APPENDIX 4:
PROGRESS REPORT
THE PROMOTION OF CONSERVATION AGRICULTURE IN THE NORTH-EASTERN FREE STATE – PHASE 1 (TWO STUDY AREAS)

For the period:
October 2018 to September 2019

Compiled by:
HJ Smith, L Visser, G Trytsman, A Jankielsohn, G du Preez, D Fourie, A Loggenberg and J van Zyl

In collaboration with:
Riemland (Reitz) and Ascent (Vrede) study groups

September 2019

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1. Introduction

This progress report covers the period of October 2018 to September 2019 of the implementation of a project funded by The Maize Trust (MT), which will assist to scale out Conservation Agriculture (CA) to grain farmers in the north-eastern Free State Province. The north-eastern and eastern parts of the Free State are seen as key grain producing areas and have very suitable conditions (soil and climate) to practice CA, however, the area still has a very low adoption percentage of farmers practising CA. Consequently, this area has been identified by Grain SA's CA Farmer Innovation Programme (CA-FIP) as a target area to promote CA among farmers in order to improve their sustainability and profitability. The Grain SA CA-FIP uses innovative, well organised and interested farmers and/or their structures (e.g. study groups, clubs, associations, etc.) as platform to launch projects and scale out CA to the surrounding farming communities. In this respect two active study groups, namely Ascent (Vrede district) and Riemland (Reitz district) have agreed to serve as platforms to launch projects in these two study areas. The study groups have consequently been engaged in various planning and implementation activities since the 2015/16 season, which have all been included in various work packages that serve as the framework for this proposal.

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

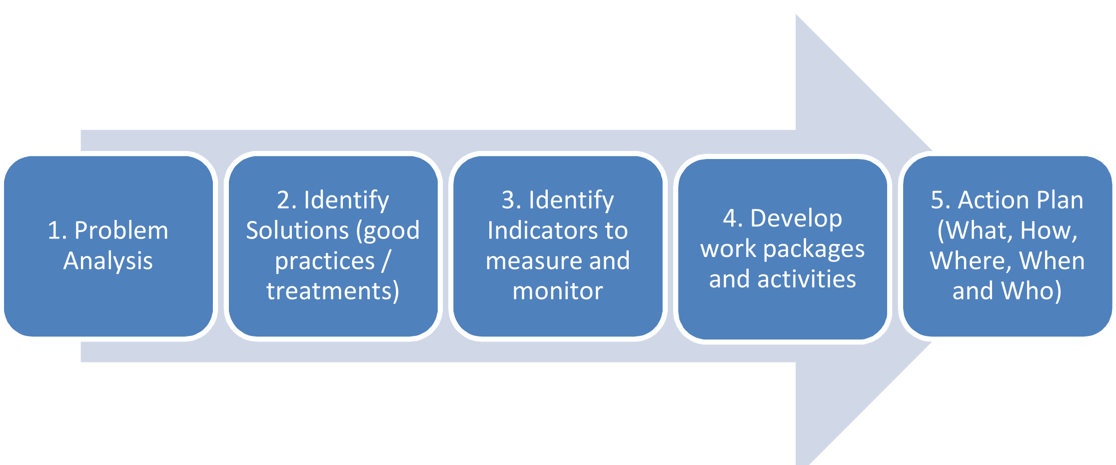

Figure 1: The participatory diagnosis and planning process followed with the Riemland and Ascent study groups

2. Description of the targeted study area(s)

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

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

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

3. Targeted beneficiaries or key project participants

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

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

4. Project aim

The aim of the project is:
To research and develop (scale out) conservation agriculture in key grain producing areas of the north-eastern Free State through a farmer-centred innovation systems process.

4.1. Objectives

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

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

d) To support farmer facilitation, administration and reporting processes.

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

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

Work Package	Lead partner - Riemland	Lead partner - Ascent
1. Coordination and management	Callie Meintjies and Danie Slabbert (Riemland study group)	Izak Dreyer (Ascent study group)
2. Assessment of soil health under CA systems	Lientjie Visser (ARC); Willie Pretorius (Soil Health Solutions)	Lientjie Visser (ARC), Paula Lourens (Vermi Solutions), Willie Pretorius (Soil Health Solutions)
3. Assessment of cover crop adaptability and suitability	Gerrie Trytsman (Private)	Gerrie Trytsman (Private)
4. Agronomic field trial planning, analyses and reporting	Lientjie Visser and Willem Killian (ARC-SG)	Lientjie Visser and Willem Killian (ARC-SG)
5. Coordination and facilitation of project activities among farmer participants	Jacques van Zyl (VKB)	Jacques van Zyl (VKB)
6. Dung beetle monitoring	Dr Astrid Jankielsohn (ARC)	Dr Astrid Jankielsohn (ARC)
7. Assessment of soil ecosystem health with nematodes as bioindicators	Dr Gerhard du Preez (NWU)	Dr Gerhard du Preez (NWU)

5. Project approach and rationale

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

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

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

5.1. Farmer-centred Innovation Systems Research

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

A series of selected on-farm, farmer-led trials, where farmers are lead or equal partners (in identifying research needs, designing, implementing and evaluating experiments), will give farmers independence, ownership and control. Experiments are usually well designed with appropriate treatments and sufficient replications spread over the entire agro-ecological zone and/or on a sufficient number of farms. Before the 2018/19 season a number of fixed monitoring points on selected ecotopes (uniform soil, slope unit) and treatments (CA, CT and veld) were identified on specific farms in the Riemland and Ascent study areas. Data from properly designed experiments and these on-farm monitoring points of farmer practices will provide a strong influence for discussion and investigation of the research questions in the project. Various appropriate indicators are being collected at each point. Hence, scientifically valid data are being generated and strengthened through the involvement of agricultural scientists in group problem solving and on-farm research (through the different work packages).

5.2. Participatory monitoring, evaluation and adaptive management

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

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

INDICATOR	YES / NO	MEASUREMENT	WHO (Ascent)	WHO (Riemland)
Compaction	Y	Root evaluation; bulk density; penetration resistance	Facilitator	Facilitator
Wind erosion	Y	Ground cover after plant (per Monitoring form)	Farmers & Facilitator	Farmers & Facilitator
Soil fertility	Y	Macro and micro nutrients – on row and in-between	ARC, Vermi Solutions	ARC
Soil biology / Soil structure	Y	Haney SHT, PLFA, Nematodes	ARC, VS & Soil Health Solutions	ARC / Soil Health Solutions
Rainfall	Y	Per event / 24 hour	Rain gauge	Rain gauge
Pests	Y	Monitoring form	Farmers & Facilitator	Farmers & Facilitator
Diseases (soil-borne)	N	Monitoring form	NA	NA
Nematodes	N	Nematode soil health tests	NWU	NWU

Production	Y	Yield; kg/mm; kg/kg NPK; biomass	Farmers & Facilitator	Farmers & Facilitator
Weeds	Y	Weed counts; keep plots clear of weeds; weed control / herbicide programme	Farmers & Facilitator	Farmers & Facilitator
Mico-toxins	N			
Economy	Y	Gross margin / savings of treatments / systems economy	Farmers & Facilitator, VKB	Farmers & Facilitator, VKB
Grain quality	Y	Grading	VKB	VKB
Record keeping	Y	Description of all physical and chemical practices on treatments	Farmers	Farmers
Water content	Y	Soil moisture probes	Facilitator	Facilitator

5.3. Reference Group

A Reference Group (technical project committee) will be coordinated for the project by Grain SA. The Reference Group (comprising key, concerned and capable persons) is tasked to provide the project team with guidance and to assist the CA-FIP in monitoring progress and evaluating, revising deliverables. The Reference Group is only required to act in an advisory capacity. At this stage the Grain SA CA forum fulfils this role on a higher level.

Reference Group (or CA forum) meetings are scheduled for September each year, while the project technical committee meets in August. Progress reports for the preceding period and work programmes for the following cycle are tabled and discussed at these meetings.

5.6. Awareness and marketing

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

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

6. Work packages

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

7. Implementation of work plan from October 2018 to September 2019 – summary

KEY ACTIVITY	TIMELINE	INDICATOR OF SUCCESS	PROGRESS TO DATE
Objective 1: To establish and facilitate on-farm trials around two local farmer structures (i.e. study groups)			
a) Prepare, establish and manage on-farm trials on selected sites (farms)	Continuous	Monitoring of selected GPS points in CA systems	The trails at Reitz ended in 2018 and were replaced with monitoring of permanent GPS reference points on farms in the district.
Objective 2: To monitor and analyse a series of on-farm, farmer-led trials on selected (volunteering) farmers' fields			
a) Participatory monitoring / data collection	January to June	Collection of a range of selected indicators from trials, especially soil samples	Collection of a range of selected indicators from trials, especially soil samples.
b) Farmer participatory M&E and discovery learning	January to June	Completion of Field monitoring form with farmers	Completion of field monitoring form with farmers.
c) Data Analysis and Evaluation	June to August	Analysis of data collected from on-farm trials and field forms	Analysis of data collected from on-farm trials and field forms.
Objective 3: To create wider awareness and innovation capacity in local farming communities on the practices and benefits of locally adapted CA systems.			
a) Annual farmers day or conference	February to March	A well organised and -attended awareness event	Vrede farmer's day - 21 February 2019 at Ascent Silo's. Landbouweekblad CA Conference – 11-12 May 2019 at Reitz.
b) Exposing on-farm trials to interested farmers and other	Continuous	Trial visits by interested people	A number of interested people (mostly farmers) have been visiting the on-farm trials through the season and had discussions with participating farmers.
Objective 4: To support social learning, farmer facilitation, administration and reporting processes.			
a) Project meetings	Bi-monthly meetings	At least six project meetings per year	A number of project meetings were held at each of the project sites to monitor and manage planned activities.

b) Farmer facilitation	Continuous	Effective deployment of a local farmer facilitation to assist implementation and M&E with farmers	Currently this role is performed by Jacques van Zyl (VKB).
c) Reference Group	August	A well organised annual reference group meeting	Feedback and planning meetings on 13 and 14 August2019 at Reitz and Ascent (Vrede) respectively.
d) Reporting	March and September	Six-monthly and annual reports according to specifications	Completed annual report for period October 2018 to September 2019.

8. Implementation of work packages from October 2018 to September 2019

8.1. Assessment of soil health under different cropping systems at Reitz

Work Package title	**Assessment of soil health under different crop management systems (combining soil, agronomic and farmer facilitator work packages)**
Work Package period	October 2018 to September 2019

Lead partners	ARC (Ms Lientjie Visser), VermiSolutions (Ms Paula Lourens) and Soil Health Solutions (Mr Willie Pretorius)
Involved partners	Riemland & Ascent study groups, ARC-SGI, Grain SA,

Objectives	• To characterize soil health according to various biological, physical & chemical parameters derived through Haney SHT, PLFA and Nematode bio-indicator test. • To compare the effect of different treatments (CA, CT and veld) on different sampling points on soil health. • 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 practices (treatments) on soil biological, 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 and data analyses 3. Monthly meetings (project team) 4. Annual reference group meeting (advisory committee) 5. Annual report and admin (technical data) 6. Participate in awareness events

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

ACTIVITIES AND DELIVERABLES

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

DELIVERABLES, PROGRESS AND RESULTS ACHIEVED PER ACTIVITY

Activities *(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)
1. Monitoring and sampling	Soil sampling and analyses, soil probes and weather station data collection	Planning meetings were held with Danie Slabbert on 6 August 2018 and Callie Meintjies on 24 August 2018. Took soil samples at Reitz from 31 August to 3 September 2018. Weather and water probe data were monitored
2. Lab and data analyses	Samples submitted and analysed	Soil samples analysed by SHS. Analysed active C samples at UFS (31 October 2018).
3. Frequent meeting (project team)	Planning meeting to reflect on data and plan for season ahead	Feedback and planning meeting on 13 August.
4. Annual planning	Participate in annual meeting, discussing problems and possible solutions	Active discussions on the Whats App group
5. Annual report and admin (technical data)	Reporting as required and popular article once enough results have been acquired	Submitted 6-monthly report in February 2019 and annual report in September 2019
6. Participate in Awareness events	Create awareness of CA farming practices through events and reporting.	Presentation at the Combined Congress in Bloemfontein (21-25 January 2019) Discussion of 2018 results and planning meeting with Riemland Study Group – 13 August 2019

8.1.1. Background to Riemland (Reitz) study area

During the Riemland (Reitz) project planning meeting in 2018, it was decided to replace the two trials in the Reitz district, which have served their purpose, with a long term monitoring framework that included as key component an annual soil assessment on referenced GPS points within selected farmer fields, to monitor the effect of conservation agriculture (CA) and conventional tillage (CT) practises on soil health. As reference the natural pasture (veld) adjacent these crop fields were also sampled.

Mr Danie Slabbert of the farm Van Rooyenwoning started with CA in 2008. The crop rotation system on his farm includes:

1. Maize with inter-row winter cover crops (delayed intercropping)
2. Soybeans
3. Wheat, directly followed by
4. Sunflower on the same field if the soil moisture is enough.

An ultra-high density grazing (UHDG) system is used since 2018 on the veld during summer months and during winter months on fields with maize stubble and winter cover crops (from intercropping).

Mr Slabbert shared historical data of three fields (L1, L5 and L18) to show the improvement of soil organic matter (SOM) and pH (H_2O) since 2011. The sampling dates were respectively on 6 May 2011 and 24 May 2018 - both dates were after harvesting of soybean. Sampling depth was 15 cm and 10 samples were collected and analysed per field. Average results of the 10 samples were reported.

Table 8.1.1. indicates an increase in soil organic matter on all the fields since 2011. The soil pH increased on L5 and L18, but stayed the same on L1. The data shows that SOM levels at the start of CA were very low due to decades of soil tillage, but the steady increase over 7 years of CA is very positive. The SOM levels in the sandier soils have a much slower build-up, compared to clay and sandy loam soils.

Table 8.1.1. Historical soil data on the farm Van Rooyenswoning

Soil Analyses Results	L1 – Sandy loam		L5 – Loamy sand		L18 - sandy	
	2011	2018	2011	2018	2011	2018
pH (H_2O)	5.7	5.7	5.3	6.0	5.3	5.6
SOM%	1.02	1.31	0.60	1.24	0.60	0.69

Mr Callie Meintjies of Driefontein wants to improve the SOM content of the dominantly sandy soils on his farm. His crop rotation system includes soybean in combination with winter and summer cover crops. The cover crops and veld are utilised for grazing. Mr Meintjies had no historical data on the fields.

8.1.2. Methods

Additional soil samples were collected at GPS reference points on 31 August 2018 (Table 8.1.2). Ten composited top- and subsamples were collected in a 20 m radius around each GPS point (Photos 1 and 2). The samples were sent to Soil Health Solutions for Haney soil health and PLFA analyses, which were done at Ward labs, USA. Additional analyses results are listed in Appendix 1, Table 1.

Table 8.1.2. GPS reference points sampled in the Reitz district

Farm	Sample name	GPS Reference
Van Rooyenswoning Neighbour	CT Field	S27°54'31,0";E28°32'05,6"
Van Rooyenswoning	Sandy loam - L1	S27°54'30,0";E28°32'07,9"
Van Rooyenswoning	Sandy - L18	S27°52'35,9";E28°32'43.8
Van Rooyenswoning	Loamy sand - L5	S27°53'25,3";E28°32'52.0"
Van Rooyenswoning	Veld Ungrazed	S27°53'57,7";E28°3153,4"
Van Rooyenswoning	Veld UHDG	S27°54'10,0";E28°31'59,2"
Van Rooyenswoning Neighbour	Veld conventional grazing	S27°54'16,35";E28°31'51,5"
Driefontein	Sandy, Higher Yield	S27°47'21,6";E028°33'10,9"
Driefontein	Sandy, Poor Yield	S27°47'24,5";E028°33'10.2"
Driefontein	Veld	S27°47'44,2";E028°33'05,7

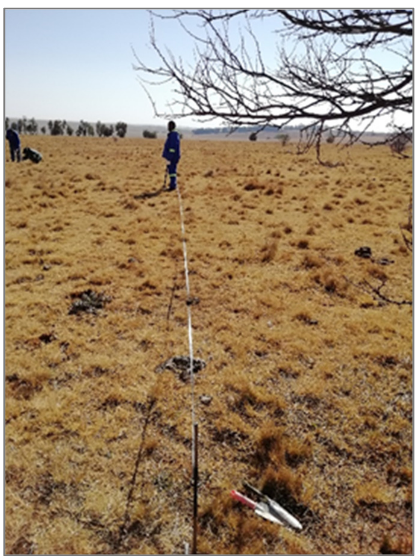

Photo 8.1.1. Soils were sampled in a 20m radius around a GPS point

Photo 8.1.2. Soil sampling at Reitz

The following field sites, or ecotopes (uniform soil and terrain units) were sampled at Van Rooyenswoning (CA) and a neighbouring conventional (CT) farm:

- Sandy loam CA field (L1)
- CT field
- Sandy CA field (L18)
- Loamy sand CA field (L5)
- Veld with UHDG
- Veld conventional grazed
- Veld Ungrazed

The following CA field sites, or ecotopes were sampled at Driefontein:

- Sandy field with high potential or yields
- Sandy field with lower potential or poor yields
- Veld conventionally grazed, moving over to UHDG

8.1.3. Results

Table 8.1.3 indicates thirteen Haney soil health parameters that were analysed. The measured values were grouped (categorised) in three modes namely - survival, progression or regeneration. The key to the three modes per parameter is listed in Table 8.1.3.

In order to analyse this comprehensive set of soil health parameters from the Haney and PLFA tests, a range of key parameters were selected from both data sets that were seen as most relevant or applicable to be used in one single index or soil health value or indicator. The method used here was simply to count the number of parameters per mode for each sample as indicated in Table 8.1.4 as a more comprehensive measure or index of soil health. This method should be seen as an initial idea to develop a much more inclusive soil health index through rigorous testing, research and verification. The ideal index should be inclusive of all or most of the important or relevant parameters in the Haney and PLFA tests, but also including other relevant and key indicators, such as soil erosion, ground cover, water use efficiency, soil structure, slaking, infiltration rate, earthworms, etc.

Table 8.1.3. An indication of the soil health mode within selected Haney and PLFA parameters in Reitz

	Mode of soil health status within measured parameters	Haney SHI	CO_2-C Respiration ppm over 24 hours	Water Extractable Organic Carbon (ppm)	Soil Organic Matter (%)	Total Microbial Biomass	Total Fungal Biomass	Micro-bial Active Carbon MAC %	Mycorr-hizae (VAM) Biomass	Water Extractable Organic N (ppm)	Protozoa Biomass	Rhizobia Biomass	Diversity Index	Fungi : Bacteria
Sampling points or ecotopes	Survival mode	< 4.5	< 35	< 170	< 2	< 1500	< 50	< 30	< 20	< 8	< 8	< 20	< 1.1	<0.05-0.100
	Progression mode	4.6 - 10	36 - 75	171 - 350	2 - 3.5	1500 - 4000	50 - 300	30 - 50	20 - 100	8 - 19	8.1- 20	20 - 80	1.1 -1.5	0.110 - 0.300
	Regenerative mode	> 10.1	> 76	> 350	> 3.6	> 4000	> 300	> 51	> 100	> 20	> 20.1	> 120	> 1.6	0.310- >0.35
V Rooyens-woning CA and neighbour CT	CT	7.3	28	168	2.2	2995	222	17	37	12	8.5	0	1.4	0.174
	L1 (CA)	8.6	41	167	2.0	1580	25	25	0	11	0.0	0	1.1	0.044
V Rooyens-woning CA Sandy + Clay soils	L18 (CA)	4.2	16	89	0.6	1324	67	18	17	8	0.0	0	1.4	0.175
	L5 (CA)	6.8	29	126	1.3	1617	149	23	43	13	13.6	0	1.5	0.216
V Rooyens-woning and Neighbour Veld	Un-grazed	8.0	23	212	2.7	6449	990	11	220	14	91.1	237	1.7	0.313
	UHDG	17.5	95	311	2.2	7672	1298	31	244	18	94.3	0	1.5	0.379
	Conventional grazed	9.0	21	264	3	3913	418	8	83	16	27.1	0	1.5	0.242
Driefontein Sandy soils	Higher yield	15.8	88	263	2.4	6064	716	33	152	18	48.3	110	1.6	0.290
	Poor Yield	11.1	58	204	1.5	2529	57	29	0	13	0.0	0	1.1	0.062
	Veld	5.3	20	127	1.3	796	16	16	0	8	0.0	0	1.1	0.052

SOIL HEALT SOLUTIONS (W Pretorius)

Table 8.1.4. A mode count of the thirteen soil health parameters measured for each sample

Sample	Survival mode	Progression mode	Regenerative mode
Van Rooyenswoning (CA) and a neighbouring conventional (CT) farm			
CT Field	4	9	0
CA Field L1	7	6	0
Sandy Field L18	5	8	0
Clay Field L5	9	8	0
Un-grazed	5	8	0
UHDG	2	4	7
Conventional grazed	1	6	6
Driefontein			
Sandy, higher yield	4	7	2
Sandy, poor yield	0	5	8
Veld	6	6	1

These counts per mode were used to develop a rating system for the evaluations of the soil health progress per sample; each mode received a weight. The calculation was done as follows:

[(Survival count × 1) + (Progression count × 2) + (Regenerative count × 3)] = Total

The totals of the mode counts per sample were categorised according to the soil health index ratings shown in Table 8.1.5.

Table 8.1.5. Soil health rating categories (or index) to indicate the progression of soil health towards a regenerative stage

Rating	Description
1-13	Survival
14-19	Slightly progressing
20-26	Progressing
27-32	Slightly regenerative
33-39	Regenerative

Field and veld samples from the Reitz district were grouped separately in Table 8.1.6. The high yielding field at Driefontein had the highest rating of 34, which indicated that the soil health in that specific field is in a regenerative mode. It corresponds with the highest saving in inorganic nitrogen fertiliser for the next crop, as well as the farmer observation of annual higher yields. Veld under UHDG were rated slightly regenerative, the same as the natural veld, while the conventional grazed veld of Van Rooyenwoning's neighbour were still in a progressing stage.

Table 8.1.6. Soil health rating and additional information of samples collected in the Reitz district

Farm	Field	Rating	Interpretation of rating	Texture classification	Previous crop	Savings in inorganic N fertiliser for the next crop
Driefontein	Higher yield	34	Regenerative	Loamy Sand	Soy bean and winter CC	R452
Van Rooyenswoning neighbour	Conventional Field	22	Progressing	Sandy Loam	Soybean lost to hail	R256
Driefontein	Poor Yield	21	Progressing	Loamy Sand	Soy bean and winter CC	R316
Van Rooyenswoning	L5	21	Progressing	Loamy sand	Soybean	R306
Van Rooyenswoning	L1	19	Slightly progressing	Sandy Loam	Wheat, sunflower lost to hail; winter CC	R276
Van Rooyenswoning	L18	17	Slightly progressing	Sand	Soybean	R148
Van Rooyenswoning	Veld	31	Slightly regenerative	Loamy Sand		
Van Rooyenswoning	UHDG	31	Slightly regenerative	Loamy Sand		
Van Rooyenswoning neighbour	Veld grazed	24	Progressing	Loamy Sand		
Driefontein	Veld grazed	17	Slightly progressing	Loamy Sand		

CC = Cover crop mix

8.1.4. Conclusion

Baseline data were collected successfully and a rating system was developed and proposed for the evaluation of soil health progress in different field and veld situations. The rating system is seen as a first step in the development of a more comprehensive soil health index, but it should ultimately include critical parameters like water infiltration rate, run off, crop information, water use efficiency, erosion, soil structure, pH and other critical nutrients. More research is needed to develop the rating system to its full potential.

8.2. Assessment of soil health under different cropping systems at Vrede

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)
1. Monitoring and sampling	Soil sampling and analyses, soil probes and weather station data collection	Planning was done with Mr Izak Dreyer and Me Paula Lourens on the GPS Reference points. Took soil samples at Vrede in September2018. Weather and water probe data were monitored
2. Lab and data analyses	Samples submitted and analysed	Soil samples analysed by SHS. Analysed active C samples at UFS (31 October 2018).
3. Frequent meeting (project team)	Planning meeting to reflect on data and plan for season ahead	Feedback and planning meeting on 13 August.
4. Annual planning	Participate in annual meeting, discussing problems and possible solutions	Active discussions on the Whats App group
5. Annual report and admin (technical data)	Reporting as required and popular article once enough results have been acquired	Submitted 6-monthly report in February 2019 and annual report in September 2019
6. Participate in Awareness events	Create awareness of CA farming practices through events and reporting.	Presentation on Vrede Farmers Day 21 February 2019 Information Day on 13 August 2019

8.2.1. Background to the Vrede study area

The farmer co-worker, Mr Izak Dreyer, followed different rotation sequences with CA practises on three ecotopes on three different localities or farms in the Vrede district (see Table 8.2.1). The short descriptions of each ecotope are as follows:

- Skulpspruit - Sandy Loam to Loamy Sandy soils with clay from 14 to16 % in the topsoil.

- Cornelia Kibe - Sandy to Sandy Loam soils, with 4 to 14 % Clay in the topsoil.
- Goedgedagt ("Turfgrond") - Sand Clay to Sand Clay Loam, clay between 30 to 40 % in the topsoil.

Table 8.2.1. Crop sequences followed on the different selected Vrede ecotopes from 2015 to 2018

Ecotopes	Field name	Crop sequences			
		2015	2016	2017	2018
Skulpspruit	Rooi blok A	Soybean Winter CC	Maize	Soybean Winter CC	Maize
Skulpspruit	Rooi blok B	Soybean	Maize	Summer CC	Maize
Skulpspruit	Good Hope Baken	Maize	Soybean Winter CC	Summer CC	Soybean Winter CC
Skulpspruit	Bloekombos A	Summer CC	Soybean Winter CC	Maize	Maize
Cornelia Kibo	Rykers	Summer CC	Maize	Summer CC	Summer CC
Cornelia Kibo	Groot A	Winter CC	Maize	Summer CC	Maize
Cornelia Kibo	Groot B	Soybean	Maize	Summer CC	Maize
Goedgedagt	Silo	Summer CC	Summer CC	Maize	Summer CC
Goedgedagt	Winkel	Maize	Soybean	Summer CC	Soybean
Goedgedagt	Wilgerboom	Soybean	Maize	Soybean	Summer CC

CC = Cover crop mix

8.2.2. Methods

Additional soil sampling on GPS reference points (Table 8.2.2) was done in September 2019. Soil samples of neighbouring farmers, who apply conventional (CT) practises, were also included. Two veld samples were taken on the farms Goedgedagt and Cornelia Kibe as well. The samples were send to Soil Health Solutions for the PLFA and Haney soil health analyses. Additional analyses results are listed in Appendix 1, Table 2.

Table 8.2.2. GPS reference points sampled in the Vrede district

Farm	Sample name	GPS reference
Skulpspruit	Rooi blok A	29.021 44; -27.251 22
Skulpspruit	Rooi blok B	29.023 71; -27.253 00

Skulpspruit	Good Hope Baken	29.026 50; -27.253 70
Skulpspruit	Bloekombos A	29.025 25; -27.250 43
Skulpspruit	Bloekombos B	29.026 21; -27.251 76
Skulpspruit Neighbour	Conventional	29.024 01; -27.248 57
Cornelia Kibo	Rykers	28.914 93; -27.237 57
Cornelia Kibo	Groot A	28.915 36; -27.239 36
Cornelia Kibo	Groot B	28.912 67; -27.242 78
Cornelia Kibo	Veld	28.904 28; -27.239 53
Cornelia Kibo Neighbour	Conventional	28.919 25; -27.229 28
Goedgedagt	Silo	29.074 30; -27.224 75
Goedgedagt	Winkel	29.073 72; -27.229 26
Goedgedagt	Wilgerboom	29.080 03; -27.231 33
Goedgedagt	Veld	29.075 41; -27.223 54
Goedgedagt Neighbour	Conventional	29.69 ; -27.226 00

8.2.3. Results

Table 8.2.3 indicates the different soil health modes of each sample that was analysed. Goedgedagt has “turfgrond’, with high clay percentages and showed the best progress towards soil health in terms of counts in the regenerative mode.

Rating results in Table 8.2.4 were listed from high to low per ecotope. The Veld samples of Cornelia Kibe and Goedgedagt ecotopes have higher soil health ratings, respectively 24 and 36, than the rest of the samples on those two ecotopes. The highest aggregate stability measured on Skulpspruit (17%) and Goedgedagt (56%) seem to correlate with the highest saving on inorganic nitrogen fertiliser (R208 and R314) for the next crop.

Table 8.2.3. An indication of the soil health mode within selected Haney and PLFA parameters at Vrede

		Soil Health Index SHI	CO2-C Respiration ppm over 24 hours	Water Extractable Organic Carbon ppm	Soil Organic Matter %	Total Microbial Biomass	Total Fungal Biomass	Microbial Active Carbon MAC %	Mycorrhizae (VAM) Biomass	Water Extractable Organic N ppm	Protozoa Biomass	Rhizobia Biomass	Diversity Index
Soil Health mode	Survival mode	< 4.5	< 35	< 170	< 2	< 1500	< 50	< 30	< 20	< 8	< 8	< 20	< 1.1
	Progression mode	4.6 - 10	36 - 75	171 - 350	2 - 3.5	1500 - 4000	50 - 300	30 - 50	20 - 100	8 - 19	8.1- 20	20 - 80	1.1 -1.5
	Regenerative mode	> 10.1	> 76	> 350	> 3.6	> 4000	> 300	> 51	> 100	> 20	> 20.1	> 120	> 1.6
Skulpspruit	Conventional	5.6	24	113	2.0	1554	24	21	0	9	0	0	1.11
	Rooi A	6.7	24	151	1.5	2611	162	16	35	13	0	0	1.35
	Rooi B	6.4	25	144	1	1556	136	17	37	11	9	0	1.46
	Good Hope Baken	6.1	23	136	1.4	1341	25	17	0	10	0	0	1.12
	Bloekom A	5.8	21	140	0.9	1683	19	15	0	9	0	0	1.10
Cornelia Kibo	Conventional	5.8	17	144	2.4	1083	14	12	0	12	0	0	1.09
	Summer CC	7.7	31	173	1.6	2007	64	18	0	12	0	0	1.19
	Winter CC	5.6	22	122	0.7	2412	80	18	35	12	0	0	1.26
	Soybean	6.7	25	154	1.0	1402	19	16	0	11	0	0	1.06
	Veld	12.7	57	260	3.3	3396	206	22	81	18	0	0	1.31
Goedgedagt	Conventional	18.7	174	148	5.8	4045	230	117	82	13	3	0	1.33
	Summer CC	12.1	78	158	4.2	2346	197	50	63	11	9	0	1.41
	Maize	13.9	120	145	4.2	2820	254	82	95	11	10	0	1.43
	Soybean	18.6	166	180	4.1	4843	364	92	135	12	12	0	1.38
	Veld	37.5	387	533	8.2	9930	1412	73	265	27	52	44	1.46

Table 8.2.4. Soil health rating and additional information of samples collected in the Vrede district

Ecotope	Field	Rating	Interpretation of rating	Aggregate Stability	Previous crop	Savings in inorganic N fertiliser for the next crop
Skulpspruit	Rooiblok B	21	Progressing	7	Summer CC	R 183
Skulpspruit	Rooiblok A	20	Progressing	17	Soybean and winter CC	R 208
Skulpspruit Neighbour	Conventional	18	Slightly progressing	13	Soybean	R 201
Skulpspruit	Good Hope Baken	17	Slightly progressing	12	Summer CC	R 178
Skulpspruit	Bloekombos A	17	Slightly progressing	10	Maize	R 135
Cornelia Kibe	Veld	24	Progressing	41	Veld	R 404
Cornelia Kibe	Groot A	20	Progressing	17	Summer CC	R 178
Cornelia Kibe	Rykers	19	Slightly progressing	17	Summer CC	R 211
Cornelia Kibe Neighbour	Conventional	18	Slightly progressing	17	Soybean	R 143
Cornelia Kibe	Groot B	17	Slightly progressing	7	Summer CC	R 176
Goedgedagt	Veld	36	Regenerative	64	Veld	R 667
Goedgedagt	Wilgerboom	32	Slightly regenerative	41	Soybean - Hail damage	R 304
Goedgedagt	Winkel	28	Slightly regenerative	41	Summer CC	R 266
Goedgedagt Neighbour	Conventional	28	Slightly regenerative	56	Soybean	R 314
Goedgedagt	Silo	27	Slightly regenerative	45	Maize	R 286

8.2.4. Conclusion

Indications are that the rating system can be applied over different sites or ecotopes under different conditions or cropping systems. However, it should include other relevant soil parameters.

8.3. Dung beetle monitoring in Riemland and Vrede study areas

Work period	October 2018 to September 2019
Lead partner	ARC (Dr Astrid Jankielsohn)
Involved partners	Riemland and Vrede study groups and other Innovation Platform (IP) partners
Objectives	• To monitor species/size/functional diversity within the dung beetle assemblage in an intensively grazed pasture system compared to a conventional pasture system. • To monitor species/size/functional diversity within the dung beetle assemblage in a crop ecosystem with cover crops compared to a conventional monoculture crop system. • To (statistically) analyse and report the results of the dung beetle composition in an intensively grazed pasture system. • To (statistically) analyse and report on the results of the dung beetle composition in a crop ecosystem with cover crops. • To create models for these systems that can be applied to other systems.

Justification	Dung beetle populations are essential components of any grazing ecosystem. Dung beetle activity in the soil is essential for soil health. There are about 4000 documented dung beetle species, which play an important role in the decomposition of dung. Dung beetles are principally important in the maintenance of ecosystem health by burying dung, which has the effect of removing surface wastes and recycling nutrients that can be used by plants. Dung beetles contribute to soil health by increasing nitrogen, phosphorous, potassium, calcium and magnesium or total proteins content and also contribute to the carbon cycle reducing GHG emissions, by carrying carbon into the soil. Dung beetle assemblages can therefore be used as bio-indicator of the health of a specific system. Monitoring the dung beetle assemblage in an area can designate the ecological status of an area. Using dung beetles can therefore indicate whether the CA systems are beneficial for soil health and as a result will improve the diversity in the system. In the case of crop ecosystems the presence of a diverse dung beetle assemblage can increase soil health in this system and as a result increase the yield of the crop.

Description of work	Monitoring of dung beetle assemblages in intensively grazed ecosystems as well as crop ecosystems in collaboration with the activities of the farmers.

Activities	i) Bi-monthly monitoring of dung beetles in both grazing and crop ecosystems by using dung baited pitfall traps. ii) Sorting, identification, and counting of collected samples. iii) Analysing data and calculating diversity indices. iv) Creation of ecological models

Deliverables	i) Reverence collection of dung beetle species in the area. ii) Report on species/functional/size diversity of dung beetle activity in the soil. iii) Analysis of ecosystem health by using dung beetle assemblages as bio-indicators. iv) Creation of models that can be applied in other systems.

Risks	Adequate involvement and participation of farmers

ACTIVITIES AND DELIVERABLES

Activities	Deliverables
i) Bi-monthly monitoring of dung beetle assemblages	Monitoring of dung beetle assemblages using dung baited pitfall traps at six sites at Reitz and six sites at Vrede.
ii) Sorting, identification, and counting of collected samples	Samples are sorted and identified to species level. A reference collection is established from these samples to determine the existing species occurring in the particular ecosystem.
iii) Analysis of data and calculation of diversity indices	The identified species from collected samples are used to calculate different diversity indices to determine the dominance, evenness, relative abundance of each species and species richness and functional diversity in each of the systems.
iv) Creation of ecological models	The analysed data and diversity indices are used to establish an ecological model to describe the different systems. This model can be applied to other systems.

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)
i) Bi-monthly monitoring of dung beetle assemblages	Monitoring of dung beetle assemblages using dung baited pitfall traps at six sites at Reitz and six sites at Vrede.	Dung beetle assemblages was successfully monitored at 6 sites at Reitz and 6 sites at Vrede on 15-18 October 2018; 4-8 December 2018; 11-14 February 2019; 13-16 May 2019 and 15-18 July 2019.
ii) Sorting, identification, and counting of collected samples	Samples are sorted and identified to species level. A reference collection is established from these samples.	Samples collected were sorted and identified. A reference collection of the identified dung beetle species was established. 17 Dung beetle species belonging to 7 genera and 6 functional groups were collected at the sites in Reitz (Table 8.3.1) and 17 Dung beetle species belonging to 7 genera and 5 functional groups were collected at the sites in Vrede (Table 8.3.2).
iii) Analysis of data and calculation of diversity indices	The identified species from collected samples are used to calculate different diversity indices to determine the dominance, evenness, relative abundance, species richness and functional diversity in each of the systems.	The counts of the identified dung beetle species were used to calculate three different diversity indices: Berger Parker (1/d), Simpson (C), and Margalef (D) for each site (Table 8.3.3). The functional group structure was also determined for each site. Reitz:

		The dominance was high in the CA system at Reitz, resulting in a low diversity value for 1/d and 1-C (Fig. 8.3.1). This indicates disturbance in the ecosystem. The species richness was average resulting in a higher D value (Fig. 8.3.1). The value for 1/d and 1-C was also low for both grazing systems, while species richness was higher in the intensively grazed system than the normal grazed system (Fig. 8.3.1). The functional diversity was low with only two FG out of seven represented in the dung beetle assemblage in the CA system at Reitz (Table 8.3.4). In the intensive grazing system the functional diversity was average with the dung beetle assemblage represented by 4 FG, while the normal grazing system was represented by 3 FG (Table 8.3.4). Vrede: The dung beetle species in the CA systems at Vrede were evenly distributed resulting in a relatively high value for 1/d and 1-C, while the species richness was high (Fig. 8.3.2). The functional diversity was average with four out of seven FG represented in the CA system at Vrede (Table 8.3.5).
iv) Creation of ecological models	The analysed data and diversity indices are used to establish an ecological model to describe the different systems. This model can be used in other systems.	The CA and CT sites monitored at Reitz and Vrede have a too short distance between the different sites that are compared (1-3 km). To compare two different ecosystems for biodiversity monitoring the systems need to be at least 20km apart. To overcome this challenge additional localities, spaced further apart, will be added to the monitoring sites. An ecosystem where there is minimal disturbance and high diversity will be used as a control and an additional CA locality will be added. Using the three CA localities (Reitz, Vrede and Heidelberg) the diversity in these ecosystems will be expressed as a percentage of the diversity in the minimal disturbed ecosystem. This can then be used to create a

		model with a scale between 1 and 9, where 1 is a highly disturbed system with low biodiversity and 9 is a minimally disturbed system with high biodiversity. This model can then be applied to any ecosystem to determine where on this scale it lies. This scale can then be applied to determine increase in biodiversity in systems over time.

Table 8.3.1: Dung beetle species occurring at different sites in the Reitz area from October 2018 to July 2019 (CA-Conservation Agriculture; CT-Conventional Agriculture; G-Conventional Grazing; IG-Intensive Grazing, or UHDG).

	FG	Sites					
		1 (CA)	3 (G)	7 (IG)	9 (G)	10 (CT)	11(CA)
Gymnopleurus fulgidus F.	II			1			
Onitis caffer	III			1	3		
Onthophagus binodis	IV	2	2	16	13	7	5
Onthophagus obtusicornis	IV		6	8		2	2
Onthophagus aeroginosus	IV				1		
Onthophagus fimentarius	IV	15	22	47	64	53	25
Othophagus pilosus	IV		3				
Euniticellus africanus	IV				2	1	1
Euniticellus intermedius	IV		1	1	1	2	
Liatongus militaris	IV			1		1	
Onthophagus variegatus	V			3		42	
Onthophagus suggillatus	V					21	
Caccobius seminulum	VI			1			
Aphodius pseudolividus	VII	30	2	1	4	4	2
Aphodius calcaratus	VII	8	3				
Aphodius teter sensu lato	VII	2			6		1
Rhysemus africanus	VII					3	

Table 8.3.2: Dung beetle species occurring at different sites in the Vrede area from October 2018 to July 2019 (CA-Conservation Agriculture; CT-Conventional Agriculture)

	FG	Sites					
		8 (CT)	19(CA)	10 (CA)	13 (CT)	14 (CA)	18(CT)
Sisyphus macroruber	II					1	
Onthophagus binodis	IV	4	3	1	3	3	
Onthophagus obtusicornis	IV	2	43	6	4	4	7

	FG	Sites					
		8 (CT)	19(CA)	10 (CA)	13 (CT)	14 (CA)	18(CT)
Onthophagus aeroginosus	IV			3			
Onthophagus fimentarius	IV		7				
Euniticellus africanus	IV		1	1	1		
Euniticellus intermedius	IV	1	3		2	2	1
Liatongus militaris	IV		2				1
Onthophagus variegatus	V		3				
Onthophagus suggillatus	V		3	3			
Caccobius seminulum	VI		2				
Aphodius pseudolividus	VII	7	69	6	3	3	
Aphodius calcaratus	VII		1				
Aphodius teter sensu lato	VII		1				
Aphodius impurus	VII		1				
Aphodius discoidalis	VII		2				
Drepanocanthus eximius	VII			1			

Table 8.3.3. Diversity indices and measurement

Diversity index	Measures
Berger Parker (1/d)	Dominance
Simpson (1-C)	Relative abundance of each species
Margalef (D)	Species richness

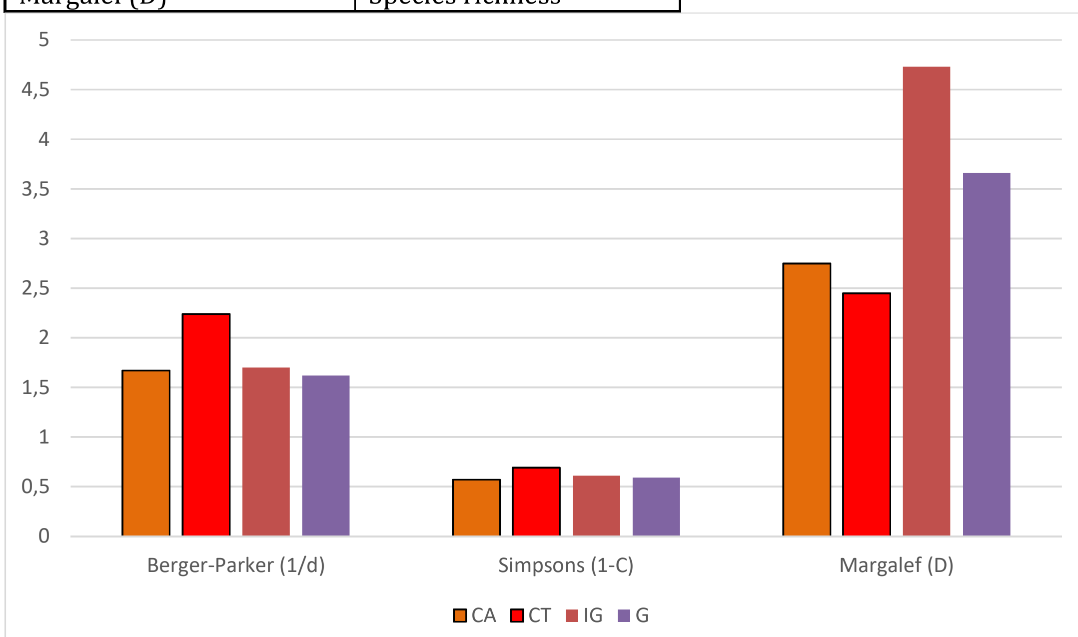

Fig. 8.3.1. Physical diversity in dung beetle assemblages in CA systems compared to CT systems in the Reitz area (CA-Conservation Agricultural system; CT-Conventional Agricultural system; IG-Intensively grazed system; G-Normal grazed system).

Table 8.3.4. Functional diversity in a dung beetle assemblage in CA systems compared to CT systems in the Reitz area.

Reitz 2019	FG	S	Nt
CA	IV	6	50
	VII	5	43
CT	IV	5	65
	V	3	64
	VII	2	7
IG	III	1	1
	IV	6	74
	V	1	3
	VII	1	1
G	III	1	1
	IV	6	116
	VII	3	15

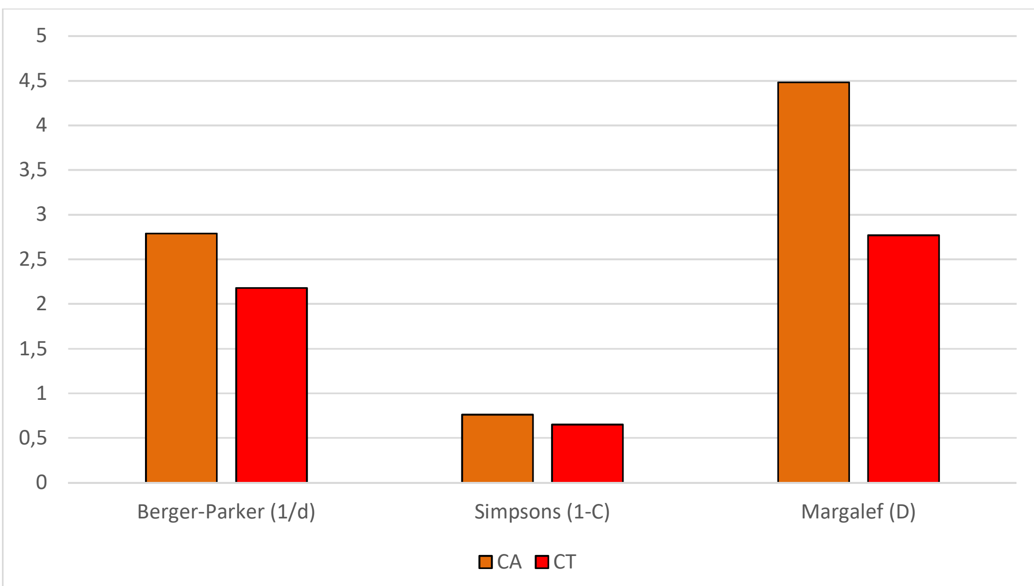

Fig. 8.3.2. Physical diversity in dung beetle assemblages in CA systems compared to CT systems in the Vrede area.

Table 8.3.5 Functional diversity in a dung beetle assemblage in CA systems compared to CT systems in the Vrede area.

Vrede 2019	FG	S	Nt
CA	IV	6	78
	V	3	64
	VI	1	2
	VII	6	84
CT	IV	5	26
	VII	1	10

Conclusion

To benefit from the ecosystem function of a dung beetle assemblage in an ecosystem both the physical and functional diversity needs to be high. Ideally there will have to be representatives of each of the seven functional groups in the assemblage or at least species representing one of FGI, II or III together with FG IV, V and VII. The physical diversity in the CA systems at Reitz was low with high dominance and uneven distribution of species. The functional diversity was also low with only two FG represented and average in the intensively grazed system with four of the seven FG represented. The CA systems at Vrede had a relatively high physical diversity with species evenly distributed. The functional diversity was average, but there were no representatives of FGI, II or III. With improvement of soil structure, combined with increased diversity both in plants and herbivores and the incorporation of undisturbed, semi-natural areas, the physical and functional diversity in the dung beetle assemblages in these systems can improve.

8.4. Assessment of soil ecosystem health with nematodes as bioindicators

Work Package title	**Assessment of soil ecosystem health with nematodes as bioindicators**

Work period	October 2018 to September 2019
Lead partner	North-West Universtity (Dr. Gerhard du Preez, Prof. Driekie Fourie and Ms. Ane Loggenberg)
Involved partners	Grain SA, Riemland & Ascent study groups

Objectives	• Measure the soil ecosystem health in conservation and conventional croplands, as well as natural veld, in different agroecological regions using nematodes as bioindicators. • Statistically analyse and report the results in a report to GrainSA.

Justification	Conventional farming practices is associated with many environmental ills including the reduction of soil diversity, loss of organic matter, and release of environmental contaminants (from excess fertilizer and pesticide application). Alternative approaches, e.g. conservation agriculture, focus on the restoration of soil health and promoting long-term sustainability. However, conservation agriculture is knowledge-intensive and the more we learn about how agricultural activities impact soil ecosystems, the better we can mitigate and prevent the adverse effects. Nematodes (mesofauna), for example, are abundant in soils and fulfil important ecosystem functions. It is estimated that every four out of five multicellular animals on planet Earth are nematodes. Furthermore, they occupy any niche that provides an available source of organic carbon in marine, freshwater and terrestrial environments. In soil environments, nematodes occupy most of the trophic levels (e.g. herbivores, grazers and predators) and present varying sensitivity. Therefore, due to its ecological relevance, this faunal group is used as indicators of food web status, anthropogenic disturbance, faunal activity, and nutrient channeling.

Activities	7. Collecting of soil samples from conventional and conservation croplands, as well natural veld, in the Reitz and Vrede areas. 8. Extraction, identification and counting of nematodes. 9. Statistical analysis and interpretation of results. 10. Reporting of results at farmers' days and conferences. 11. Writing of Grain SA report.

Risks	Spatial and temporal variation of biotic and abiotic attributes of soil health.

Progress with activities

Activities	**Progress and results achieve**
7. Collecting soil samples	Samples from all the selected fields and veld were collected in July 2019.
8. Extraction, identification and counting of nematodes	Nematodes were extracted, counted and identified to family level. This was completed 9 August 2019.
9. Statistical analysis	Analysis of results were performed on 12 August 2019.

10. Knowledge dissemination	Results were presented to Riemland and Ascent study groups on the 13th and 14th of August 2019, respectively.
11. Report writing	Final report to Grain SA completed 2 September 2019.

8.4.1. Samples collected and nematodes extracted at Reitz and Vrede (July 2019)

From selected farms in the Reitz and Vrede areas, soil samples were collected from conservation (CA) and conventional (CT) agricultural fields, as well as natural veld [Reitz (Table 8.4.1); Vrede (Table 8.4.2)]. Nematodes were extracted, identified (up to family level) and counted [Appendix 2: Reitz (Table 8.4.A1); Vrede (Table 8.4.A2)] after which nematode-specific indices were calculated (see next section). This information was used to obtain an indication of the soil quality/health of the sampled fields in terms of beneficial nematodes (not infecting and feeding on crops/plants).

Table 8.4.1: Sampling sites, agricultural activities and coordinate locations associated with the Reitz area

Farm	Sample	Sample Name	Soil Texture Class	Location
Driefontein	1	Sand – High potential	Loam Sand	S27°47'21,60"; E028°33'10,8"
Driefontein	2	Sand Poor yield	Loam Sand	S27°47'25,00"; E028°33'10.5"
Driefontein	3	Veld Grazed	Loam Sand	S27°47'43,40"; E028°33'05,1"
Van Rooyenswoning	4	L18 Sand	Sand	S27°52'40,57"; E28°32'38.10"
Van Rooyenswoning	5	L5 Clay	Sand Loam	S27°53'25,37"; E28°32'51.91"
Van Rooyenswoning	6	L8 –High potential	Sand Loam	S27°53'06.02"; E28°32'25.98"
Van Rooyenswoning	7	Veld UHDG	Loam Sand	S27°54'09,68"; E28°31'59,15"
Van Rooyenswoning	8	Veld – ungrazed	Loam Sand	S27°53'57,66"; E28°3153,36"
Neighbour	9	Veld – Conventional grazed	Loam Sand	S27°54'16,35"; E28°31'51,57"
Neighbour	10	Conventional Field	Loam Sand	S27°54'33,51"; E28°32'0,.03"
Neighbour	11	Veld	Loam Sand	S27°54'11.40"; E28°31'55.50"
Van Rooyenswoning	12	CA L1 field	Sand Loam	S27°54'30.00"; E28°32'7.90"

Table 8.4.2: Sampling sites, agricultural activities and coordinate locations associated with the Vrede area

Farm	Sample	Sample Name	Soil Texture Class	Location
Skulpspruit	1	Rooi blok A	Sand Loam	S27°15'04.39"; E29°01'17.18"
Skulpspruit	2	Rooi blok B	Loam Sand	S27°15'10.80"; E29°01'25.35"
Skulpspruit	3	Good Hope Baken	Sand Loam	S27°15'13.32"; E29°01'35.40"
Skulpspruit	4	Bloekombos A	Loam Sand	S27°15'01.54"; E29°01'30.90"
Skulpspruit	8	Conventional Neighbour	Not analysed	S27°14'54.85"; E29°01'26.43"
Cornelia Kibo	9	Rykers	Sand	S27°14'15.25"; E28°54'53.74"
Cornelia Kibo	10	Groot A	Sand	S27°14'21.69"; E28°54'55.29"
Cornelia Kibo	11	Groot B	Sand	S27°14'34.00"; E28°54'45.61"
Cornelia Kibo	13	Conventional Neighbour	Not analysed	S27°13'45.40"; E28°55'09.30"
Goedgedagt	14	Silo	Sand Clay	S27°13'29.10"; E29°04'27.48"
Goedgedagt	15	Winkel	Sand Clay	S27°13'45.33"; E29°04'25.39"
Goedgedagt	16	Wilgerboom	Sand Clay	S27°13'52.78"; E29°04'48.10"
Goedgedagt	17	Veld	Sand Clay Loam	S27°13'24.74"; E29°04'31.47"
Goedgedagt	18	Conventional Neighbour	Not analysed	S27°13'33.60"; E29°04'08.72"

8.4.2. Soil ecosystem health

8.4.2.1. Framework for the classification of soil ecosystem health status

The faunal analysis is used to measure the status of the soil food web (Sieriebriennikov et al., 2014; Yeates et al., 2009). It relies on two nematode-specific measures, namely the enrichment and structure indices, both scored from 0 - 100. While the enrichment index represents the level of resource availability in the soil, the structure index serves as a measure of the complexity and stability of the soil ecosystem. Higher structure values are therefore indicative of healthier soils. The enrichment and structure indices are calculated by considering the trophic group(s) (bacterivore, fungivore, omnivore, and predators) and colonizer-persister classification (c-p) (Table 8.7.3) of beneficial nematodes present in the soil. The c-p classification series ranges from 1 to 5, concurrently ranging from the most tolerant to the most sensitive nematodes groups with regards to environmental disturbance.

Using the calculated structure and enrichment index values, a sample (from field or trial) is plotted in one of four quadrants (Figure 8.7.1), which reflects the food web status of that sample. Please consider Figure 8.7.1 for the food web characteristics of each quadrant.

Table 8.7.3: Characteristics of nematodes assigned a specific colonizer-persister (c-p) value. The trophic groups relevant to this classification system include bacterivores (Ba), fungivores (Fu), predators (Pr), and omnivores (Om)

	Life cycle	Offspring production	Trophic groups	Sensitivity
c-p 1	Short	High	Ba	Tolerant
c-p 2	Longer	Lower	Ba, Fu, Pr	Tolerant
c-p 3	Longer	Lower	Ba, Fu, Pr	More sensitive
c-p 4	Longer	Lower	Ba, Om, Pr	Greater sensitivity
c-p 5	Longest	Lowest	Om, Pr	Greatest sensitivity

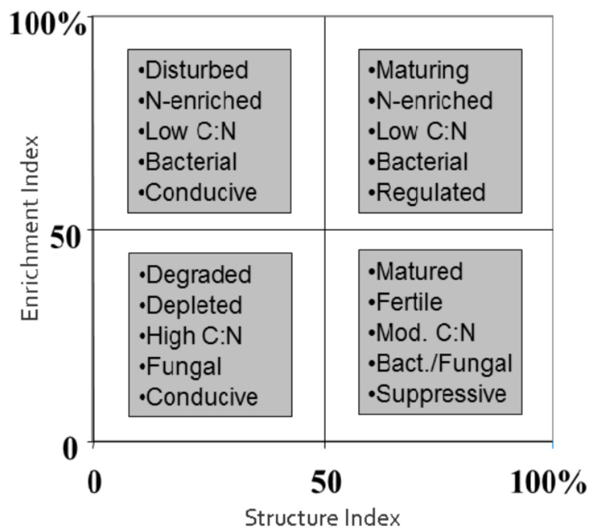

Figure 8.4.1: Criteria for interpreting the food web analysis scheme using beneficial nematodes as bioindicators (Ferris et al., 2001)

8.4.3. Results: soil ecosystem health status of collected soils in Reitz

The faunal analysis of soils collected from the Reitz area is presented in Figure 8.7.2, while additional information on the classification of the soil ecosystem status are provided in Table 8.7.4. Two farmlands, nl. **Driefontein (Sand)** and **Van Rooyenswoning (CA Land)**, were classified as degraded and depleted, while **Driefontein (Brak)**, **Van Rooyenswoning (Sand)** and **Van Rooyenswining (Hoë potensiaal)** were classified as disturbed and enriched. **Van Rooyenswoning (Klei)**, in turn, was classified as mature and fertile. The conventional fields and natural veld (Figure 8.7.2b) presented either degraded and depleted or maturing with moderate enrichment soil ecosystems.

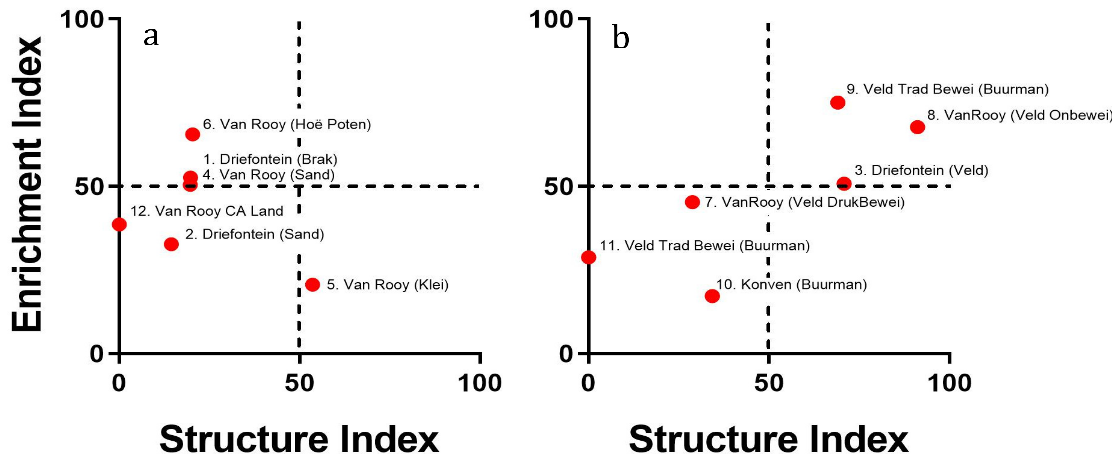

Figure 8.4.2: Food web analysis of soil samples from the Reitz area. This analysis is based on the occurrence and abundance of beneficial nematodes. This profile provides an assessment of the food web (soil ecosystem health) status based on the enrichment and structure indices

8.4.3.1. Level of disturbance

The Maturity Index serves as a measure of soil ecosystem disturbance and ranges on a scale from 1 (disturbed) to 5 (stable). Higher Maturity Index scores are therefore indicative of healthier soils, while lower values are indicative of disturbed soils (Yeates et al., 2009).

The Maturity Index values of the Reitz soils are presented in Table 8.4.4. This index indicated that **Van Rooyenswoning Veld (onbewei)** presented the least disturbed soils, followed by **Driefontein Veld (bewei)** and **Van Rooyenswoning L5 (Klei)**. The remainder of the soils presented greater ecological disturbance.

Table 8.4.4: The Maturity Index values of the Reitz soils

Farm	Sample	Sample Name	Soil ecosystem health status	Maturity Index
Driefontein	1	Sand – High potential	Disturbed, N-enriched, Low C:N ratio, Bacterial dominated	1.91
Driefontein	2	Sand Poor yield	Degraded, depleted, High C:N ratio, Fungal dominated	1.98
Driefontein	3	Veld Grazed	Maturing, Moderate enrichment	2.64
Van Rooyenswoning	4	L18 Sand	Disturbed, N-enriched, Low C:N ratio, Bacterial dominated	1.97
Van Rooyenswoning	5	L5 Clay	Matured, Fertile, Moderate C:N ratio, Bacterial and fungal	2.43
Van Rooyenswoning	6	L8 –High potential	Disturbed, N-enriched, Low C:N ratio, Bacterial dominated	1.79
Van Rooyenswoning	7	Veld UHDG	Degraded, depleted, High C:N ratio, Fungal dominated	2.03
Van Rooyenswoning	8	Veld – ungrazed	Maturing, Moderate enrichment	3.37
Neighbour	9	Veld – Conventional grazed	Degraded, depleted, High C:N ratio, Fungal dominated	1.96
Neighbour	10	Conventional Field	Degraded, depleted, High C:N ratio, Fungal dominated	2.19
Neighbour	11	Veld	Maturing, Moderate enrichment	2.18
Van Rooyenswoning	12	CA L1 field	Degraded, depleted, High C:N ratio, Fungal dominated	1.91

8.4.4. Results: soil ecosystem health status of collected soils in Vrede

The faunal analysis of soils collected from the Vrede area is presented in Figure 8.7.3, while additional information on the classification of the soil ecosystem status are provided in Table 8.7.5.

Farmlands including **Skulpfontein** (**Rooi blok A**, **Rooi blok B** and **Bloekombos A**), **Cornelia (Rykers)** and **Goedgedagt (Winkel)** were classified as degraded and depleted, while **Skulpfontein (Good Hope Baken)**, were classified as disturbed and enriched. **Cornelia** (**Groot A** and **Groot B**) and **Goedgedagt (Wilgerboom)**, in turn, were classified as maturing with moderate enrichment. **Goedgedagt (Silo)** was classified as mature and fertile. The conventional fields (Figure 8.7.3b) ranged from degraded and depleted to maturing with moderate enrichment, while the natural veld was classified as mature and fertile.

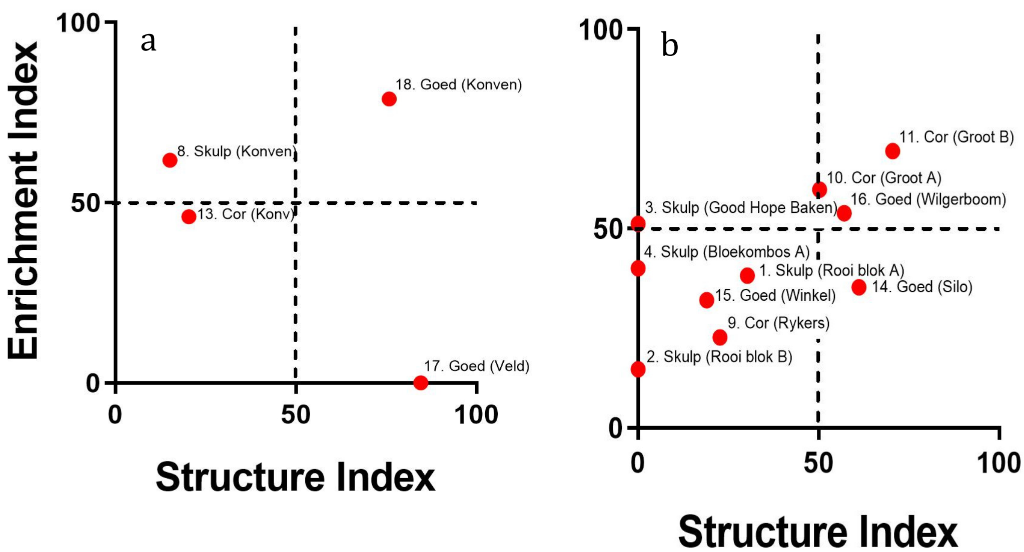

Figure 8.4.3: Food web analysis of soil samples from the Reitz area. This analysis is based on the occurrence and abundance of beneficial nematodes. This profile provides an assessment of the food web (soil ecosystem health) status based on the enrichment and structure indices

8.4.4.1. Level of disturbance

The Maturity Index values of the Vrede soils are presented in Table 8.7.5. This index indicated that **Goedgedagt (Veld)** presented the least disturbed soils, followed by **Goedgedagt (Silo), Cornelia (Groot B), Goedgedagt (Wilgerboom)** and **Goedgedagt (Konvensioneel Buurman)**. The remainder of the soils presented greater ecological disturbance.

Table 8.4.5: Faunal analysis and maturity index of soils collected from the Vrede area. Indices calculated using nematodes as bioindicators of soil ecosystem health.

Farm	**Sample**	Sample Name	**Soil ecosystem health status**	**Maturity index**
Skulpspruit	1	Rooi blok A	Degraded, depleted, High C:N ratio, Fungal dominated	2.05
Skulpspruit	2	Rooi blok B	Degraded, depleted, High C:N ratio, Fungal dominated	2.00
Skulpspruit	3	Good Hope Baken	Disturbed, N-enriched, Low C:N ratio, Bacterial dominated	1.81
Skulpspruit	4	Bloekombos A	Degraded, depleted, High C:N ratio, Fungal dominated	1.98
Skulpspruit	8	Conventional Neighbour	Disturbed, N-enriched, Low C:N ratio, Bacterial dominated	1.81
Cornelia Kibo	9	Rykers	Degraded, depleted, High C:N ratio, Fungal dominated	2.09
Cornelia Kibo	10	Groot A	Maturing, Moderate enrichment	2.10
Cornelia Kibo	11	Groot B	Maturing, Moderate enrichment	2.33
Cornelia Kibo	13	Conventional Neighbour	Degraded, depleted, High C:N ratio, Fungal dominated	1.98
Goedgedagt	14	Silo	Matured, Fertile, Moderate C:N ratio, Bacterial and fungal	2.47
Goedgedagt	15	Winkel	Degraded, depleted, High C:N ratio, Fungal dominated	2.06
Goedgedagt	16	Wilgerboom	Maturing, Moderate enrichment	2.29
Goedgedagt	17	Veld	Matured, Fertile, Moderate C:N ratio, Bacterial and fungal	3.33
Goedgedagt	18	Conventional Neighbour	Maturing, Moderate enrichment	2.26

8.4.5. Concluding remarks

The conservation agriculture fields from the Reitz and Vrede areas presented varying levels of soil ecosystem health, which generally ranged from degraded and depleted to mature and fertile. Although all the fields did not present healthy ecosystems, the classification of some field ecosystems as maturing or mature is a positive indication. Keeping in mind that soil ecosystems can take years to recover following anthropogenic disturbance, it is advised that the monitoring of the fields is continued in order to generate long term data on the rate of ecosystem recovery. If possible, also monitoring the fields during the summer growing and rainy season will allow the evaluation of seasonal effects on soil ecosystem health.

8.4.6. References

Ferris, H., Bongers, T., De Goede, R.G.M., 2001. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. Appl. Soil Ecol. 18, 13–29.

Sieriebriennikov, B., Ferris, H., de Goede, R., 2014. NINJA: an automated calculation system for nematode-based biological monitoring. Eur. J. Soil Biol. 61, 90-93.

Yeates, G., Ferris, H., Moens, T., Van der Putten, W., 2009. The role of nematodes in ecosystems, in: Wilson, M.J., Kakouli-Duarte, T. (Eds.), Nematodes as Environmental Indicators. CABI Publishing, Wallingford, pp. 1-44.

8.5. Assessment of cover crop adaptability and suitability for soil health and livestock integration

Work package

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

Work Package period	October 2018 to September 2019
Lead partner	Independent researcher (Mr. Gerrie Trytsman)
Involved partners	Grain SA, Riemland & Ascent study groups / IP's

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

Justification	Cover crops offer many benefits for agriculture productivity and sustainability while reducing off farm environmental effects. For agricultural productivity, sustainability and soil health these include: erosion control, compaction remediation, increased water infiltration and storage, improved soil biodiversity, increased organic matter, nitrogen fixation, and improved nutrient recycling and retention of macro and micro nutrients. Environmental benefits include: reduced nutrient leaching, reduced sediment and phosphorus deposition, reduced runoff, and increased carbon sequestration; while suppression of weeds, diseases and nematodes and improved beneficial insect habitat results in reduced pesticide use. Other conservation benefits include: pollinator enhancement, wildlife enhancement as well as aesthetic value (Stivers-Young and Tucker, 1999; and Snapp *et al.,* 2005). The use of no-tillage systems greatly increases the benefits of cover crops and vice versa. No-till systems increases water conservation by maintaining cover crop residues on the surface. No-till systems reduce the disruption of the soil reducing: soil erosion, water runoff, organic matter oxidation and increases infiltration and all 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 only some of the many details of farming that changes when converting 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.

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.)

Progress with activities

Activities	Deliverables	Progress and results achieve
1. Land preparation	Weeding and management of cover crops prior to planting.	Trial plots were selected on the farms of Izak Dreyer (Skulpspruit, Vrede) and Danie Slabbert (Van Rooyenswoning, Reitz). Both farmers sprayed herbicide before planting the Sorghum and mixture trials. Izak sprayed Round-up and Danie sprayed Paraquate.
2. Purchase Materials & Equipment	Acquisition of seed, inoculum, stickers, implements, chemical inputs.	Seed was purchased from the different seed companies (K2, Barenbrug, AGT and Agricol) and was delivered to farmers in October. Trial was discussed in detail and possible outcomes that will be achieved.
3. Establishing and Planting of trials	Establish trial according to the field plan.	Both farmers used commercial planters. Both vacuum and tine planters are used. Good seed to soil contact will increase success. Izak Dreyer planted middle December with a Great plain planter 25cm rows, while Danie Slabbert planted end January with a Jumil 50cm planter.
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.	Both farms were visited on 7 and 8/01/2019 inspecting the fields where the trial would be planted. The lay-out was discussed. The different seed crosses were placed next to each other in the field trial for evaluation purposes. Danie had to buy special seed plates for planting the sorghum trial. Izak had problems with weed. A decision was taken to let young bulls consume the herbage to get the weed count lower. A winter cover crop mixture was then established.

	Photos from trial during visits	Izak applied 2 tons of chicken manure to the site at planting. Also applied top-dress N. The latter gave rise to problems of nitrate poisoning. Four cattle were lost. Photos were taken when visiting the trials to monitor progress. Part of the trial was grazed by livestock at Izak after the first harvest. Later in the season the grazed part was harvested to measure the regrowth. At Danie the trial was harvested only once. Hail damaged the crop during March.
5. Monitoring and Sampling	Completed data sheets for 1. Input cost 2. Germination 3. Cover % 4. Height of cover of each addition 5. Biological productivity t/ha^{-1}	Determine germination density of the treatments at Danie Slabbert on the 31/01/2019. Did a veld survey with Frits van Oudtshoorn. Harvest trial at Izak, first cut for the sorghums and the mixtures. Dry samples to determine DM at Roodeplaat. Report back on the findings were done in August.
6. Lab Analyses	C:N content of plant material	Veld samples were dried to determine DM for the veld grazing at Danie. Took leave samples for analysis to Penny Barnes at Irene. Sample for N analyses were also supplied to ACR-SCW.
7. Monthly meetings (project team) & Training	Partake in monthly forum meetings, discussing problems and possible solutions to that.	Constant communication with Andre in regards to UHDG on sorghums. Information day held at Danie was attended. Simon Hodgson and Adlington were guest speakers.
8. Annual reference group meeting (advisory committee)	Report progress and findings to advisory committee. Discussion and evaluation of trials. Learning from previous mistakes.	A presentation was given during a farmer's day at I. Dreyer's farm. One article was written for the Grain SA magazine. Similarly, one for LBW. Also helped Mr Dreyer with his fertilizer rate of maize. Discussed next year's trial with both farmers.
9. Annual report and admin (production & technical data)	Written a technical report covering trial procedures, results and progress.	Technical progress report was submitted by middle March. Technical progress report will be submitted in September.

10. Participate in Awareness events	Trial visits with stakeholders; participate in awareness events, such as information day and/or cross-visits.	Technical report back at a field site at the farmer's day. Wrote an article for the LBW on crop livestock integrated systems Report back on DM and morphological traits of sorghum given during August report back session.

8.5.1. Background

This year the focus of research shifted to screening trials of sorghum and the evaluation of summer cover crop mixtures from four seed companies. The main reason for the sorghum screening trial was that summer cover crop mixtures almost always contain sorghum type annual grasses. These grasses supply the bulk of the biomass production and are of great importance to animal production. The price difference between varieties can differ significant, up to 1500%. When grazed, these grasses are stimulated to produce additional roots which stimulate the production of aggregates in the soil. With stems that have a high C:N ratio the mulch created by sorghum protects the soil against surface compaction and run-off.

To stimulate cover crop interest, the seed companies were also requested to enter a summer cover crop mixture for evaluation. This mixture was planted at all the sites next to the different accessions of summer grass or sorghum type cultivars.

Treating cover crops as a cash crop is deemed important to get optimal benefit from the activity. Only then biomass production, resource restoration and animal production will positively impact the system as a whole. In the report we argue that Skulpspruit, the farm of Izak dreyer, can be seen as a best practise situation in terms of optimal production of sorghum and the trial planted at Van Rooyenswoning as less than optimal scenario as describe in Table 8.51.

Table 8.5.1: Planting scenarios at two locations

Skulpspruit (Vrede)	Van Rooyenswoning (Reitz)
Planting took place on the 12/12/2019 and a Great Plain planter with a row width of 25cm was used. The soil type is a Clovelly soil form with a yellow-brown apedal (structureless to weak structure) B-horizon. A plant density of between 11 and 13 kg/ha were used. Weeds were controlled using 2.2lit of Roundup before planting. For fertilizer management 2 tons of chicken manure was applied and a further 60kg of N top dressed with fertilizer. Problems encountered during the trial period includes drought and weeds during the early part.	Planting took place after wheat was harvested late January. Planting was done using a Jumil 50cm planter. The soil type is a shallow Westleigh soil form (70cm deep). A plant density of 10kg/ha was used to establish the trial. Paraquate was sprayed at a rate of 2lit/ha and no fertilizer was used during the trial period. Problems encountered during the trial period include late planting, weeds and hail.

Four different seed companies were approached to supply us with their best performing sorghum type seed. Most of them supplied us with four different types which include babala, sorghum sudan crosses, sweet sorghum and sudan grass. In table 8.5.2 the cultivars, their pedigree, species and price is mentioned for clarity.

Table 8.5.2: Cultivars used in the screening trial

Cultivars	Pedigree	Species	Price/kg
Millet (BAR)	Pearl millet	*Pennisetum* spp.	R 9.60
Millet (AGT)	Pearl millet	*Pennisetum* spp.	R 18.00
Okashana (Agricol)	Pearl millet	*Pennisetum* spp.	R 18.72
Pearler (BAR)	Hybrid millet	*Pennisetum* spp. X	R 148.00
Agrigreen (Agricol)	Hybrid millet	*Pennisetum* spp. X	R 48.00
Sugargraze (K2)	Sweet sorghum	Sweet sorghum X	R 60.00
Sweetfeed (AGT)	Sweet sorghum	Sweet sorghum X	R 36.00
Barsweet (BAR)	Sweet sorghum	Sweet sorghum X	R 53.50
Hunnigreen (Agricol)	Sweet sorghum	(PPS) Sweet sorghum X	R 77.50
Bargrazer (BAR)	Sorghum X Sorghum	Sorghum X	R 10.75
Supergraze (AGT)	Sorghum X Sudan	Sorghum X Sudangrass	R 10.00
AgFlash (Agricol)	Sorghum X Sudan	Sorghum X Sudangrass	R 15.20
Sentop (K2)	Sorghum X Sudan	Sorghum X Sudangrass	R 10.80
Nutritop plus (K2)	Sorghum X Sudan	(BMR) Sorghum X Sudangrass	R 58.00
K2 sudan (K2)	Sudan X Sudan	Sudangrass X	R 34.00

Key: BAR – Barenbrug; AGT – AGT seeds; K2 – K2 Agric

Gaps analysis 2018: There is a need to look at individual crops and the genetic diversity within species. For the 2018/19 season a decision by the different role players were taken to include a principal crop, such as sorghum. Sorghum (sweet and general), sorghum crosses, sudan grass, sudan grass crosses with BMR mutations genes, as well as babala and hybrid babala will be researched. This decision was taken on the basis that most of the summer mixtures used as cover crops contain various amounts of summer annual grasses. The difference in cost of these cultivars are huge. The focus of the study will include the regrowth potential, biomass, cyanide poisoning potential of the different treatments.

At Ascent the producer Izak Dreyer planted the sorghum trial and mixtures of the different seed company's fairly early, in middle December 2018. This year Izak planted a total of 560 ha of summer annual cover crops. At the Riemland study group the trial was planted at Danie Slabbert, late January 2019. This will give us as researchers and farmers some insight as to how planting dates influence the biological production of these different crops. Danie planted 18 ha of annual cool-season crops under irrigation after harvesting potatoes and a further 50 ha of summer annual crops to be grazed. Sorghum type crops are very sensitive for minimum temperature below 15 degrees.

The morphological data and the biomass for each addition of sorghum type treatment will be discuss in the report. We divided the 15 sorghums into eight groups which also include traits such as PPS (photoperiod sensitive), BMR (brown midrib trait) and also hybrid millet for the animal production qualities evaluation. We send samples of the different groups to Penny Barnes of the ARC to be tested for various nutritional values from the early harvest. Samples were also taken at Humanskraal from the full harvest treatment for nutritional analysis.

8.5.2. Characteristics of the different summer cover crop grasses or genotypes

8.5.2.1. Sweet sorghum

Sweet sorghum has a vigorous growth habit. Leaves are very coarse and resemble that of maize. Plants are typically tall and generally late in maturing. They have low tillering capacity and re-growth rate after cutting or grazing. They are not recommended for grazing; they are mainly harvest for silage once they are past heading in order to maximize DM yield rather than quality. The level of cyanide in sweet sorghum are higher than other summer annual grasses.

8.5.2.2. Sudangrass

Sudangrass is native to Sudan in Africa; it is a tall annual forage crop with erect stems and narrow leaves. It is very fine stemmed with exceptional tillering capacity and excellent regrowth after cutting or grazing. However, sudangrass produces less forage yield compared to other summer annuals. Sudangrass is therefore recommended for either grazing or forage conservation. Plants do not tolerate frost and cold conditions and they then become dormant.

8.5.2.3. Sorghum x Sudangrass

Sorghum x sudangrass is a cross between sorghum (*Sorghum bicolour* (L) Moench) as the female plant and sudangrass (*Sorghum sudanense* (Piper.) Stapf) as the male parent. They are the most common hybrid, and they are considered as possible forage alternatives to maize silage in drought prone areas. These hybrids are intermediates of sweet sorghum and sudangrass in terms of character expression (medium tillering, regrowth capacities and nutrient value). The hybrids are higher yielding than sudangrass and pearl millet but they yield less than sweet sorghum. In order to ensure an excellent quality, it should be harvested or grazed to at least 45 to 60 cm.

8.5.2.4. Pearl millet

This is a summer annual grass that originates in Africa and India. Of all the millets, pearl millet is the most important crop. It is robust and quick growing and can be interchanged with sorghum and maize. It is more drought resistant than sudangrass and sorghum x sudangrass. Hence, it produces excellent pasture and it has better digestibility than sorghum x sudangrass grown under the same conditions. Pearl millet is very sensitive to cold temperatures and at 2 – 3 ^{0}C will kill the crop. It is also very sensitive to overgrazing and a stubble high of less than 15 cm can be detrimental to the crop.

8.5.2.5. Hybrid millet

Grazing Management - Pearler poses no risk of prussic acid poisoning, therefore it can be grazed at a much earlier stage than forage sorghum. For best results graze early - as soon as the plants are not easily pulled out of the ground. There may not appear to be a lot of feed at this stage, but due to quick regrowth and high tillering ability, feed supply is good. Early grazing will maximize protein and energy content, boosting animal productivity. High stocking rates - Pearler's quick regrowth and lack of prussic acid means it can be grazed heavily for long periods (information used from the product catalogue of Barenbrug).

Soil selection - Although Pearler can produce exceptional livestock productivity, it does require suitable soil and management conditions to achieve this. Being a forage Pennisetum X, a good well-drained soil is required and a soil temperature of 18°C or more. Because Pearler has small seeds (60,000 to 80,000 seeds/kg) compared to the 32 00 seeds/kg for sorghum varieties, it can be planted at lower seeding rates.

8.5.3. BMR and PPS traits

Mutants and traits that influence the nutritional value and the growing season length of sorghum.

a) BMR (Brown Mid Rib) **gene**

Sorghum varieties have also been improved by crossing them with mutants containing the Brown Mid Rib (BMR) gene in order to improve yield and digestibility. BMR is a marker related to decreased lignin content in sorghum, pearl millet and maize. It is most noticeable in the mid-rib of leaf as shown in Plate 8.5.1, but do occur in the plant as a whole.

Plate 8.5.1: BMR gene in sorghum (Nutritop plus)

b) PPS (Photoperiod sensitive) **trait in sorghum**

The transition from vegetative to reproductive growth in sorghum type plants hastens the decline in quality of the vegetative portion of the plant. Floral initiation is affected by several environmental factors but daylength is probable the most important. Regulation of flowering by daylength is referred to as photoperiodism. The delayed flowering is proposed to slow the decline in forage quality associated with floral innitiation. Floral initiation will not occur untill daylength is less than 12 hours and 20 minutes.

All measurements are provided/shown as average ranges for the varieties of sorghum types pooled.

A base line study of the species composition of natural pasture by livestock was also deemed important. Frits van Oudtshoorn was called upon to help with this activity. The report will be presented in appendix 2.

8.5.4. A short description of the different morphological properties

8.5.4.1. Tillering ability of different genotypes

It is well known that the fine stems, extensive tillering, and rapid regrowth of Sudangrass and Pearl millet make it better suited to pasturing than other types of sorghum. A new development on the market is the crosses of *Pennisetum* spp. (hybrid millet) with the same attributes. In Figure 8.1 the tillering ability of the different sorghum genotypes are displayed. It is clear that under conditions of low fertility and late planting three *Pennisetum* spp. at Reitz produced less tillers than at Vrede. The sweet sorghum varieties which are often use for silage and standing hay lack the ability to produce lots of tillers.

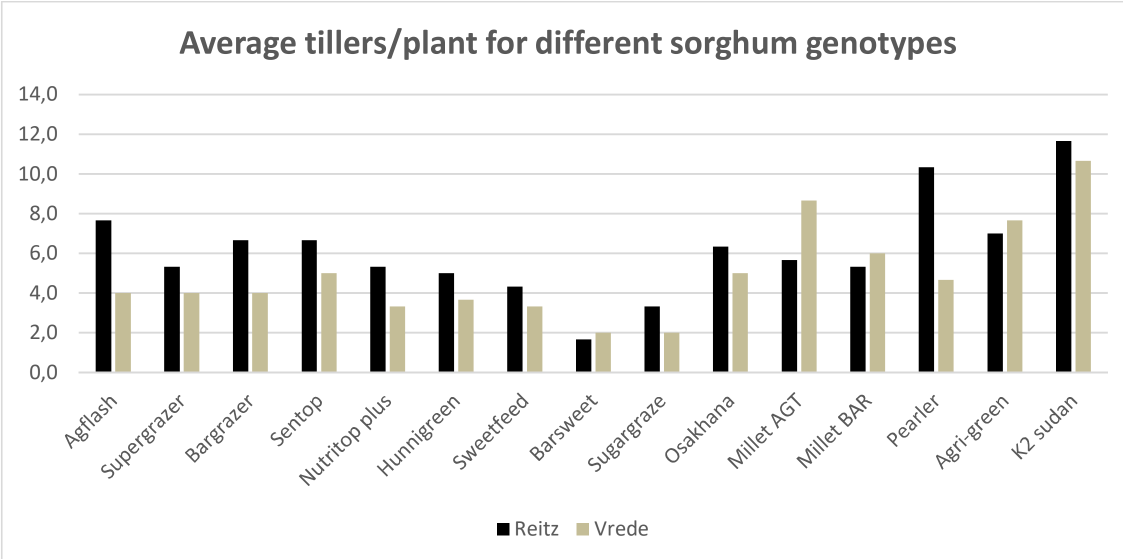

Figure 8.5.1: Average tillers for sorghum genotypes

The overall impression though is that low fertility and late planting increase the sorghum sudan crosses to produce more tillers. Also the sweet sorghum treatments, except for barsweet, displayed the same attribute.

8.5.4.2. Stem diameter

Of the sorghum types grown for forage, Sudangrass and hybrid millet have the finest stems, most profuse tillers and the most rapid regrowth following cutting of grazing. The finer stems usually are a trademark for better pasturing suitability. Millet, sudangrass and sorghum x sorghum sudangrass hybrids are widely grown commercially for direct pasture, hay, haylage, greenchop and silage. Thicker stems with higher sugar content makes sweet sorghum better suited for standing foggage and silage.

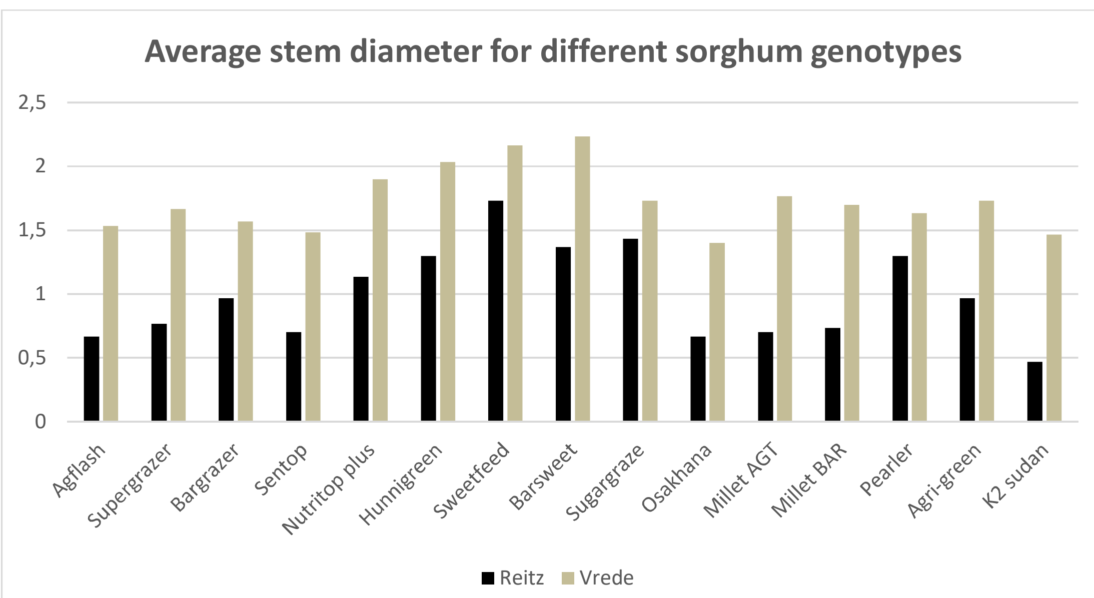

Figure 8.5.2: Average stem diameter for different genotypes

From figure 8.5.2 it is clear that under condition of optimal growing conditions the average stem diameter seems to increase. Early planting and nutritional management seems to benefit the trait in all sorghum types.

The thicker stems play a vital role in creating a surface mulch. This mulch, due to the high lignin content, usually protects the soil from the impact of raindrops. It also protects the soil from erosion and slower the water movement after raining events.

Lignin compounds is also very complex for breakdown by micro-organisms and plays a vital role in creating long term carbon (humus) in the soil. Soil cover create soil surface temperatures that can be tolerated by plants and micro-organisms. After grazing sorghum mulch has a white coloration and reflect sunlight, which lower soil temperatures due to the albedo effect.

8.5.4.3. Leave width and height (functions of leave)

The leaves may be considered as the most important life-giving part of the plant body. The carbohydrate that is produced in the leaves in the process of photosynthesis sustains animal life, both directly and indirectly. This organic compound contains the energy which the plant obtains from the sun, the same energy that powers animal and human life. Likewise, the oxygen that plant leaves release, is essential to the continuing existence of animals and other aerobic organisms.

Plants lose a large volume of water through the leaves in the form of vapour. It is estimated that the loss of water via stomata through the process of transpiration exceeds 90 percent of the water absorbed by the roots. Transpiration as a process is also responsible for water and nutrient uptake from the soil. It also cools the plant during hot weather conditions.

The leaves serve as food storage organ of the plant both temporarily and on long-term basis. Under favourable conditions, the rate of photosynthesis may exceed that of translocation of photosynthates toward other organs. During the daytime, sugars accumulate in the leaves and starch is synthesized and stored in the chloroplasts. At night-time, the starch is hydrolysed to glucose and respired or converted to transportable forms like sucrose.

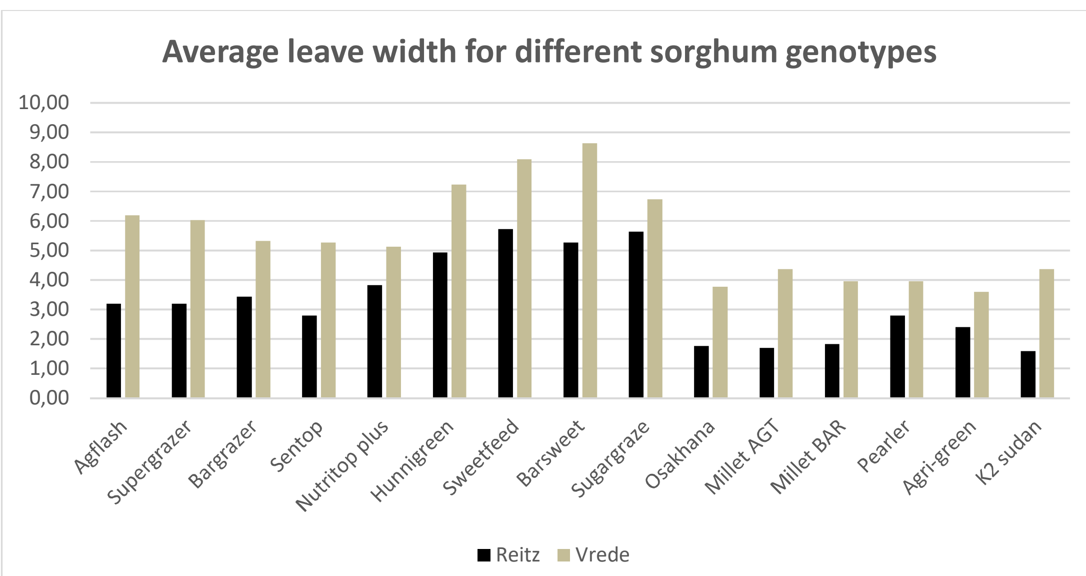

Figure 8.5.3: Average leave width for different sorghum genotypes

Studying Figure 8.5.3 it is evident that leave width is correlated with yield of the different genotypes. Sweet sorghum, having the widest leaves, produced the highest yield and sudan crosses, having the narrowest leaves, produced the lowest yield. Narrow leaves are also associated with multi-cut genotypes. Broad leave varieties also seemed to grow higher so a positive relationship exist between height and leave width in Figure 8.5.4 Sudan X seems the exception in this case and this season grown tall.

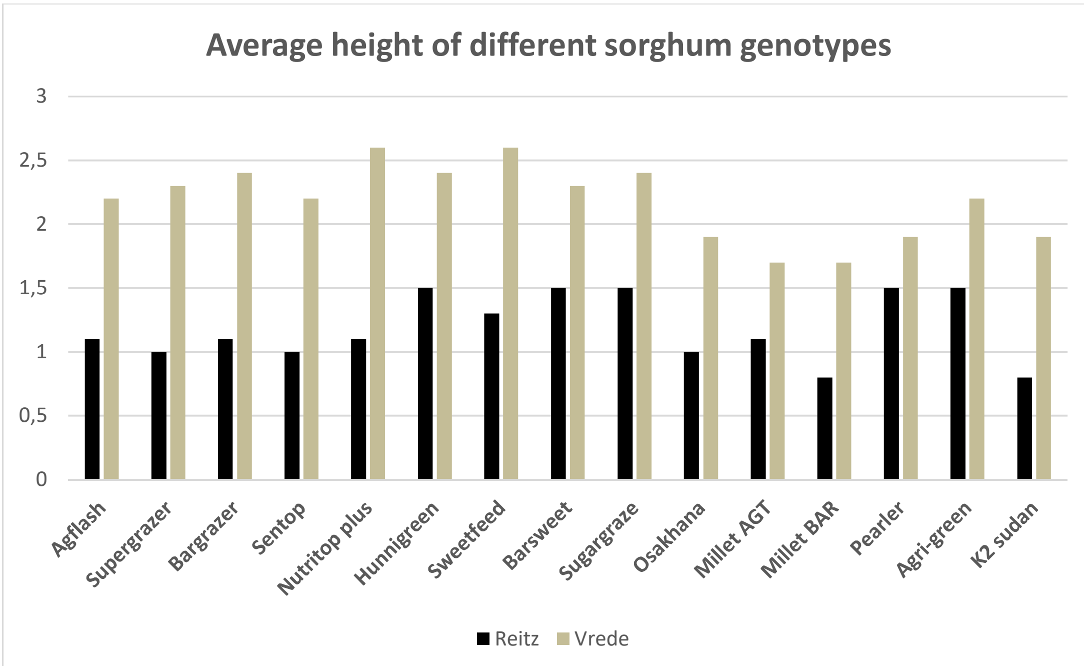

Figure 8.5.4: Average height of different sorghum genotypes

8.5.4.4. Basal cover percentage

Basal cover can be defined as that area of the plant that extend into the soil surface. Measuring basal cover provides us with a cover percentage that can be used to determine the soil's vulnerability to experience soil erosion. For sorghum, growing very tall and is funnel shaped, erosion can still be 50% of bare soil due to the height of the plants. A basal cover of 20% for sorghum type varieties can be regarded as significant to lessen the effect of running water at the soil surface. Figure 8.5.5 clearly shows that millet, sweet sorghum and sudangrass did not use the space optimally. Higher plant density and amount of tillers will, as a rule, influence basal cover positively.

Basal cover or basal area is determined by considering the cross-sectional area of plants near the ground, usually taken at a height of 2.5 cm for herbaceous plants. The main stem and the tillers from a single plant was used to determine the diameter for a single plant. An accession such a Barsweet that performed badly for the trait produced lots of single stem plants.

After harvesting the biomass, the diameter of the basal area of the stem was determine with a venire. The amount of plants for the 1 m^2 was counted and by doing a simple calculation the basal cover could be determined. The positive impact of basal cover is summed up in the following paragraph.
Compared to other estimates of cover, basal cover is:

- More stable from year to year and less sensitive to changes due to climatic fluctuation.

➢ Not affected by utilization by grazing animals.
➢ Usually used for trend comparisons or for calculation of species composition.
➢ Can be difficult to measure for forbs or grasses with a single, small stem.
➢ Most often used to determine the watershed stability of the site.

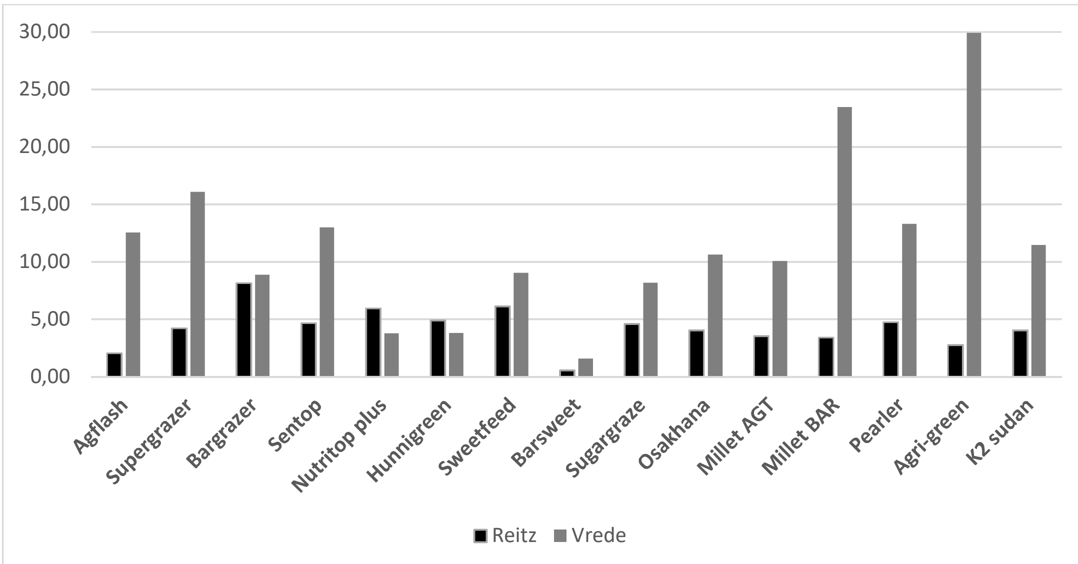

Figure 8.5.5: Basal cover percentage for different sorghum genotypes

8.5.4.5. Biomass production of the different genotype

In the sorghum trial the accessions in the trial and the mixtures were subjected too different treatments. Part of the trial was grazed by livestock whiles sorghums were still actively growing, during the vegetative growing season. Another part of the trial was harvest for DM measurements before grazing in a reproductive stage and the last treatment include the treatment of no grazing.

The grey area in figure 8.5.6 is an indication of the dry matter yield 57 days after planting took place with the first grazing treatment. The sweet sorghum crosses (Supergrazer, Sentop and Agflash) accessions produced well. With the highest DM yield of 8.4 t/ha for supergrazer. The millet accessions (Okashana, Millet bar, Millet AGT) did very well in terms of DM considering the low cost of seed. The sweet sorghums were a bit of a let-down, but hopefully these accessions (Barsweet, Sweetfeed and Sugargraze) will come into their own later in the season. Hybrid millet (Pearler and Agri-green) produce well, but at this stage Pearler at a price of R140/kg should have the ability to produce at least 45kg of meat/ ha more than other the Millets to be profitable. Also traits such as BMR and PPS need to step-up in terms of DM to make sense when a decision to plant these crops is emanating.

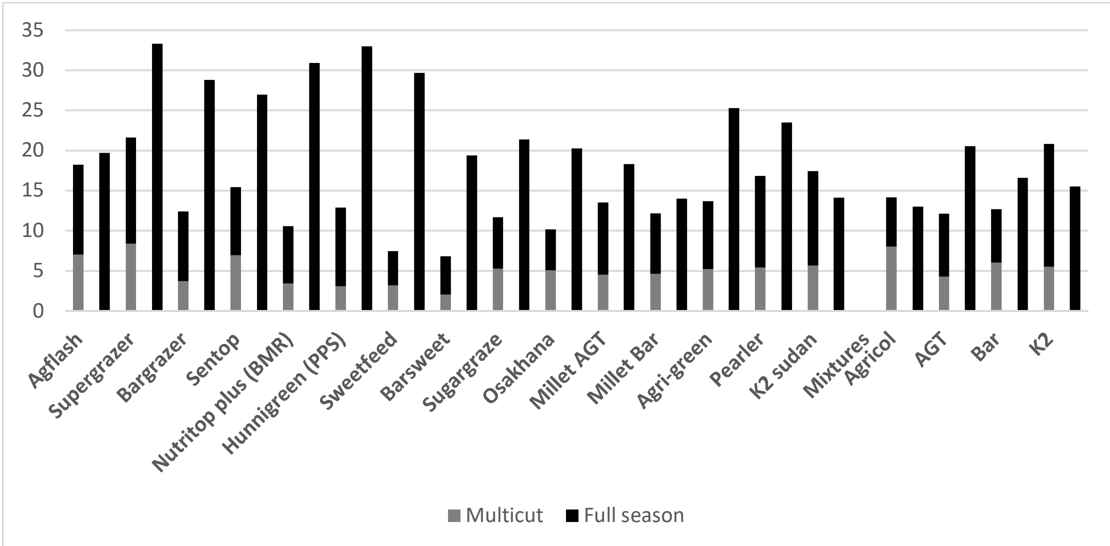

Figure 8.5.6: DM production at Skulpspruit 2018/2019 season

With the second cut again Supergrazer and Agflash from the sorghum crosses performed well with 13 and 11 tons of DM/ha for regrowth, respectively as shown by the black area on the grey in the Figure 8.5.6. Sudan grass, K2 and Pearler a hybrid babala that also produced in excess of 11 tons of DM/ha with Hunnigreen accession from the sweet sorghums group performing the best in that group in terms of DM for regrowth.

Sorghum crosses outperforming the sweet sorghums in terms of DM/ha at the full season grazing treatment, was unexpected. With the low cost of seed for these accessions and the high DM production a must in any mixtures. Sweetfeed performed the best for the sweet sorghums with Hunnigreen and Barsweet with the second and third highest DM, respectively.

For the babala and hybrids the accession of Barenbrug Pearler performed the best in terms of total DM. The high nutritional value and quick initial growth rate of the babala types as well as the fact that it do not possesses any threats of prussic acid poisoning make it valuable for grazing during the early growth season.

For the mixture the Agricol and K2 had good regrowth whiles AGT mixture outperformed the rest in terms of DM production in the treatment that consist of late grazing.

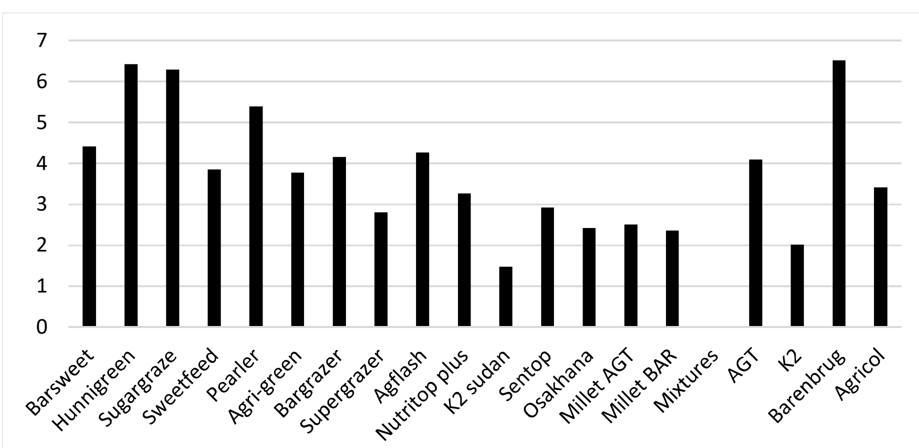

Figure 8.5.7: DM production at Van Rooyenswoning 2018/19 season

The picture that emerged for Van Rooyenswoning in Figure 8.5.7 is closer to what is expected in terms of DM production, asking the question if sorghum is not mostly planted under sub optimal agronomic conditions by farmers. In terms of DM the sweet sorghums Hunnigreen and Sugargraze performed well. The hybrid Pearler outperformed the rest of the millets and Agflash from Agricol did the best for the sorghum crosses. Under sub-optimal condition a loss of up to 75% in DM can be expected for these type of crops.

Barenbrug mixture outperformed the other mixture for DM production. To conclude it should be mentioned that sorghum should be treated as a cash crop. Early planting and some form of fertilizer management needs to be performed for optimal growth.

8.5.5. Prices/kg for the different sorghum types:

In terms of the different groupings the prices for the millets en the sweet sorghum x sudan crosses is relatively low in Figure 8.5.8. With a value of R145/kg the hybrid millet, Pearler from Barenbrug is by far the most expensive. Although Barenbrug claims that the hybrid should be planted at 4-5 kg/ha while for millet, the recommended seeding rate is 20 kg/ha. Planting at a rate of 5 kg/ha is very difficult with modern planters and at Skulpspruit a planting density of 11 kg/ha was applied.

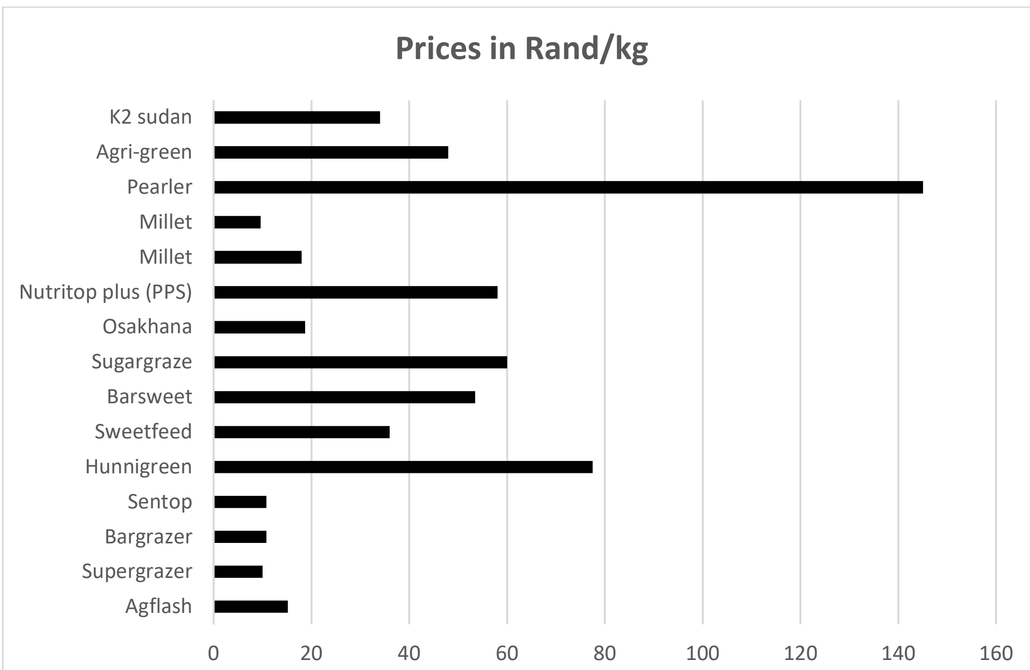

Figure 8.5.8: Prices of the different sorghum types

At this stage it is the sweet sorghum x sudan crosses (SS) that seems the most viable options. Sweet sorghum sugar content will first become a factor later in the season. So if you want to start grazing early in the season and possibly use the regrowth later the SS with lower prussic acid and better regrowth abilities seems the better choice. If your aim is to let the sorghums growth to maximum biomass and be used as a standing hay later might be that the sweet sorghum will be a good choice. The permutation is endless and mixtures of millets and hybrids that do not contain prussic acid can be a good forage to start the livestock on.

Farmers such as Izak already expressed their gratitude with the amount of insight gained by having the trial done. The trial also received a lot of attention during the farmer's day held at Ascent recently.

8.5.6. Animal production

Animal production is governed by intake and it relationship to digestibility is well known. We look at Crude Protein (CP), ADF (Acid Detergent Fibre) and NDF (Neutral Detergent Fibre) in relation to animal production. These factors in forage determine the nutritional value to a large extend and some important conclusion can be drawn from it.

8.5.6.1. Forage quantity

Environmental properties do have an influence on crop yield but the most important factor influencing nutritional value in relation to animal production is the stage of utilization. Older plants have less cell content and more fibres. This has a detrimental effect on intake and digestibility. The most important factors that determine animal production.

Sorghum varieties is greatly affected by the environment in which they grow. Any environmental condition such as temperature, drought, hail damage and late sowing, which are below the optimum for plant growth and development can be described as stressful for plants. High temperatures increase dry matter production and tiller size, but reduce tiller numbers, leaf/stem ratio and organic nitrogen concentration in the DM.

The potential of forage to produce the desired animal response. It comprises of the nutrient value, anti-quality factors and potential intake, while nutritive value describes nutritive concentrations and digestibility or can be seen as a measure of a diet's ability to meet animal requirements for production and growth.

Feed quality (digestibility, metabolisable energy, neutral detergent fibre (NDF), acid detergent fibre (ADF) and crude protein) of specific forage is influence by the amount and type of compounds in the forage. Animal productivity on a forage diet is determined by the amount of intake, digestibility and the digestion rate of cell wall components.

The crude protein (CP) quality in plants is influenced by the type of species grown, management practises and maturity at harvest. When sorghum plants are young and growing rapidly, CP content may reach 20%, but as they increase in height, and near maturity, this decline to less than 7%.

This low value is less than the required rate for maintenance of livestock. For growing cattle and other ruminants a CP content of up to 19% might be required for optimal production. In Figure 8.5.9 leave samples from the different sorghum types were tested at the lab at Irene.

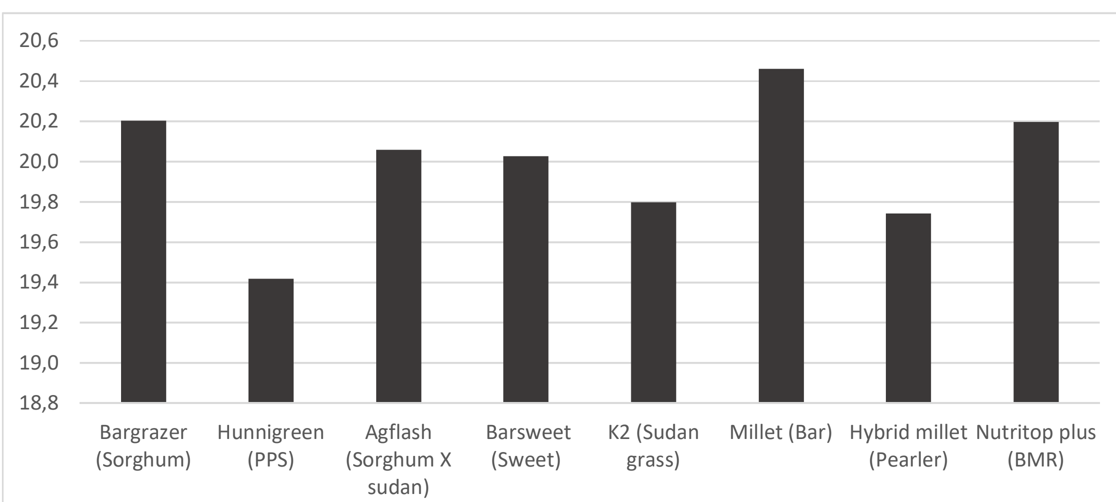

Figure 8.5.9: Crude protein % on DM basis for leaves

The leave samples were taken at a vegetative growing stage at Skulpspruit when sorghums plants were approximately 1 m in height. All treatments recorded above optimal CP content for high producing ruminants in Figure 8.5.9. Samples were also taken from the different treatments at Humanskraal (Ottosdal) when sorghum genotypes were at a late soft dough stage and a complete opposite picture emerges as shown in Figure 8.5.10 below.

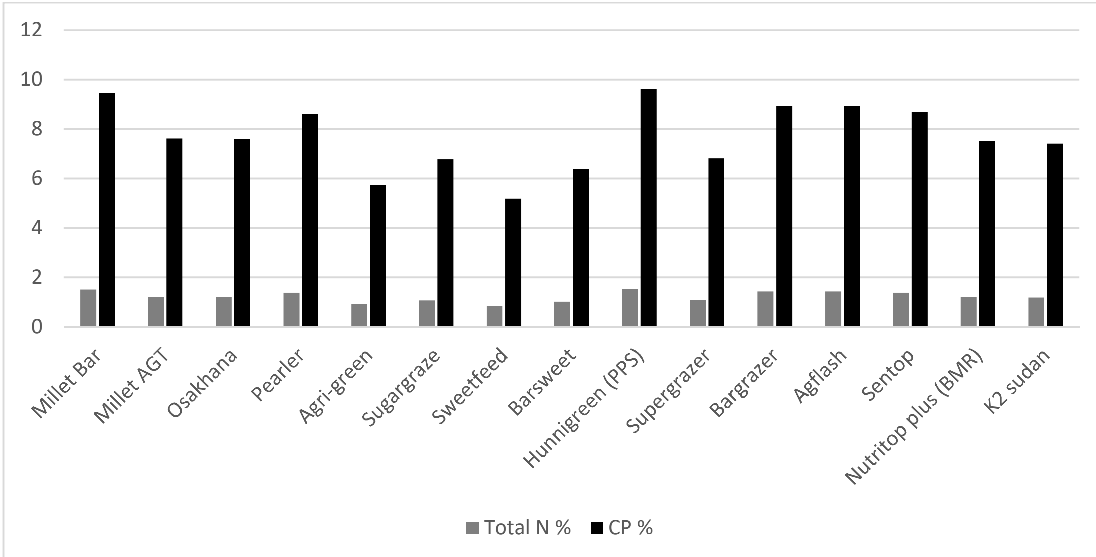

Figure 8.5.10: Total N% and CP% for sorghum at Humanskraal

The SCW lab determined the N% for the different treatments. Multiplying the N% content X 6.25 gives us a value for CP%. It is clear that Hunnigreen with the PPS trade, sorghum sudan crosses and one millet had the highest value for CP. The sweet sorghum varieties values fell below the requirements for animal maintenance at around 6% CP. Even as a mulch, this low value for nitrogen will create a situation where nitrogen will be tied up, while the residues are broken down in a CA system and create a nitrogen negative situation in the soil.

ADF and the NDF values from the young sorghum leaves sampled at Skulpspruit were also determined. ADF determine forage digestibility: the lower the lignin content, the more of the ADF fraction is digestible, and the higher the energy value of the forage. With ADF values below 30 in Figure 8.5.11 all genotypes will have a high energy value and will support high animal performance.

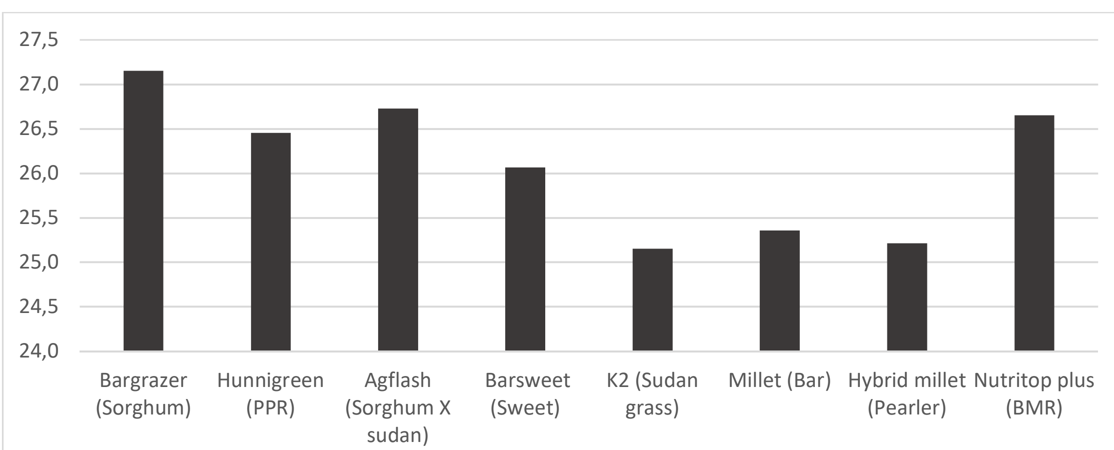

Figure 8.5.11: ADF values for sorghum genotypes 2019

NDF indicates the cell wall content of forages and hence determines the rate of digestion. Feed that is highly digestible encourages high feed intake because of faster digestion rates, the more quickly the digestive track will be emptied and the more space is available for the next meal. The portion of DM that will be digested will increase and will increase the energy available. It is clear from Figure 8.5.12 that the *Pennisetum* spp. are more digestible than the other sorghum types. All the values, however, are below 60 and highly digestible and high forage intake will be possible when sorghums are in a vegetative stage.

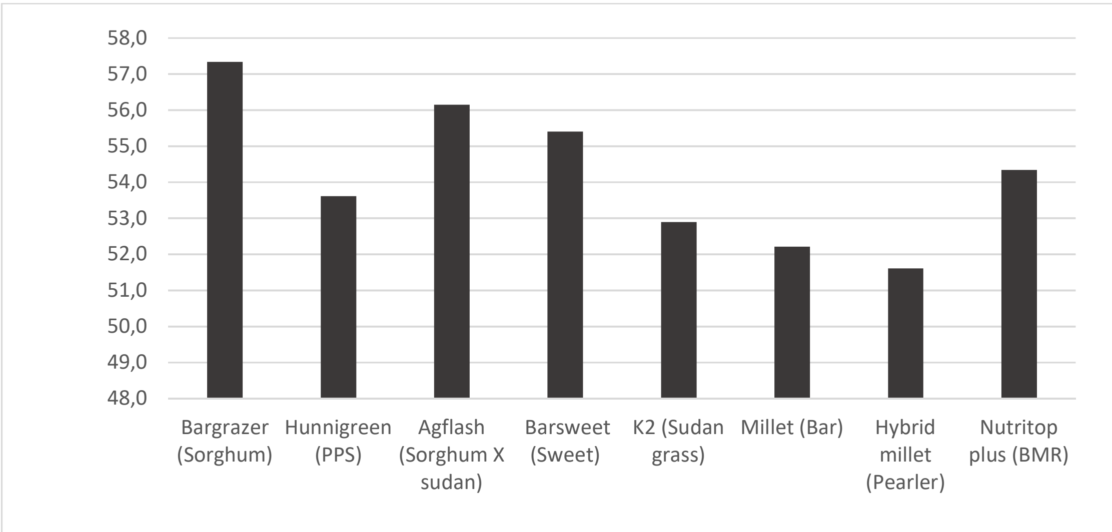

Figure 8.5.12: NDF values for sorghum genotypes 2019

8.5.7. Root evaluation

To perform the root evaluation, a grid of 1 m^2 was divided into 20cm x 20cm blocks. A back actor was used to dig holes in the ground 1 m deep. The farmer evaluated the roots in each block. A score of 4 represented an excellent root distribution and 1 a lesser amount of roots in a block. Grazed as well as ungrazed treatments of two genotypes were evaluated and in both cases the ungrazed treatments performed better than the grazed plots. An example of the evaluation, done only at Skulpspruit, is given in Table 8.5.3.

Table 8.5.3: Root evaluation done at Skulpspruit

Root evaluation of Sugargraze for ungrazed treatment at Skulpspruit 4/6/2019

	0-20cm	20-40cm	40-60cm	60-80cm	80-100cm	Total
0-20cm	4	4	4	4	4	20
20-40cm	4	4	4	4	4	20
40-60cm	3	3	3	3	3	15
60-80cm	2	2	2	2	2	10
80-100cm	2	2	2	2	2	10
Total						75

During severe drought, sorghum has the ability to extract water from the sub-soil (45 – 135 cm), while pearl millet absorbs water from all layers (0 – 135 cm). For this reason, it makes the latter a preferred choice in drought stricken regions.

In order to get maximum DM, the sowing date should be delayed until the ground temperatures reached at lease 15 - 17 °C. Table 8.3 is testimony to the prolific root system of sorghum plants. Sorghum received a score of 75 which is above average. Pearl millet had a score of 80 for the same trait.

8.5.8. Anti-quality factors associated with fodder sorghum type plants

8.5.8.1. Prussic acid

Prussic acid and nitrate poisoning is a real threat when grazing sorghum. Careful management, especially under drought condition, frost and trampling since this could cause prussic acid to increase. The rupture of the cells should be avoided at all cost.

Sorghum and sudangrass plants contain a compound called dhurrin, which can break down to release prussic acid (hydrogen cyanide, HCN). Sudangrass has low levels of this compound and rarely kills animals. Sorghum has the highest levels and sorghum-sudangrasses are intermediate. There is also considerable varietal difference in prussic acid content for all types of sorghums. Dhurrin content is highest in young plants. Millet and hybrid millet contains no dhurrin and do not pose any treat of prussic acid to livestock.

Animals have the ability to break prussic acid down as long as there is enough sulphur reserve in their body tissue; however, if depleted, sulphur deficiency cause a reduction in appetite which in turn leads to a decline in average daily gain or milk production.

To avoid prussic acid and nitrate poisoning, the following are recommended:

a) Do not graze the crop when it is showing signs of severe stress caused by factors such as low soil moisture, trampling and initial growth after stress is also high in prussic acid.
b) Feed livestock first before introducing it to sorghum feed.
c) Do not graze the crop before it reaches 0.6 m high.
d) Introduce only a few animals rather than the whole herd and observe their reaction.
e) Provide sulphur salt lick to livestock.
f) Use low risk varieties.

8.5.8.1. Nitrate poisoning

Sorghum can accumulate nitrates (NO_3) during any weather conditions that interferes with normal plant growth; however, drought is the most common cause. NO_3 is converted to nitrate (NO_2) in the rumen, which it diffuses into the bloodstream and binds to haemoglobin. Most NO_3 accumulates in the stems or lower portions of the plant. Ensiling the forage can lower the NO_3 by 50%.

8.5.9. Why choose forage sorghum types?

Sorghum type summer grasses have the following good characteristics:

- ✓ Drought tolerant
- ✓ Long planting window
- ✓ Rotational benefits
- ✓ Extensive root system
- ✓ Improve control of resistant weeds
- ✓ Low input cost compare to other crops
- ✓ Good crop on marginal soils
- ✓ It is multi-purpose

8.5.10. Conclusion

The planting season at the start was very dry but still the sorghum trial is doing well. Participating farmers seem to see the benefit of the trials for future planning. Much credit and gratitude are hereby expressed towards these two farmers for their help and support.

8.6. Budget summary statement by August 2019

Description	Total Actual YTD	Total Budget YTD Sept 19	Available to use
NE FS, Reitz: Soil	-	83 696	83 696
NE FS, Vrede: Soil	4 502	67 500	62 998
NE FS: Cover crops	140 987	158 144	17 157
NE FS; Reitz: Agronomy	35 054	77 154	42 100
NE FS; Vrede: Agronomy	29 209	33 816	4 607
NE FS; Reitz: Grain SA	62 902	145 000	82 098
NE FS; Vrede: Grain SA	41 038	51 000	9 962
NE FS; Reitz: Dung Beetle Monitoring	48 826	82 280	33 454
NE FS; Vrede: Dung Beetle Monitoring	42 716	84 256	41 540
Total	**405 234**	**782 846**	**377 612**

APPENDIX 1

Table 1: Soil analyses data from the Reitz district (Soil Health Solutions)

FARM	DRIEFONTEIN			VAN ROOYENSWONING							
Sample name	High Potential	Poor yield	Veld	L18 Sand	L5 Clay	L1 Sand Loam	CT Neighbour	Conventional Grazed	UHD Grazed	Not Grazed	SHS Recommendation
Element or Category	Biological Analysis										
Soil Organic Matter %	2.4	1.5	1.3	0.6	1.3	2.0	2.2	3.0	2.2	2.7	More than 2.5
Soil life - Solvita CO2	88	58	20	16	29	41	28	21	95	23	More than 50
% Microbial Active Carbon (MAC)	33	29	16	18	23	25	17	8	31	11	More than 20
Soil Health Index	16	11	5	4	7	9	7	9	18	8	More than 7
	Nitrogen Analysis										
WEON released & available to roots ppm	18.0	12.6	4.8	5.9	12.2	11.0	7.9	5.1	17.7	6.1	As high as possible
WEON reserve NOT RELEASED	0.0	0.0	2.9	2.3	1.0	0.2	3.9	11.3	0.0	7.8	As low as possible
Total available Nitrogen in Kg/ha	61	34	15	28	45	32	28	42	48	29	
	Phosphate Analysis										
Total available (ppm)	24.4	33	13.4	49.9	40.3	45.6	14.3	3	5.5	2.4	10 - 20
% P Saturation Ca	10.5	18.6	17.4	29.3	9.7	16.8	15.1	2.4	1.8	1.8	Plus 5
% P Saturation Fe / Al	8.2	9.8	4.2	15.4	12.0	10.4	3.0	2.8	3.4	1.4	Plus 5
	Haney H3A Extract Analysis										
Soil pH (Water)	5.4	6	5.2	6	6.3	6.5	5.8	5.7	5.8	5.5	5.5 - 6.5
Soluble salts mm ho/cm	0.35	0.35	0.15	0.15	0.2	0.02	0.02	0.3	0.3	0.3	Lower than 0.65
Potassium K ppm	181	227	119	154	97	146	201	254	232	101	120 - 200
Calcium Ca ppm	232	183	92	185	433	279	110	245	322	238	Ratios important
Magnesium Mg ppm	98	87	41	44	72	75	53	82	116	90	Ratios important
Sulphur S ppm	17	9	6	8	14	7.4	8.8	9	7	8	More than 12

Iron Fe ppm	145	98	138	102	144	154	190	57	45	200	20 - 80
Zinc Zn ppm	2	2	1	2	2	3	1	1	1	1	1 - 3
Manganese Mn ppm	36	33	20	20	17	40	54	31	32	14	4 - 6
Copper Cu ppm	0.2	0.4	0.5	0.6	0.5	1.3	1.8	0.3	0.4	0.3	0.5 - 1.0
	Key chemical ratios										
Calcium : Magnesium	1.4	1.3	1.4	2.6	3.7	2.3	1.3	1.8	1.7	1.6	More than 5
(Calcium + Magnesium)/Aluminium	3.4	1.8	0.9	1.4	3.6	1.8	0.7	3.3	5.6	5.5	More than 1.7
Magnesium : Potassium	1.7	1.2	1.1	0.9	2.4	1.6	0.8	1.0	1.6	2.9	1 to 2
Potassium : Sodium	8.9	11.1	5.8	6.0	3.0	10.7	16.9	8.3	9.7	4.0	More than 1
	Plant Effective CEC Saturation analyses										
Calcium Ca %	38	29	23	35	56	40	19	38	44	46	More than 68
Magnesium Mg %	26	22	16	14	15	17	15	21	26	28	10 to 20
Potassium K %	15	18	15	15	6	11	18	20	16	10	More than 5
Sodium %	1.7	1.6	2.6	2.4	2.1	1.0	1.1	2.4	1.7	2.5	Less than 2

Table 2: Soil analyses data from the Vrede district (Soil Health Solutions)

FARM	SKULPSPRUIT					CORNELIA KIBE					Goedgedagt					
Sample name	**Bloekom A**	**Rooiblok A**	**Rooiblok B**	**Good Hope Baken**	**CT Neighbour**	**Rykers**	**Groot A**	**Groot B**	**Veld**	**CT Neighbour**	**Silo**	**Winkel**	**Wilger-boom**	**Veld**	**CT Neighbour**	**SHS Recommendation**
Element or Category	**Biological Analysis**															
Soil Organic Matter %	0.9	1.5	1.4	1.4	2.0	1.6	0.7	1.0	3.3	2.4	4.2	4.2	4.1	8.2	5.8	More than 2.5
Soil life - Solvita CO2	21	24	25	23	24	31	22	25	57	17	78	120	166	387	174	More than 50
% Microbial Active Carbon (MAC)	15	16	17	17	21	18	18	16	22	12	50	82	92	73	117	More than 20
Soil Health Index	6	7	6	6	6	8	6	7	13	6	12	14	19	38	19	More than 7
Volumetric Aggregate stability %	10	17	7	12	13	17	17	7	41	17	45	41	41	64	56	More than 45

	Nitrogen Analysis															
WEON released & available to roots ppm	5.4	8.3	7.3	7.1	8.1	8.4	7.1	7.0	16.1	5.7	11.4	10.6	12.1	26.6	12.5	As high as possible
WEON reserve NOT RELEASED	3.4	5.0	3.5	3.4	1.3	3.4	2.7	3.8	2.2	6.4	0.0	0.0	0.0	0.0	0.0	As low as possible
Total available Nitrogen in Kg/ha	14	26	18	20	37	22	23	17	79	29	34	37	40	62	40	
	Phosphate Analysis															
Total available (ppm)	17.6	23.9	27.7	38.3	18.6	18.3	29.3	33.3	17.1	7.5	6.5	10	8.3	6.4	7.3	10 - 20
% P Saturation Ca	11.4	11.4	11.4	11.4	7.3	11.4	11.4	11.4	11.4	2.7	11.4	11.4	11.4	11.4	2.6	Plus 5
% P Saturation Fe / Al	10.7	10.7	10.7	10.7	3.7	10.7	10.7	10.7	10.7	1.8	10.7	10.7	10.7	10.7	2.5	Plus 5
	Haney H3A Extract Analysis															
Soil pH (Water)	5.9	7.2	6.8	6.9	7	7.1	5.9	7.1	6.6	7	6.7	6.5	6.7	6.6	7	5.5 - 6.5
Soluble salts mm ho/cm	0.2	0.2	0.2	0.25	0	0.15	0.15	0.2	0.35	0	0.15	0.2	0.15	0.2	0	Lower than 0.65
Potassium K ppm	91	180	161	177	123	182	148	126	330	152	17	47	24	119	65	120 - 200
Calcium Ca ppm	152	501	381	378	278	416	90	218	250	344	409	364	415	463	285	Ratios important
Magnesium Mg ppm	50	118	98	104	67	114	34	65	141	138	442	418	474	477	432	Ratios important
Sulphur S ppm	14	6	8	8	11	7	9	14	12	8	7	14	8	12	9	More than 12
Iron Fe ppm	242	99	123	122	213	132	222	235	151	211	67	86	81	74	82	20 - 80
Zinc Zn ppm	2	3	3	3	2	2	1	2	2	2	0	0	0	0	1	1 - 3
Manganese Mn ppm	17	35	35	31	34	31	20	21	22	43	3	4	4	6	19	4 - 6
Copper Cu ppm	0.6	1.0	0.7	0.6	1.0	0.6	0.5	0.7	0.5	1.4	0	0	0	0	1	0.5 - 1.0
	Key chemical ratios															
Calcium : Magnesium	1.9	2.6	2.4	2.2	2.5	2.2	1.6	2.0	1.1	1.5	0.6	0.5	0.5	0.6	0.4	More than 5
(Calcium + Magnesium)/Aluminium	1.4	4.5	3.0	2.9	1.5	3.1	0.8	1.5	3.1	2.5	8.0	7.6	8.3	11.0	6.4	More than 1.7
Magnesium : Potassium	1.8	2.1	2.0	1.9	1.7	2.0	0.7	1.7	1.4	2.9	83.3	28.5	63.3	12.8	21.3	1 to 2
Potassium : Sodium	3.0	8.1	6.3	8.0	6.0	7.1	4.8	2.0	6.9	8.9	0.3	1.0	0.6	2.8	1.4	More than 1
	Plant Effective CEC Saturation analyses															

Calcium Ca %	33	53	47	45	39	46	22	34	30	39	31	29	30	32	24	More than 68
Magnesium Mg %	18	20	20	20	15	21	14	17	28	26	55	55	57	54	59	10 to 20
Potassium K %	10	10	10	11	9	10	18	10	20	9	1	2	1	4	3	More than 5
Sodium %	3.4	1.2	1.6	1.3	1.5	1.4	3.8	5.2	2.9	1.0	2.3	2.0	1.6	1.5	1.9	Less than 2

Appendix 2

Table 8.4.A1: Nematode families identified and counted from croplands in the Reitz area in July 2019

Nematode family	Reitz 1	Reitz 2	Reitz 3	Reitz 4	Reitz 5	Reitz 6	Reitz 7	Reitz 8	Reitz 9	Reitz 10	Reitz 11	Reitz 12
Alaimidae	0	0	0	0	20	20	0	0	80	0	0	0
Aphelenchidae	420	120	220	400	140	200	220	100	80	20	260	400
Aphelenchoididae	0	0	0	0	0	60	0	0	40	0	0	0
Aporcelaimidae	80	60	180	40	40	20	20	200	120	40	0	0
Belondiridae	0	0	0	0	0	0	20	20	0	0	0	0
Cephalobidae	1880	2060	340	580	340	1180	760	42	400	440	700	1100
Criconematidae	0	0	0	0	0	0	80	280	480	0	120	0
Diplogasteridae	40	0	40	0	0	80	0	60	0	0	0	0
Diphtherophora	0	0	0	0	0	20	0	60	40	0	0	0
Discolaimidae	20	0	20	0	0	0	0	0	0	0	0	0
Dolichodoridae	40	20	0	20	0	0	20	0	40	40	140	0
Dorylaimellus	0	0	0	0	0	0	100	0	0	0	0	0
Hoplolaimidae	920	180	420	40	220	3180	720	1200	1200	2560	2280	4140
Leptonchidae	0	0	0	0	0	0	0	0	0	0	0	0
Longidoridae	0	0	0	0	0	20	20	40	0	0	0	0
Meloidogyne	20	0	0	80	0	0	60	40	0	20	0	20
Monhysteridae	0	0	0	0	0	0	0	0	0	0	0	0
Mononchidae	0	0	0	0	20	0	0	20	0	0	0	0
Nygolaimidae	0	0	0	0	0	0	0	0	0	0	0	0
Panagrolaimidae	300	20	20	60	0	540	60	0	160	20	40	100
Plectidae	240	40	40	40	60	340	60	20	0	20	80	280
Pratylenchus	1580	1460	60	140	240	480	0	100	0	260	0	240
Prismatolaimus	0	0	0	0	60	0	0	0	0	0	0	0
Qudsianematidae	0	0	20	0	20	40	0	20	0	0	0	0
Rhabditidae	260	220	40	100	0	160	100	0	200	0	0	80
Rotylenchulus	0	0	0	0	60	0	0	0	60	0	0	0
Thornenematidae	0	0	20	0	0	0	40	20	0	0	0	0
Trichodoridae	60	80	20	600	40	0	0	0	0	20	20	80
Tripylidae	0	0	0	0	0	20	20	0	0	0	0	0

Table 8.4.A2: Nematode families identified and counted from croplands in the Vrede area in July 2019

Tylenchidae	1120	200	1340	180	160	700	780	760	240	160	1260	140

Nematode family	Skulp 1	Skulp 2	Skulp 3	Skulp 4	Skulp 8	Cor 9	Cor 10	Cor 11	Cor 13	Goed 14	Goed 15	Goed 16	Goed 17	Goed 18
Alaimidae	0	0	0	0	0	0	0	0	0	20	0	0	0	60
Aphelenchidae	60	100	480	220	280	180	100	140	240	80	40	100	0	60
Aphelenchoididae	20	0	80	140	60	0	0	0	0	0	0	0	0	0
Aporcelaimidae	0	0	0	0	20	80	60	140	20	0	0	0	0	60
Belondiridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephalobidae	240	400	3160	380	980	1460	660	420	540	340	620	200	40	180
Criconematidae	0	0	0	0	0	0	0	20	0	0	0	0	20	0
Diplogasteridae	0	0	20	0	0	0	140	80	0	0	0	0	0	0
Diphtherophora	0	0	0	0	0	0	0	0	40	0	20	0	0	0
Discolaimidae	0	0	0	0	20	0	0	0	0	40	0	0	0	0
Dolichodoridae	0	0	0	0	0	0	0	20	40	140	0	0	40	0
Dorylaimellus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dorylaimidae	0	0	0	0	0	0	0	0	0	80	40	60	0	0
Hoplolaimidae	300	300	220	580	3720	540	880	1460	1800	200	420	100	20	260
Leptonchidae	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Longidoridae	0	0	0	0	0	60	20	0	0	0	0	0	40	0
Meloidogyne	0	0	80	0	0	0	0	0	40	100	0	0	20	0
Monhysteridae	0	0	0	0	0	0	0	20	0	0	100	60	20	40
Mononchidae	0	0	0	0	0	0	20	20	0	0	40	60	20	0
Nygolaimidae	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Panagrolaimidae	0	0	0	0	160	20	60	160	100	0	0	0	0	160
Plectidae	20	80	320	60	80	60	60	80	60	20	80	0	0	60
Pratylenchus	80	40	1420	500	360	1300	780	460	380	320	260	140	0	0
Prismatolaimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Qudsianematidae	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhabditidae	20	0	900	20	320	60	80	100	20	40	120	80	0	140
Rotylenchulus	2940	2440	0	1300	0	0	0	0	0	0	0	0	0	0
Thornenematidae	0	0	0	0	0	0	60	100	0	0	0	0	40	0
Trichodoridae	0	0	0	20	0	180	180	160	0	0	0	0	0	0
Tripylidae	0	0	0	0	0	0	0	0	0	20	0	0	0	0
Tylenchidae	80	40	660	180	260	180	100	260	140	300	320	80	40	120