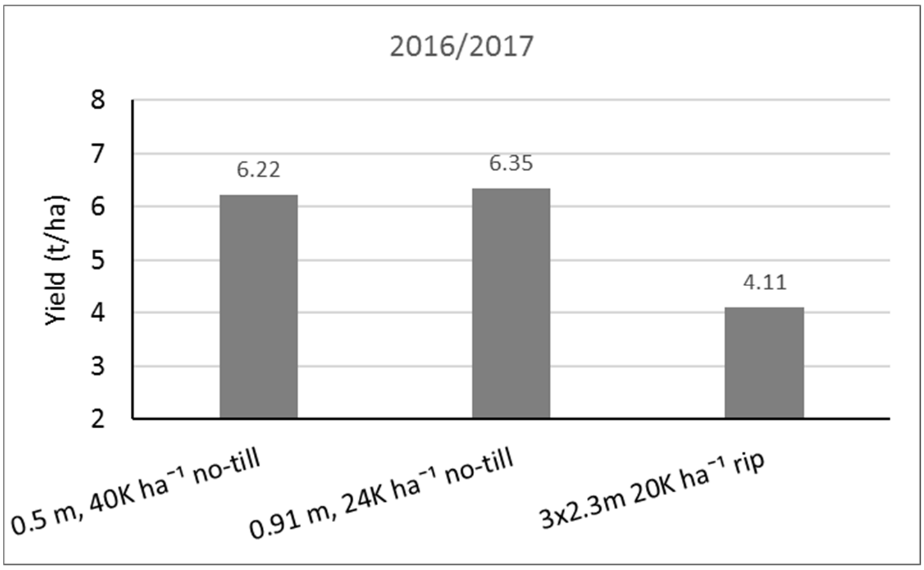


Fig 5.8 The yield of maize as affected by tillage, row width and population density on the farm of Pieter van Vuuren in 2015/2016 and 2016/2017.

Trial 6: Optimum plant population of crops in conservation agriculture

Introduction

The plant population of crops remains an important aspect of the optimization of 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 14 000 to 24 000 plants ha^{-1} are currently used for maize, around 40 000 plants ha^{-1} for sunflower and 300 000 plants ha^{-1} 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 plant populations currently used, should be increased or decreased for conservation agriculture systems for maize, soybean sunflower and sorghum.

Procedures

From 2013/2014 to 2016/2017 eight no-till field trials were done with maize and two each with sunflower and sorghum, and one trial with soybean. Plant population densities varied from 15 000 to 40 000 ha^{-1} in the various field trials for maize, from 155 000 to 300 000 ha^{-1} for soybean, 60 000 to 120 000 ha^{-1} for sorghum, and 35 000 to 50 000 ha^{-1} for sunflower with row widths of either 0.76 or 0.91 m. Yields were measured on plots of at least 60 m^2. Quadratic curves ($Y = a + bX - cX^2$ where, Y = grain yield and X = plant density and a,b and c are coefficients) were fitted to yield data from each trial to determine if yield were related to plant population density.

Results and Discussion

Maize

Maize responded well to plant population density in all eight trials (Figs 5.9). Three of the response curves of the 0.9 m spaced rows indicate that the optimum plant population density is between 30 000 and 38 000 ha^{-1} while the third curve is inconclusive. Two of the 0.76 m row spaced trials suggest an optimum plant density of between 23 000 and 30 000 ha^{-1}. The two remaining curves of the 0.76 m row spaced trials is inconclusive.

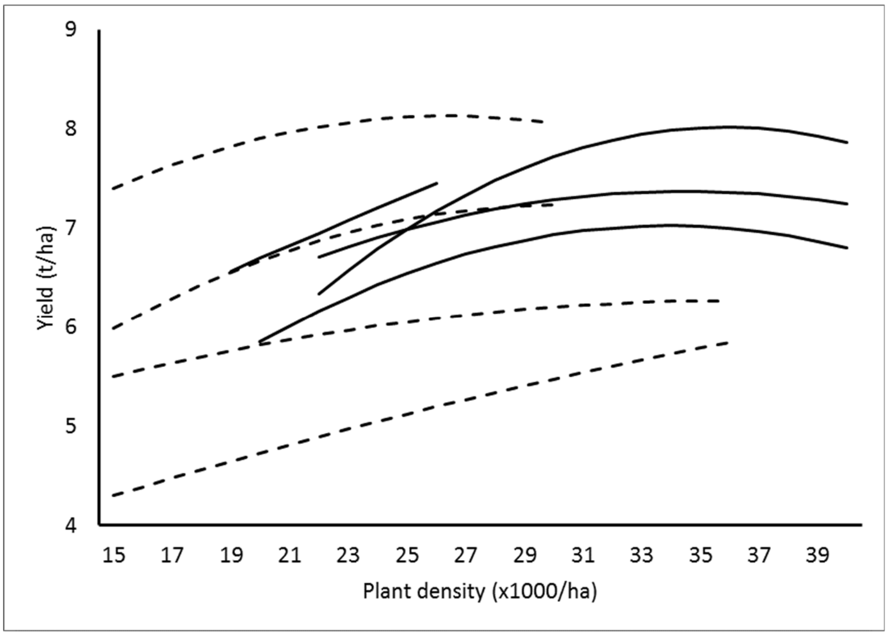


Fig. 5.9 No-till maize yield as related to plant population density in eight field trials from 2013/2014 to 2016/2017. Row widths of 0.76 and 0.91 m are represented with dotted and solid lines respectively.

Sunflower

Sunflower showed no response to plant population density in any of the two trials done (Fig 5.10). Although curves were fitted for these two trials, the regression analysis for each indicated a non-significant relationship.

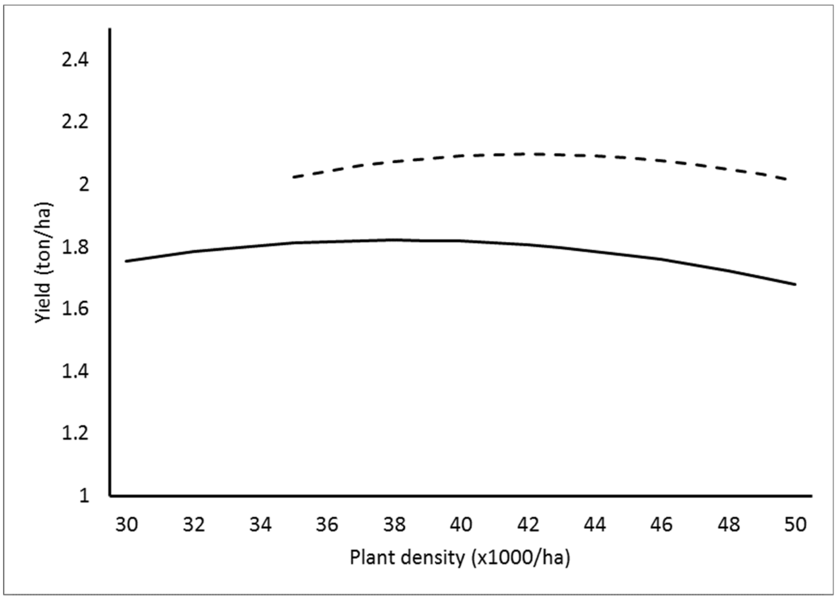


Fig. 5.10 Sunflower yield as related to plant population density in 2013/2014 and 2014/2015 with 0.76 and 0.91 m row widths indicated by dotted an solid lines respectively.

Sorghum

Sorghum yield also showed no significant relationship with plant population density as indicated by the regression analyses (Fig. 5.11).

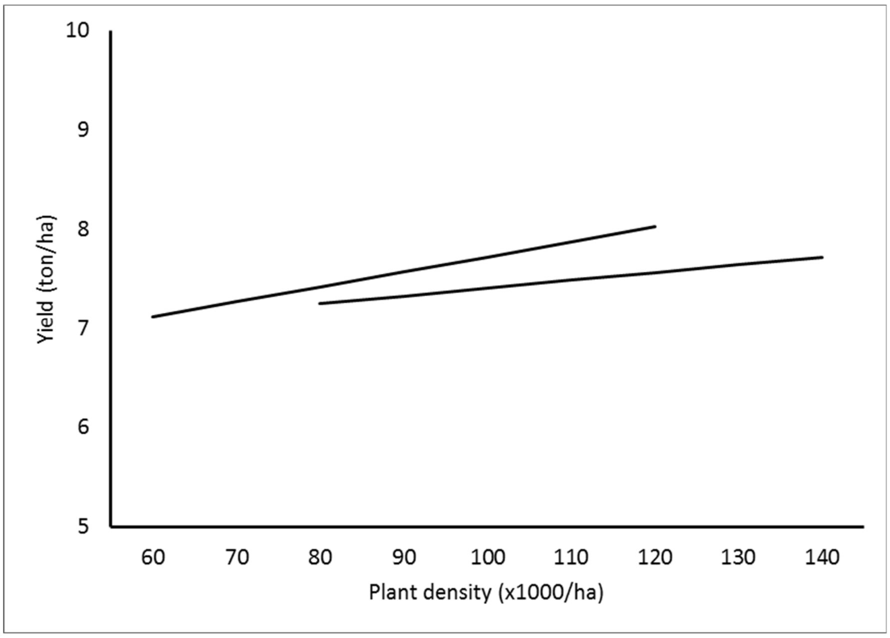


Fig. 5.11 Sorghum yield as related to plant population density.

Soybean

The yield of soybean on the other hand, responded to plant population density with an optimum higher than 300 000 plants per ha^{-1} (Fig. 5.12). The yield response rate was approximately 3 kg ha^{-1} per 1000 plants ha^{-1}.

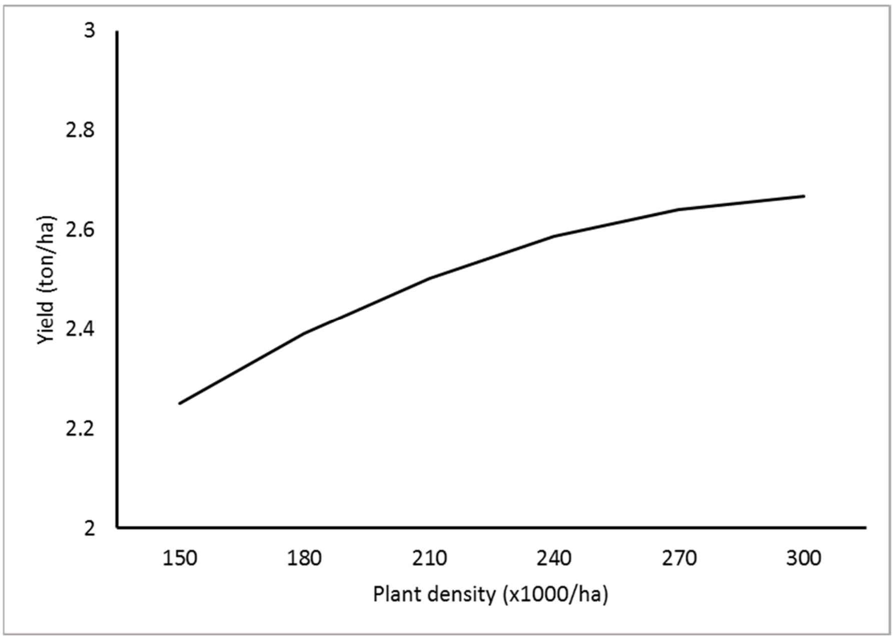


Fig. 5.12 Soybean yield as related to plant population density in 0.76 m rows.

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 2016 to September 2017

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 (March 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 2016-2017
4. Monitoring and Sampling (Done with activity 3 above)	Assist farmers to complete field forms Assist to collect soil samples Monitor the farmer-led actions	Completed seasonal activities for 2016-2017
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.	Was sick and could not attend meeting in August 2017.
8. Annual report and admin (2 days)	Written report covering trial implementation, results and progress.	NA
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 held on 6-7 March 2017.

Table 6.1: List of location and type of trials established in Ottosdal area, 2016/17 season

Trial Number:	**1**	**2**	**3**	**4**	**5**	**6**
Farmer co-worker:	**Plant pop (own planter)**	**Crop Rotation**	**Local vs Argentina**	**Tine depth**	**Cultivars**	**Convens vs 90cm vs 50cm**
Hannes Otto	Sunflower Maize		Maize	√		
George Steyn		√	Maize		√	
		+ Cover crops	Soya (poor emergence)			
Dirk Laas		√			√	
Niel Rossouw						√
Piet v Vuuren						√
Jaco Bamberger						√
Koos Bezuidenhout						
Total Farmers	**1**	**2**	**2**	**1**	**3**	**3**

7. Summary of expenses on August 2017

Description of Ottosdal CA project work packages	Total Actual YTD Aug 17	Total Budget YTD Sept17	Available to use
Soil	10 396	91 300	80 904
Cover crops	134 718	161 850	27 132
Weeds	-	29 250	29 250
Agronomy	49 733	60 900	11 168
Grain SA	87 473	121 500	34 027
Farmer facilitator	109 462	110 445	983
Total	**391 781**	**575 245**	**183 464**

*** Expenses and invoices still expected which will affect the final amount until 30 September 2017.**