APPENDIX 2: BERGVILLE ANNUAL PROGRESS REPORT

CA Farmer Innovation Programme for smallholders in Bergville

Period: October 2018 – September 2019

Farmer Centred Innovation in Conservation Agriculture in upper catchment areas of the Drakensberg in the Bergville region of KwaZulu-Natal

Compiled by:

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Project implemented by:

Mahlathini Development Foundation

Promoting collaborative, pro-poor agricultural innovation.

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Time of operation: 2003-2016
Legal status: NPC
BEE status: 4. – Certificate available.

Funded by:

Identification of the project

Description and selection of study areas

Work in the Bergville (KwaZulu-Natal) site continued with the 18 village learning groups brought on board in the 2017-2018 season. Attention has been given to consolidating and expanding the learning groups within each village. The overall number of participants for the Bergville site is now 348 smallholder farmers with between 1-6 years of experience under conservation agriculture. This season 14 new participants came on board.

Approach and Methodology

The farmer centred innovation systems research process underpinning the programme, which is based on working intensively with farmer learning groups and local facilitators in each of the villages, has been continued and strengthened.

Within the learning groups farmer innovators volunteer to set up and manage farmer-managed adaptive trials as the 'learning venues' for the whole learning group. Farmer Field School methodologies are used within the group to focus the learning on the actual growth and development of the crops throughout the season. New ideas are tested against the 'normal' practise in the area as the controls. Farmers observe, analyse and assess what is happening in the trials and discuss appropriate decisions and management practices. Small information provision and discovery-learning (training) sessions are included in these workshops/ processes. These are based also on the seasonality of the crop and the specific requests and questions from farmer learning group participants.

Local facilitators are chosen from within and by members of the learning group to be a person who has the required experience, knowledge and a willingness to support the other farmer innovators in their implementation. Facilitators are only chosen and appointed where people with the appropriate skill and personality exists. Local facilitators receive a stipend for a maximum of 10 working days per month, for their support to the farmer innovators. They fill in detailed timesheets outlining their activities against which they claim a monthly stipend.

Learning group members agree to a season long learning process and put forward the farmer innovators to run the trials. Each prospective innovator is interviewed and visited and signs an agreement with the Grain SA team regarding their contribution to the process. They undertake to plant and manage the CA trials according to the processes and protocols introduced as well as a control plot of the same size. For the latter, farmers provide their own inputs.

The adaptive trials are also used as a focus point for the broader community to engage through local learning events and farmers' days. Stakeholders and the broader economic, agricultural and environmental communities are drawn into these processes and events. Through these events, *Innovation Platforms (IPs)* are developed for cooperation, synergy between programmes and development of appropriate and farmer-led processes for economic inclusion. These IPs also provide a good opportunity to focus scientific and academic research on the 'needs' of the process.

In this season (2018-2019) the project has continued to focus on the following elements of the model, namely:

a) Support farmers who are in their 1st, 2nd , 3rd , 4th , 5th and 6th seasons,

b) Conscious inclusion of crop rotation to compare with inter cropping trials,
c) Inclusion of summer cover crops in the crop rotation trials,
d) Continuation with experimentation with winter cover crops, but planted in separate plots rather than in-between maize,
e) Planting of late season beans,
f) More focussed introduction of lab-lab beans,
g) Fodder production and supplementation and,
h) Initiation of nodes for farmer centres that can offer tools, input packs and advice,
i) Support for existing VSLAs and initiation of new savings groups where requested,
j) Conscious inclusion of the local facilitators in the crop and progress monitoring processes,
k) Further supply of tools (MBLI planters, animal drawn planters and knapsack sprayers) to learning groups.

Key activities: October 2018-September 2019

For this season the focus has been on working with the Local facilitators to manage the processes of distribution of the trial inputs, running the planting demonstration workshops, assisting their learning group members with planting and monitoring of progress with planting and crop growth, along with implementation of the co-funded process from LandCare. Support here has been in the form primarily of seed and fertilizer and for hosting of farmers' days.

Researcher-managed trial plots have now been set up in Ezibomvini, Eqeleni, Ndunwana and Mhlwazini to work on quantitative benchmarking of some of the visual CA indicators being used in this process. This includes rain gauges, runoff plots, a weather station and gravimetric soil sampling; with the intention of comparing water balances across control and CA trial plots.

In addition, a training session has been conducted for all field staff and interns in quantitative measurements as well as **initiating the new methodology** for Visual Soil Assessments. A small case study was conducted in Stulwane, alongside a MSc student from the University of Pretoria.

Soil health samples have been taken for 12 participants across five villages, along with 24 soil fertility samples for new participants (Ezinyonyane, Emahlathini, Emadakaneni, Ndunwane, Ezibomvini, Stulwane) and 44 repeat samples for existing participants to build a body of information about the soil fertility and soil health status of the CA trial participants.

Two stakeholder innovation platform event/ farmers' day were conducted in collaboration with KZNDARD and LandCare; Stulwane, November 2018 and Emahlathini, March 2019. Cross vistis were conducted for smallholder farmers from Growing Nations in Lesotho (March 2019) and for the Maize trust board members (May 2019).

The fifteen (15) VSLA's (Village savings and Loan Associations) have continued. The group members (258) have saved R880 000 in the last 13month cycle, but very little of these savings have gone towards the procurement of inputs, as expected.

Progress for the farmer centre in Ezibomvini has again been monitored. **Three new farmer centres have been initiated**. Small business development training has been offered to the VSLA members, with a focus on agriculture.

Financial reporting

Below is a summary of the key result areas and budgets provided under the 2018/19 project cycle.

Table 1: Bergville SFIP budget outline for 2018-2019

Bergville Milestones: Farmer Centred Innovation in CA. October 2018- September 2019			
Milestones/ Outputs	**Key activities**	**Outcomes/ deliverables**	**Budgets**
	Capital Equipment		R -
Farmer experimentation Bergville	Administration and sundries	Travel, accommodation, admin, publications, monitoring and evaluation	R 131 160,00
	Farmer centred innovation systems	Farmer experimentation, researcher managed experimentation, savings groups, farmer centres	R 565 811,00
	Innovation platforms	Stakeholder meetings, platform building and events	R 24 000,00
TOTAL: Oct 2018-Sept 2019			**R 720 971,00**

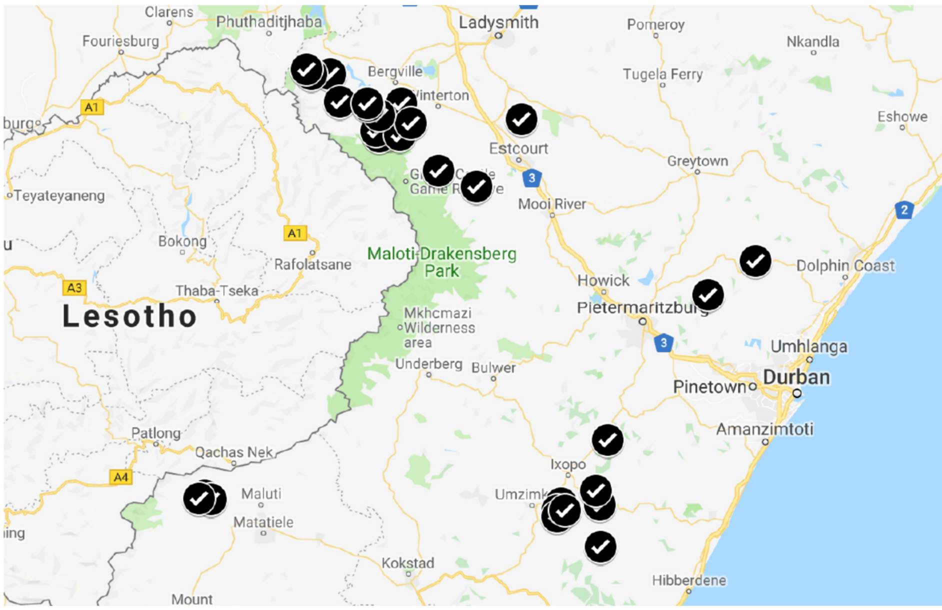
Expenditure by MDF has followed the key activities above. The inputs subsidies paid in by farmers has amounted to R19 400 for the year. These monies have been ploughed back into the community by providing rotating loans to the start-up farmer centres, as well as materials for the fodder supplementation experimentation process initiated.

The table below outlines expenditure on inputs for the 12-month period of this project.

Date	**Inputs**	**Amount**	**Pd for by grainSA**	**Farmer's payments**
2018/10/22	TWK Agri Winterton		R65 330, 30	
2019/10/18	AGT Foods; cover crops		R16 175,90	R6 900,00
2019/10/18	AGT Foods; cover crops		R1 932,00	R12 500,00
Sub-total		R 0,00	**R 83 438,20**	R19 400,00
	Total	**R64038,20**		

Progress

The project is now operational across 18 villages in the Bergville area, with a total of 348 learning group participants and 207 farmer-level trials.



LEGEND
BERGVILLE SITES:
Ezibomvini
Stulwane
Eqeleni
Emabunzini
Emadakaneni
Emafefetheni
Emahlathini
Mhlwazini
Ndunwana
Ngoba
Vimbukhalo
Magangangozi
Emazimbeni
EMangweni (2)
Nsuka
Okhombe
Thamela

The basic experimental design was followed for all 1st year participants and most of the 2nd year participants as well. Variations have included crop rotation, intercropping, summer and winter cover crop mixes, planting of lab-lab beans, late season planting of beans and fodder crops for the 3rd-6th year participants.

The table below outlines activities related to objectives and key indicators for the period of October 2018 -September 2019.

Table 2: Summary of progress (October 2018 -September 2019) related to objectives and key activities

Objectives	Key activities	Summary of progress	% completion and comment
1. Document lessons learned	*Documentation for learning and awareness raising:*	Farmer Field School methodology and process reports	- To be done at end of season
		Farmer level learning materials; manuals – isiZulu, English (re-print)	- No reprint done
		Project reports (monthly, 6 monthly and yearly).	- Monthly reports (Oct2018-Sept 2019) interim and annual report
		Articles and promotional material to engage stakeholders in the broader environment.	- Not done

		Sharing of information through various innovation platforms and processes; including the internet, social and networking platforms and conferences	-Stulwane and Emahlathini farmers days, Growing Nations and MT board cross visits, MDF Website updated, (100% completion)
	Final report	- 6 monthly interim reports	- Interim and annual reports finalised. (100% completion)
***2* Increase focus and efficiency of CA systems, scale out sustainable farming systems scenarios and build social platforms**	*Farmer centred innovations systems research* *Scale out using information systems approach.*	1st , 2nd , 3rd , 4th , 5th and 6th level experimentation Develop and manage PM&E framework; – weekly and monthly M&E visits Innovation platform events- cross visits, conferences, workshops, meetings, farmers' days Action planning with innovation platform events; Major planning event for experiments Bi-annual steering committee meetings	- Undertaken for 19 villages (100% completion) - New VSA methodology, staff training in Quantitative measurements, pendragon e-survey for crop monitoring - Stulwane and Emahlathini farmers days, Growing Nations and MT board cross visits - Small business Dev training for 4 learning groups - Soil fertility and soil health learning sessions for 2-3 groups - Future fodder experimentation planned in association with AGT Foods and Cedara Soil Science dept. -Mycotoxin research planned in association with the ARC (Potchefstroom) -Planned for Sept 2019 (100% completion)

A performance dashboard is indicated below. This provides a snapshot of performance according to suggested numbers and outputs in the proposal.

Table 3: Performance dashboard; September 2019

Outputs	Proposed (March 2018)	Actual (Feb 2019)
Number of areas of operation	2	2
Number of villages active	19	19
No of 1st level farmer experiments	90	14
No of 2nd level farmer experiments	56	38
No of 3rd level experiments	120	84
No of 4th level experiments	70	37
No of 5th- 6th level experiments	14	24
No of local facilitators	12	9
No of direct beneficiaries	350	207
VSLAs	11	11
Participatory monitoring and evaluation process (farmer level)	Yes	Yes

The extremely dry conditions during the planting season (October- December 2018), linked to difficulties with providing inputs due to lack of supply through the LandCare process led to a smaller no of farmer level trials being undertaken. The drought continued through January 2019 and further reduced planting of late season beans and winter cover crops. It also meant that the 2-row planter procured for expansion of CA implementation and for farmer level experimentation was not used this season.

Results achieved to date

The framework for scaling out implementation included: Continuation with existing farmer experimentation options for 1st, 2nd and 3rd level participants and mentoring and monitoring for 4th and 5th year participants. This includes intercropping, crop rotation, late season planting of beans and combinations of summer and winter cover crop mixes.

The table below outlines the villages, numbers of participants and experimentation processes for the present learning groups in the Bergville area.

Table 4: Activities and numbers of farmers involved, per village for October 2018-September 2019.

BERGVILLE	**Year started with CA**							**2018 /19**	**COMMENTS**
Villages	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**	**Trials**	
Emabunzini				9		4	13	7	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas
Emangweni-Engodini			14	3	3		20	10	1st and 2nd level experimentation; intercropping
Emangweni-Emaqeleni				8	6		14	7	intercropping 1st level experimentation; intercropping
Eqeleni	7	3	4	4	5		23	13	1st, 2nd and 3rd level experimentation; MBLI's hand hoes and animal drawn planters; intercropping crop rotation summer and winter cover crops, late season beans
Ezimbovini		6	4	10	6		26	24	1st, 2nd and 3rd level experimentation; MBLI's hand hoes and animal drawn

									planters; intercropping crop rotation summer and winter cover crops, late season beans
Magangangozi		9	1	2	4		16	6	1^{st} and 2^{nd} level experimentation; intercropping
Mhlwazini		6	10	7			23	10	1^{st}, 2^{nd} and 3^{rd} level experimentation; MBLI's hand hoes, intercropping crop rotation summer and winter cover crops, late season beans
Ngoba			6	5	3		14	9	1^{st}, 2^{nd} and 3^{rd} level experimentation; MBLI's hand hoes and animal drawn planters; intercropping crop rotation summer and winter cover crops, late season beans
Nsuka-Zwelisha				11			11	9	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas
Okhombe		5		6	6	7	24	14	1^{st} and 2^{nd} level experimentation; intercropping
Potshini	1						1	0	3^{rd} level experimentation
Stulwane	7	4	2	3	5		21	18	1^{st}, 2^{nd} and 3^{rd} level experimentation; MBLI's hand hoes and animal drawn planters; intercropping crop rotation summer and winter cover crops, late season beans, fodder crops
Thamela				11	6		17	13	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas

Thunzini				21	5		26	6	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas
Vimbukhalo		8	4	10	6		28	6	1^{st} and 2^{nd} level experimentation; intercropping, crop rotation, Lab-Lab, SCC
Ndunwana			14	5	6		25	21	1^{st} and 2^{nd} level experimentation; intercropping
Emahlathini					12		12	12	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas
Emazimbeni				10	9	3	22	17	Intercropping with hand hoes and MBLI planters; Maize, beans, cowpeas
Emafefetheni					12			5	1^{st} and 2^{nd} level experimentation; intercropping
Grand Total	**18**	**41**	**59**	**125**	**94**	**14**	**348**	**207**	**15,2ha ha trials; ~4ha controls**

348 Participants across 19 villages have joined the CA experimentation process between 2013-2018 and have been implementing the CA trials for between 1-5 seasons. This year 207 trials have been planted of whom 14 participants started this season for the first time.

The level of planting of CA control plots- normal planting for participants- was very low; again due to the very dry conditions and late planting dates for this season.

CA practice

After the 3^{rd} year, the farmer experimentation protocols for each farmer participant is defined by their own preferences, given that those farmers with more experience can now incorporate some of their own learnings and preferences in the trials, but the 1^{st} and 2^{nd} level trial participants still need to get used to the overall CA planting process and thus the close spacing intercropping trial plots are 'prescribed' for them.

The protocols are outlined below:

Year 1(1^{st} level) trial outlines

Experimental design is pre-defined by the research team (based on previous implementation in the area in an action research process with smallholders). It includes a number of different aspects:

- Intercropping of maize, beans and cowpeas

- Introduction of OPV and hybrid varieties for comparison (1 variety of maize and beans respectively)
- Close spacing (based on Argentinean model)
- Mixture of basin and row planting models
- Use of no till planters (hand held and animal drawn)
- Use of micro-dosing of fertilizers based on a generic recommendation from local soil samples
- Herbicides sprayed before and/or at planting
- Decis Forte or Kemprin used at planting and top dressing stage for cutworm and stalk borer
- Planting of cover crops; winter mix in Autumn

Experimental design includes 2 treatments; planter type (2) and intercrop (2)

Year 2 (2nd level) trial outlines

Based on evaluation of experiment progress for year 1, this includes the addition of options that farmers choose from. Farmers also take on spraying and plot layout themselves:

- A number of different OPV and hybrid varieties for maize
- A number of different options for legumes (including summer cover crops)
- Planting method of choice
- Comparison of single crop and inter cropping planting methods
- Use of specific soil sample results for fertilizer recommendations
- Early planting and
- Own choices.

Year 3 onwards (3rd level) trial outlines

Based on evaluation of the experimentation process to date this protocol includes issues of cost benefit analysis, bulk buying for input supply, joint actions around storage, processing and marketing. Farmers design their experiments for themselves to include some of the following potential focus areas:

- Early planting; with options to deal with more weeds and increased stalk borer pressure.
- Herbicide mix to be used pre and at planting (Round up, Dual Gold, Gramoxone)
- A pest control programme to include dealing with CMR beetles
- Intercropping vs crop rotation options
- Spacing in single block plantings
- Use of composted manure for mulching and soil improvement in combination with fertilizer, or singly.
- Soil sample results and specific fertilizer recommendations
- Planting of Dolichos and other climbing beans
- Summer and winter cover crops; crop mixes, planting dates, management systems, planting methods (furrows vs scatter)
- Seed varieties; conscious decisions around POVs, hybrids and GM seeds
- Cost benefit analysis of chosen options
- Fodder crop and supplementation experimentation and
- Farmer level monitoring of trials for selected individuals.

Rainfall

This season rain gauges were installed in six villages within the Bergville study site. The monthly average rainfall data for these gauges are summarised in the table below and are compared to the local weather station data (Davis weather station in Ezibomvini)

Table 5: Rainfall data for 6 villages in the Bergville site; September 2018-May 2019

Rainfall (mm/month) 2018-2019 summer rainfall season; Bergville villages									
	Village							Weather station (Ezibomvini)	
Month	Stulwane	Ndunwana	Ezibomvini	Eqeleni	Emhlwazini	Thamela	Average	Rain (mm/ month)	ETc (mm/ day)
Sep-18	5	71	15				30,3	5,8	154,36
Oct-18	19,5	28	6				17,8	24,6	117,47
Nov-18		106	68,1	180	74,8	47,7	95,3	50,4	148,16
Dec-18	64	22	61	64	76,5	52	56,6	80	152,34
Jan-19	57	321	27,5	258,5	290,4	97	175,2	70,6	142,01
Feb-19	135	253	218,7	254	171,8	356	231,4	139,8	108
Mar-19	177,5	73	214	205,5	63,2	66	133,2	212,4	100
Apr-19	136,5	63	89	67		53	81,7	149,9	100
May-19	0	0	0	0	0	0	0,0	11	84,92
TOTALS	**594,5**	**937**	**699,3**	**1029**	**676,7**	**671,7**	**768,0**	**744,5**	**1107,26**

Note: values in dark grey were estimated from online weather data for the period – as the weather station was faulty during this period

The seasonal average for the rain gauges and weather station compare quite well at 768mm and 744mm respectively. This can be considered a reasonably high rainfall for this area, but given the extremely late onset of rain and the high evapotranspiration values for this season, crop growth was severely hampered.

The average rainfall recorded for the 2017-2018 season for December- May was averaged at 563mm. For this season in the same time period the average rainfall was 678mm. The actual evapotranspiration (Etc) for 2017-2018 was however substantially lower at 702,8 mm than this year, which was calculated at 1107,3 mm for the season. This indicates the major difference between the two seasons and why the crops fared so badly this year, even with higher rainfall than last year.

This observation is supported by a number of other studies, indicating the evaporative potential in a growing season has a much greater potential effect on maize yield potential than overall rainfall and temperature, as explained in the quote below:

"Recent studies indicate that the negative effect of high summer temperatures is due less to effects on reproductive growth (e.g., heat damage between anthesis and silking, reducing pollen and grain set) and more to increased moisture stress driven by vapor pressure deficit (VPD). Rising VPD increases evapotranspiration, which has a two-fold impact on crop moisture stress: 1)

photosynthesis declines as crops that are unable to meet transpirative demand reduce their stomatal conductance and 2) soil water supply to the crop declines due to increased evaporation from the soil surface"[1]

These authors proposed the need for increased soil organic matter to effect greater water holding capacity (WHC) in the soil to mitigate these effects. *They also state that "Other strategies will be required to complement WHC increases, such as crop genetic improvement, cropping system design, and irrigation technologies, among others".*

Runoff

This season 4 farmers managed runoff plots in their CA trials alongside their rain gauges to ascertain the difference in runoff between the conservation agriculture trial plots and a conventional control plot. The results are summarised below.

Data is summarised on a monthly basis, with the understanding that the runoff is generally related to amount and intensity of rainfall as well as dryness of the soil. Given that the soils in Bergville are high clay soils they also tend to be quite compacted and become extremely hard when dry. This could lead to increased runoff, but this depends on the intensity of the rainfall events.

Table 6: Runoff results for 4 participants across Bergville; 2018-2019

	Stulwane		**Ndunwana**		**Ezibomvini**		**Eqeleni**	
	Runoff CA Trial(ml)	**Runoff Control (ml)**	**Runoff CA Trial(ml)**	**Runoff Control (ml)**	**Runoff CA Trial(ml)**	**Runoff Control (ml)**	**Runoff CA Trial(ml)**	**Runoff Control (ml)**
Nov-18					2808,0	3267,0		
Dec-18	3 343	2 600	11	14	35,2	39,5	5 800	5750
Jan-19	5 900	2 250	305	348	30,8	31,0	10 000	12750
Feb-19	3 266	6 275	471	609	66,0	74,5	12710	13 250
Mar-19	2 423	1 615	69	117	24,1	27,5	9 800	9 000
Apr -19	4 836	5 875	41	29	2,7	2,3	4 000	4 000
Average Nov-Apr	**3 954**	**3 723**	**179,4**	**223,4**	**494,5**	**573,6**	**8 500**	**8950**

From the table above it can be seen that for 3 of the 4 villages the runoff in the CA trial plots were on average lower than the conventional control plots. The difference in runoff between the CA trial and conventional control plots is not as significant as it has been in previous years. This is likely due to the larger number of small rainfall events this season. In addition, because of the

[1]Williams A, Hunter M.C, Kammerer M,. Kane D.A, Jordan N.R, Mortensen D.A, Smith R.G, Snapp S, and. Davis A.S. 2016. Water Holding Capacity Mitigates Downside Risk and Volatility in US Rainfed Maize: Time to Invest in Soil Organic Matter? Published: August 25, 2016https://doi.org/10.1371/journal.pone.0160974Soil.

difficult growing season none of the plots (M+B, M+CP and M only), were well covered with a lot of exposed soil, with a lot more erosion evident than in previous seasons.

In the section below the effect of different cropping options within each of the CA trials is explored in more detail.

Stulwane

Table 7: Runoff results or different cropping options within the CA trial; Stulwane 2018-2019

Stulwane; Nelisiwe Msele							
	Rainfall	**CA Plot 1 (M+CP)**	**CA Plot 3 (Maize)**	**CA Plot 6 (Beans)**	**CA Plot 9 (M+CP)**	**CA average**	**Conventional Control**
	mm	ml	ml	ml	ml		ml
Dec-18	64	3 750	1 170	4 100	4 350	3 343	2 600
Jan-19	57	11 000	9 600	2 000	1 000	5 900	2 250
Feb-19	135	4 995	2 955	2 135	2 980	3 266	6 275
Mar-19	177,5	3 950	1 050	0	2 270	2 423	1 615
Apr-19	136,5	6 333	3 910	6 100	3 000	4 836	5 875
Average seasonal runoff						**3 954**	**3 723**

For Nelisiwe Msele the expected trend of higher runoff on the CA plots early in the season, leading into lower runoff values towards the end of the season is clearly visible, as is the trend for the conventional (ploughed control) of having less runoff early in the season and higher runoff as the season progresses. This trend has been recorded in the literature and can be explained through increased macropores in the soil after ploughing, that gradually collapse throughout the season to lead to higher compaction in the soil. Soils under CA are also generally more compacted, but aggregate stability and micropores are present that improve water infiltration and water holding capacity (Cavalieri et al., 2009, Basset ,T.S 2010)[2].

Overall the CA plots for Nelisiwe had slightly greater average runoff than her conventional control plot. She has been practicing CA for 5 years, but her soil cover has been recorded at between 1-5% over the years; meaning that it has remained very low primarily due to grazing of stray livestock.

If one considers the percentage rainfall that has been converted to runoff, as shown in the small table below, it can be seen that this percentage is quite low, averaging 4,6% for the CA trial plots and 4,3% for the conventional control plot. This can be related to the general stability of high % clay soils as well as the reasonably high percentage of organic matter (OM), namely 4,3% in the CA trial plot.

Table 8: Percentage rainfall converted to runoff for CA trial and conventional control plots in Stulwane; 2018-2019

[2] Cavalieri K.M.V., da Silva A.P., Tormena C.A., Leão T.P., Dexter A.R. and Håkansson I., 2009. Long-term effects of no-tillage on soil physical properties in a Rhodic Ferrasol in Paraná, Brazil. Soil and Tillage Research, 103 (158-164).
Basset, T.S. 2010. A comparison of the effects of tillage on Soil physical properties and microbial Activity at different levels of nitrogen Fertilizer at Gourton farm, Loskop, Kwazulu-Natal. MSC thesis. Dept of Soil Science, UKZN.

Percentage rainfall converted to runoff			
	Rainfall	**CA**	**Conv**
	mm		
Dec-18	*64*	*5,2%*	*4,1%*
Jan-19	*57*	*10,4%*	*3,9%*
Feb-19	*135*	*2,4%*	*4,6%*
Mar-19	*177,5*	*1,4%*	*0,9%*
Apr-19	*136,5*	*3,5%*	*4,3%*
Average % runoff		**4,6%**	**3,6%**

Phumelele Hlongwane: Ezibomvini

Table 9: Runoff results or different cropping options within the CA trial; Ezibomvini 2018-2019

Phumelele Hlongwane: Ezibomvini							
	Rainfall	**runoff (ml)**					
	mm	**CA Plot 2 (M+CP)**	**CA Plot 6 (M+B)**	**CA Plot 9 (Maize)**	**CA trial ave**	**CA control**	**Conven contrl**
Sep-18	15						
Oct-18	6						
Nov-18	68,1	2393,0	2016,0	4015,0	2808,0	3267,0	
Dec-18	61	35,0	37,0	33,5	35,2	39,5	
Jan-19	27,5	35,1	29,4	28,0	30,8	31,0	1007,5
Feb-19	218,7	60,0	72,5	65,5	66,0	74,5	16,5
Mar-19	214	31,7	21,2	19,5	24,1	27,5	3,0
Apr-19	89	4,0	2,0	2,0	2,7	2,3	1,8
Ave Seasonal runoff		**426,5**	**363,0**	**693,9**	**494,5**	**573,6**	**257,2**

Phumelele has converted most of her farming to CA. She is in her 5th year of implementation. This year we attempted to find a conventional control plot; the plot selected was planted to sweet potatoes, which means it was cultivated. For Phumelele her % soil cover linked to crop residues or stover is around 10%, given that she has fenced her field and control her livestock's grazing in this field. Although this percentage is still quite low, it is in fact substantially higher than for those participants who do not practice controlled grazing, which is the vast majority of participants. It is also lower this season, given that she has had cover of between 20-35% in previous seasons. It is likely an indication of the lack of winter grazing in the area, due to difficult climatic conditions and Phumelele's temptation to allow the cattle to graze more of the residue as a result.

This season the average seasonal runoff in her Maize only CA plot was substantially higher than for her intercropped plots (M+B and M+CP). As Phumelele rotates the crops in her plot every season, it would appear that the differences in runoff between the plots is related a lot more to the specific soil properties in each plot, than the specific seasonal cropping option. This result may also be linked to canopy cover – this season, growth of the crops was impeded by the weather conditions and canopy cover was never reached, while in the previous season full canopy cover had been reached by the end of January.

If one considers the percentage rainfall that has been converted to runoff, as shown in the small table below, it can be seen that this percentage is very low, averaging 0,95% for the CA trial plots, 1,11% for the CA control plots and 0,36% for the conventional control plot. In Phumelele's case her %OM is 3,6% for her CA Trial plot and 2,9% for her conventional control. It is unclear why the runoff for the conventional control plot is lower than that of the CA trial. It is possible that the slope of the runoff pans were not well calibrated and that the cultivation practices for sweet potatoes provide for different runoff conditions in this plot. In retrospect, using a field allocated to a different crop may not have been such a good idea. The trend for lower runoff from the CA trial plot, when compared to the CA control plot, which has been observed in the 2 previous seasons has continued into this season.

The percentage rainfall converted to runoff for Phumelele is substantially lower than that of Nelisiwe (presented above) and attests to her continued good soil management practices.

Table 10: Percentage rainfall converted to runoff for CA trial and conventional control plots in Ezibomvini; 2018-2019

Percentage rainfall converted to runoff				
	mm (Weather station)	**CA trial**	**CA control**	**Conv control**
Nov-18	50,4	5,57%	6,48%	
Dec-18	80	0,04%	0,05%	
Jan-19	70,6	0,04%	0,04%	1,43%
Feb-19	139,8	0,05%	0,05%	0,01%
Mar-19	212,4	0,01%	0,01%	0,00%
Apr-19	149,9	0,00%	0,00%	0,00%
Average % runoff		**0,95%**	**1,11%**	**0,36%**

Ntombakhe Zikode: Eqeleni

Table 11: Runoff results or different cropping options within the CA trial; Eqeleni 2018-2019

Ntombakhe Zikode; Eqeleni								
	Rainfall	**Runoff (l)**						
	mm	**CA plot 1**	**CA plot 2**	**CA plot 3**	**CA Ave**	**CA Control**	**Convenl Control**	**Control Ave**
Dec-18	64	5,5	5,5	6,5	**5,8**	5	6,5	**5,75**
Jan-19	258,5	10	10,5	9,5	**10,0**	13	12,5	**12,75**
Feb-19	254	14	10,5	13,5	**12,7**	14	12,5	**13,25**
Mar-19	205,5	9	9	11,5	**9,8**	8,5	9,5	**9**
Apr-19	67	4	4	4	**4,0**	3,5	4,5	**4**
Ave Seasonal runoff		**8,5**	**7,9**	**9**	**8,5**	**8,8**	**9,1**	**8,95**

Ntombakhe Zikode is in her 6th year of CA implementation. She also employs a combination of multi-cropping and crop rotation in her CA trial and has improved her soil management practices substantially over the last five years. Because of pressure from livestock in the area, her soil cover from stover is still low; averaging around 3-5%. In addition, the %OM in her CA trial plot averages around 1,9%, which shows some improvement, but is still quite low for the area.

It can be seen from the table above that her runoff from both her CA trial plots (Ave 8,8l) are quite high and much higher than those for Ezibomvini (Ave 0,5l) and Stulwane (Ave 4,4l).This points towards the damage of her soil caused by long term monocropping and ploughing and the length of time required to re-build her soil. Ntombakhe has ploughed her fields regularly for many years, unlike Nelisiwe, who has only done this occasionally and Phumelele who has always tilled by hand.

Table 12: Percentage rainfall converted to runoff for CA trial and conventional control plots in Eqeleni; 2018-209

Percentage rainfall converted to runoff				
	mm	**CA trial**	**CA control**	**Conv control**
Dec-18	64	9,38%	7,81%	10,16%
Jan-19	258,5	3,87%	5,03%	4,84%
Feb-19	254	5,00%	5,51%	4,92%
Mar-19	205,5	4,77%	4,14%	4,62%
Apr-19	67	5,97%	5,22%	6,72%
Average % runoff		**5,80%**	**5,54%**	**6,25%**

Predictably, the percentage rainfall converted to runoff in Ntobmakhe's plots is much higher as well. Runoff in her CA plots 9both the trial and the control) is lower than her conventionally tilled plot.

Ndunwana; Boniwe Hlatswhayo

Table 13: Runoff results or different cropping options within the CA trial; Ndunwana 2018-2019

Nduwane; Boniwe Hlatshwayo			
	Rainfall	**CA runoff (M+B)**	**Conventional runoff**
	mm	ml	ml
Dec-18	22	11	14
Jan-19	321	305	348
Feb-19	253	471	609
Mar-19	73	69	117
Apr-19	63	41	29
Average seasonal runoff		**179,4**	**223,4**

She is in her 4th year of CA implementation and still following the 400m^2 trial layout of 2 plots of M+B and M+CP intercrops. She has received good yields averaging around 9,6t/ha for her maize in the 2017-2018 season. For the CA trail plot the organic matter has been recorded at 2,9% and for her conventional control plot at 2,75%. Boniwe recorded very low runoff values, for both her CA and conventional control plots – with a lower average seasonal runoff value for the CA plots.

Table 14: Percentage rainfall converted to runoff for CA trial and conventional control plots in Ndunwana; 2018-2019

Percentage rainfall converted to runoff			
	mm	**CA trial**	**Conv control**
Dec-18	22	0,05%	0,06%
Jan-19	321	0,10%	0,11%
Feb-19	253	0,19%	0,24%
Mar-19	73	0,09%	0,16%
Apr-19	63	0,07%	0,05%
Average % runoff		**0,10%**	**0,12%**

Boniwe's percentage of rainfall converted to runoff results are very low and are similar to those for Phumelele in Ezibomvini. This provides some weight to the argument that in the longer term, hand tillage, followed by CA has led to stable, well- structured soils.

Conclusions

- Runoff for the 2018-2019 season was much lower than the runoff measured in the two previous seasons, despite the fact that the overall rainfall was not that different. This can be attributed mainly to the rainfall intensity and periodicity but also to slowly improving organic matter content in the soil
- Historical land management practices have a large effect on the localised soil structure and soil health. It may take many seasons to rebuild a living soil with good aggregate stability and the related characteristics of reduced runoff and improved infiltration. There is evidence that those smallholder farmers who have always practiced hand tillage have soils that are in a much better state than those who ploughed continuously prior to starting their CA implementation.
- Even within the CA trial plots (which are divided into $10m^2$ blocks), there can be considerable variation in soil quality, which again is related to historical management practices. It is considered that the differences in runoff between these blocks is related much more to the differences in historical land management practices than the different cropping options presently implemented.
- On average, the mixed cropped CA trial plots show less runoff than the CA control plots which have been mono cropped to maize.
- For this season, the conventional control plots (ploughed) have on average shown less runoff than the CA trial plots. Although there has been a steady, but slow increase in percentage soil organic carbon (and %SOM) in the CA trial plots, the comparison of these CA plots with newly ploughed conventional plots has been problematic. As will be discussed in the following section, we have battled to find appropriate conventionally tilled plots, as the farmers in question have converted all their production to CA.

Water holding capacity

In the Bergville area, the WHC (water holding capacity) of the soil is naturally high, given the high clay content and reasonably high SOM content (2-4%). A study conducted with 5 participating smallholder farmers in Stulwane, by a Soil Science Masters student from the University of Pretoria (Palesa Motaung), confirms these generalisations.

As in many of our present analyses, students, interns and fieldworkers battle to conceptualise the importance of control samples and also battle to find appropriate controls – as in many cases the farmers that we are now working with for these measurements have moved across to CA for their entire cropping areas and do not have conventional tillage control plots. In Palesa Motaung's study, given that she is focussing on soil health aspects, she used veld samples as her controls.

She has used both the Visual Soil Assessment methodology refined by our team as well as the Cornell comprehensive soil health assessment framework – which uses chemical, biological and physical soil measurements to provide indices[3] and scores for soil health.

Among the soil health tests that she conducted, she calculated available water holding capacity (AWC) for the following plots for five 5th year CA farming participants in Stulwane:

- CA maize only
- Ca maize and beans
- Veld

The results are shown in the small table below

Water holding capacity (g water per g soil)	**Treatment average of 5 farmers (Stulwane)**
0,58	CA maize only
0,58	CA maize and beans
0,62	Veld

The AWC is the amount of water available to plants – between the field capacity and wilting points for the particular soil. For the samples tested, the AWC is scored at 100% for all three treatments (CA maize only, CA maize and beans and Veld). This means that the water holding capacity of the soils in our study area are high. In addition, the water holding capacity of the CA trials are very close to the veld benchmark, indicating the benefit of the implemented CA system. The system consists of rotated plots of different combinations of mono-cropped maize, legumes and cover crops.

Table 15: Soil quality scores provided by the Cornell soil assessment framework for 5 participants in Stulwane; 2018-2019

Treatment	**Overall Quality Score**	**Overall Biological Quality Score**	**Overall Chemical Quality Score**	**Overall Physical Quality Score**
Description		***Soil organic matter, active carbon, microbial respiration***	***Extractable P, K and pH***	***Available water capacity, wet aggregate stability***
CA Maize Only	60,7	48,2	62,6	76,7

[3]B.N. Moebius-Clune, D.J. Moebius-Clune, B.K. Gugino, O.J. Idowu, R.R. Schindelbeck, A.J. Ristow, H.M. van Es, J.E. Thies, H.A. Shayler, M.B. McBride, K.S.M. Kurtz, D.W. Wolfe, and G.S. Abawi .2017. Comprehensive Assessment of Soil Health. The Cornell Framework. Third Edition. Cornell University, Ithaca New York.

CA Maize & Beans	54,7	43,2	51,2	77,3
Veld	63,0	56,4	61,1	75,9

The differences in the scores between the CA maize only and CA maize and bean plots were to some extent artificial and related to sampling, rather than the treatments. Extractable P for example was extremely high for a few of the CA plots – but were likely due to recent fertilization – rather than an overall over supply of P in the soil, but led to much lower scores, as indicated in the pink shaded block of the table above.

For 3 of the 5 participants, the scores for biological properties were lower for their CA maize and bean plots than for their CA maize only plots – as indicated in the blue shaded block in the table above. A trend that has been noticed already in this research process is that soil quality within participants' fields can vary considerably and that microbial respiration and active carbon also varies considerably between the different treatments in a 10- block layout (10mx10m blocks). Treatments consist of monocropping and intercropping mixes, with cover crops, which are rotated. This variation is not directly related to the present crop combination in the block, or rather there have been no discernible trends in the data recorded to date. A trend that has been noticed, is that the participants who have used both intercropping and crop rotation in their experimental blocks, have higher average values for these biological properties. It is postulated here that the basic soil quality within these farmers' fields differ markedly due to a combination of historical management practices, and natural variability and that the CA management practices will even these differences out over time.

Conclusions

- The practice of CA has improved the physical properties of the soil over time, to the extent that both water holding capacity and aggregate stability for the CA fields are higher than for natural veld in the area (this is a high benchmark for comparison)
- The CA practices have also improved the pH and nutrient availability in the soil (extractable P and K) to levels equivalent to and higher than the natural veld benchmark

Gravimetric water

The intention of doing the gravimetric water calculations is twofold;

1. To gain a visual representation of water availability in the soil for different cropping options within the CA system and
2. To ascertain trends in water holding capacity in the soil, given the assumption that CA and specifically multi- cropping options within the CA system improves the water holding capacity of the soil.

Results from a gravimetric water content analysis in and of itself, cannot fully answer these questions, as there are numerous factors at play and a much more in-depth analysis would be required. This process has thus been exploratory in nature.

This process has been conducted for the last two seasons.

For the 2017-2018 season samples were taken for three participants (Phumelele Hlongwane, Ntombakhe Zikode and Zodwa Zikode), for different crop combinations within the CA trials (M, M+B, M+CP, SCC). The results were quite confusing and were only written up for one of the participants- Phumelele Hlongwane.

This season only one set of soil samples (Phumelele Hlongwane) were taken for gravimetric soil water assessments, given the time- consuming nature of this activity. These samples would give an indication of soil water content at different depths (30cm, 60cm, 90cm and 120cm), at different stages of crop growth, during the season. Samples were combined for her CA trial and were also taken for a CA control and a conventional control plot.

Right and Far Right:: Taking the gravimetric soil samples in Phumelele's CA trial plot, at planting (2018/11/07)

Below is Phumelele Hlongwane's 1000m^2 CA trial plot layout (2018/2019). Green shading indicates plots where gravimetric sampling was done.

Plot 5 M	Plot 4 M+B	Plot 3 M+CP	Plot 2 M+CP	Plot 1 SCC
Plot 6 M+B	Plot 7 M+B	Plot 8 M+B	Plot 9 M	Plot 10 LAB LAB

Phumelele took a risk and planted a lot earlier in the season than most of the other farmers in the area, who planted towards the end of November and early December only. Her crops suffered considerably from the continued lack of rain and high temperatures prevailing during November and December 2018.

Table 16: Gravimetric soil water sampling dates, compared to average monthly rainfall data

Gravimetric water samples taken	Date of sampling	Average rainfall for the sampling period
Planting (0 days)	2018/11/07	50
Establishment (4-6 leaf stage) (20-30 days)	2019/01/01	80
Vegetative growth (40-50 days)	2019/02/12	101
Productive stage (tasselling) (60-70 days) and	2019/03/14	212
Harvesting (physiological maturity) (80-110 days).	2019/04/25	150

The table above indicates the trend noticed by the farmers; that the rainfall during the establishment and early vegetative growth stages of the crop was not enough to sustain growth and rainfall towards the end of the season was unusually high, hampering maturation of the crops.

Germination and early growth were hampered, but maize growth in the later vegetative stages improved. Growth of the leguminous crops, specifically beans, was severely hampered, with almost zero harvests recorded. Lab-lab (Dolichos) and cowpeas survived well, even under these stressfull conditions. Of the summer cover crops the Sunhemp and millet (babala) survived well, but sunflowers did not. The photos taken below for Phumllele Hlongwane are indicative.

Right to far-Right:

Growth of different crops, towards the end of the productive phase (2019/04/11); Dolichos, Sunhemp and millet (Babala)

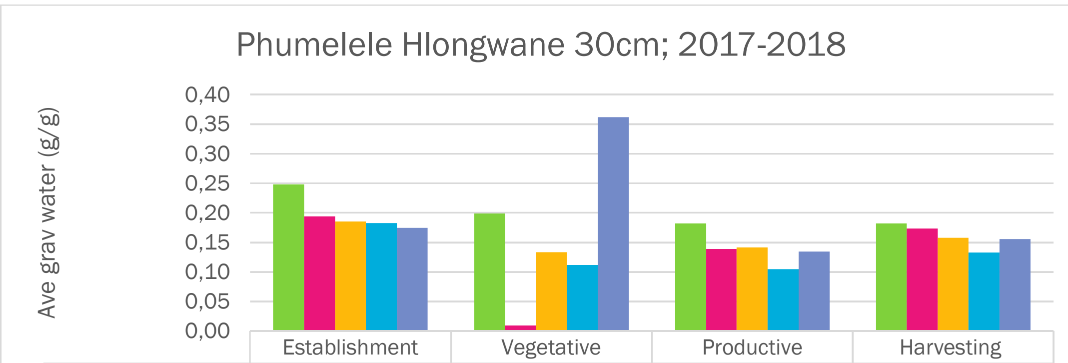
Right: Cowpeas grew well, but because of heavy rains in the productive phase did not seed well

Far Right: Maize germination was patchy and growth was compromised. Late rains caused a lot of damage to cobs.

Comparison of gravimetric water content results for two seasons (Phumelele Hlongwane – Ezibomvini)

For the 2017-2018 season, calculations for gravimetric water content between the different cropping options were in fact very similar; meaning that the water content at the different depths were similar within each of the cropping options. There were some interesting differences between the cropping options.

The figure below indicates the results at 30cm depth.



	Establishment	Vegetative	Productive	Harvesting
30 Plot 5 (Lab lab)	0,25	0,20	0,18	0,18
30 Plot 6 (M+CP)	0,19	0,01	0,14	0,17
30 Plot 8 (B)	0,19	0,13	0,14	0,16
30 Plot 9 (SCC)	0,18	0,11	0,10	0,13
30 Control (M+B)	0,17	0,36	0,13	0,16

Figure 1: Gravimetric water content at 30cm depth for different cropping options (Phumelele Hlongwane, 2017-2018)

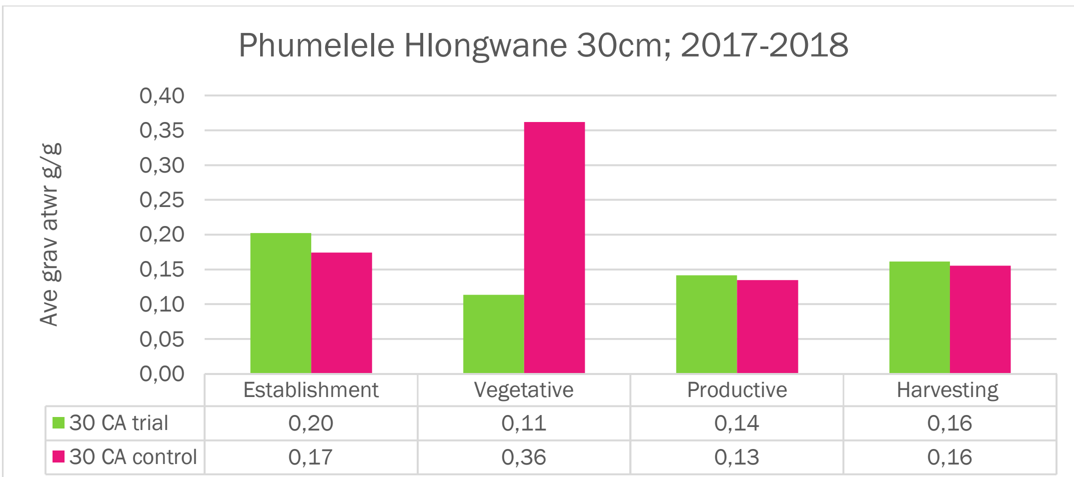
From the figure above the following trends can be seen:

- At establishment, vegetative stage, productive and harvesting; for depths 30,60,90,120 the values are similar within each plot of the CA trial for 2017-2018, meaning the water content of the whole profile was similar in each plot (results for 60cm-120cm are not shown here)
- The water content for the plot planted to Lab-Lab beans (Dolichos) remained higher than the other plots for most of the season. The assumption here is that the mulching capability of the Dolichos reduced the evaporation and improved soil water content.
- The soil water content for the summer cover crops, Plot 9, was lower than for the other cropping options in the trial plots for the entire season. This provides a reasonably clear indication that the SCC used more water than the other crop combinations tested (Lab-Lab beans, maize and cowpea intercrop and beans). For the vegetative and productive growth period the measurements of 0,11 and 0,1 (g/g) of water to soil is considered suboptimal for unimpeded growth.
- Generally, the CA control and the CA trial plots had similar gravimetric water content readings for the season, indicating the water holding capacity of the soil is not changed greatly by the particular cropping options within the CA farming system.

- The gravimetric water content for the maize and cowpea intercrop (Plat 6), indicates a severe dip in water content in the soil during the vegetative growth phase. It is not clear why this would be the case, but it could be an indication of temporary competition for water between the maize and cowpeas in the vegetative growth stage – although the severity of the result (0,01 g/g) would rather indicate an error in sampling and analysis.

In general, these results indicate that the water holding capacity of these soils under the CA system of mixed cropping and crop rotation supported good growth of all crop combinations in this season.

To compare the results of 2017-2018 with the present season (2018-2019), the results for all trail plots were combined and averaged and were then compared to the CA control and a conventional control (2018-2019 only). These results are shown in the two figures below.



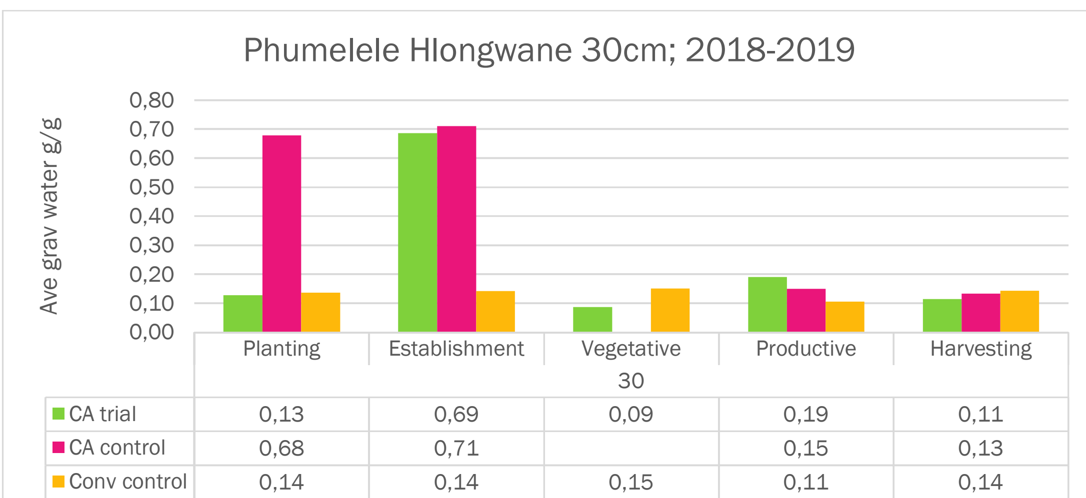
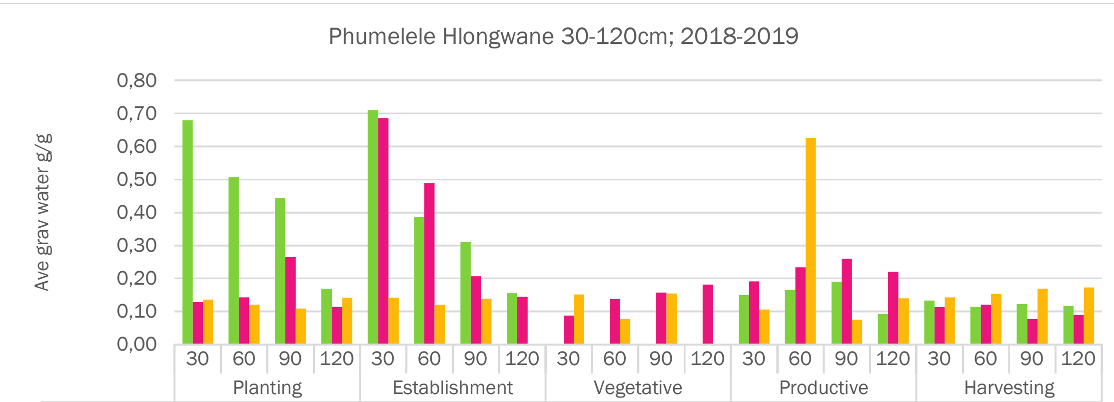


Figure 2: Comparison of gravimetric water content results between 2017-2018 and 2018-2019 season, for CA trial and control plots for Phumelele Hlongwane (Ezibomvini)

From the above figures the following observations can be made:

- Overall the water content was lower at the beginning of the season and higher at the end of the season for 2018-2019, when compared to 2017-2018. This trend follows the rainfall patterns and ETo for these two periods.
- For the 2018-2109 season the water content for the CA control for the planting and establishment phases is relatively high. It then dips sharply during the vegetative phase (result missing)
- For the CA trial plot water content during the establishment stage is high and dips sharply to a value below optimal growth during the vegetative growth stage.
- The gravimetric water content for the CA trial and CA control is higher during the productive phase than the conventional control for the 2018-2019 – indicating potential for better production from the CA plots.
- During the harvesting phase the water content for the CA trial plot for 2018-2019 is lower than the two control plots. This is likely an indication of continued active growth of the cover crops and lab-Lab beans planted in the trial.

The only conclusion that could confidently be drawn from these results is that the soil water content of the vegetative growth stage in 2018-2019, for the CA trial and CA control pots was well below the levels required for unimpeded crop growth. The high water content values are not congruent with the rainfall and ETc data gathered for this season and are hard to explain – unless per chance samples were taken very soon after rainfall events.



	Planting 30	Planting 60	Planting 90	Planting 120	Establishment 30	Establishment 60	Establishment 90	Establishment 120	Vegetative 30	Vegetative 60	Vegetative 90	Vegetative 120	Productive 30	Productive 60	Productive 90	Productive 120	Harvesting 30	Harvesting 60	Harvesting 90	Harvesting 120
CA control	0,68	0,51	0,44	0,17	0,71	0,39	0,31	0,16					0,15	0,16	0,19	0,09	0,13	0,11	0,12	0,12
CA trial	0,13	0,14	0,27	0,11	0,69	0,49	0,21	0,14	0,09	0,14	0,16	0,18	0,19	0,23	0,26	0,22	0,11	0,12	0,08	0,09
Conv control	0,14	0,12	0,11	0,14	0,14	0,12	0,14		0,15	0,08	0,15		0,11	0,63	0,07	0,14	0,14	0,15	0,17	0,17

What can be seen from this figure is the following:

- There is a great reduction in water content in the soil, throughout the profile (30-120cm depth) moving from the vegetative to productive stages and in fact there is too little water in the soil during that period to sustain the crop growth as a gravimetric water content in clay-loam soils of 0,11 -0,14 (g/g) is required as a minimum prior to wilting point being reached
- The CA trial plots recovered well during the productive phase and indicate a higher soil water content than both the control plots throughout the soil profile. This points towards better water holding capacity in these soils linked to the multi cropping options and shows also that the potential competition during the vegetative growth phase did not continue into the productive phase

- Towards the end of the season (harvesting stage) the deeper soil levels have dried out considerably for the CA trial, more so than the control plots; indicating an increased drying in the lower levels of the soil profile for the multi-species CA trial. This is likely due to the continued growth of the Lab-Lab beans and cover crops, which were not present in the control plots.

Overall, for both seasons, the gravimetric soil water content of the CA trials are somewhat lower than the CA control plots. This indicates that the multi-cropping options used in the CA trial use more water than a monocropping option (such as used in the CA controls). This result is not unexpected. There is also an indication that the multi-cropping led to decreased water availability during the vegetative growth phase for the 2018-2019 season, which could in turn affect the maize yields for this season. The beans intercropped with maize died back during this period and no yields have been recorded. Cowpeas however, survived well. This provides a good indication of the drought tolerance of cowpeas. For the summer cover crop combination, sunflowers also died during this vegetative growth phase due to water shortages, but the millet and Sunhemp survived well and seeded. Interestingly the water content is much improved for the CA trial when compared to the CA and conventional controls- indicating a good recovery for the CA trial plots in this phase

Bulk Density

Below is a summary of the results of the bulk density calculations for different cropping practices within the CA system of the three participants. They were chosen for having differing period of cropping under CA and for inclusion of a number of practices within their CA system; namely intercropping and planting of summer cover crops (SCC).

Table 17: Bulk density (pb) results for three CA participants

Village	**Period under CA**	**Name and Surname**	**Control CT**	**Control CA**	**M**	**M+B**	**M+CP**	**SCC**	**Average**
Ezibomvini	4	Phumelele Hlongwane	1,30	1,36	1,38	1,33	1,38	1,28	**1,34**
Eqeleni	5	Ntombakhe Zikode		1,35		1,49	1,37	1,32	**1,38**
Thamela	1	Mkhuliseni Zwane			1,14	1,08	1,09	1,07	**1,10**
Average bulk density									**1,27**

These results indicate an increase in ρb over the period of involvement in CA. This trend is expected. There is little to no difference between the CA practices, although in all three cases the planting of SCC has reduced the ρb fractionally.

Soil Health

This season soil health analysis was undertaken for 10 participants across five villages in Bergville;

- Eqeleni (2) Stulwane (2); 6th year of implementation; when was sample taken??
- Ezibomvini (2); 5th year of CA implementation; when
- Mhlwazini (2); 3rd year of CA implementation; when
- Ndunwana (2); 3rd year of CA implementation; when

The intention is to compare the soil health characteristics for a number of cropping options within the CA trials, with conventionally tilled mono-cropped control plots, over time.

The Haney soil health tests (as analysed by Soil Health Solutions in the Western Cape and Ward Laboratories in the USA) provides insight into microbial respiration and populations in the soil, organic and inorganic fractions of the main nutrients N, P and K, and assessment of organic carbon percentage organic matter (%OM). An overall soil health score (SH) is also provided for each sample.

Haney Soil health tests parameters[4]

These analyses are benchmarked against natural veld for each participant, due to high local variation in soil health properties, measured at different times. The veld scores provide for high benchmarks to compare the cropping practices against.

Soil Respiration 1-day CO2-C: This result is one of the most important numbers in this soil test procedure. This number in ppm is the amount of CO2-C released in 24 hours from soil microbes after soil has been dried and rewetted (as occurs naturally in the field). This is a measure of the microbial biomass in the soil and is related to soil fertility and the potential for microbial activity. In most cases, the higher the number, the more fertile the soil.

Microbes exist in soil in great abundance. They are highly adaptable to their environment and their composition, adaptability, and structure are a result of the environment they inhabit. They have adapted to the temperature, moisture levels, soil structure, crop and management inputs, as well

[4] Haney/Soil Health Test Information Rev. 1.0 (2019). Lance Gunderson, Ward Laboratories Inc.

as soil nutrient content. Since soil microbes are highly adaptive and are driven by their need to reproduce and by their need for acquiring C, N, and P in a ratio of 100: 10: 1 (C:N:P), it is safe to assume that soil microbes are a dependable indicator of soil health. Carbon is the driver of the soil nutrient-microbial recycling system.

Water extractable organic C (WEOC): Consists of sugars from root exudates, plus organic matter degradation. This number (in ppm) is the amount of organic C extracted from the soil with water. This C pool is roughly 80 times smaller than the total soil organic C pool (% Organic Matter) and reflects the energy source feeding soil microbes. A soil with 3% soil organic matter when measured with the same method (combustion) at a 0-3 inch sampling depth produces a 20,000 ppm C concentration. When the water extract from the same soil is analysed, the number typically ranges from 100-300 ppm C. The water extractable organic C reflects the quality of the C in the soil and is highly related to the microbial activity. On the other hand, % SOM is about the quantity of organic C. In other words, soil organic matter is the house that microbes live in, but what is being measured is the food they eat (WEOC and WEON).

If this value is low, it will reflect in the C02 evolution, which will also be low. So less organic carbon means less respiration from microorganisms, but again this relationship is unlikely to be linear. The Microbially Active Carbon (MAC = WEOC / ppm CO2) content is an expression of this relationship. If the percentage MAC is low, it means that nutrient cycling will also be low. One needs a %MAC of at least 20% for efficient nutrient cycling.

Water extractable organic N (WEON): Consists of Atmospheric N2 sequestration from free living N fixers, plus organic matter degradation. This number is the amount of the total water extractable N minus the inorganic N (NH4-N + NO3-N). This N pool is highly related to the water extractable organic C pool and will be easily broken down by soil microbes and released to the soil in inorganic N forms that are readily plant available.

Organic C: Organic N: This number is the ratio of organic C from the water extract to the amount of organic N in the water extract. This C:N ratio is a critical component of the nutrient cycle. Soil organic C and soil organic N are highly related to each other as well as the water extractable organic C and organic N pools. Therefore, we use the organic C:N ratio of the water extract since this is the ratio the soil microbes have readily available to them and is a more sensitive indicator than the soil C:N ratio. A soil C:N ratio above 20:1 generally indicates that no net N and P mineralization will occur. As the ratio decreases, more N and P are released to the soil solution which can be taken up by growing plants. This same mechanism is applied to the water extract. The lower this ratio is, the more organisms are active and the more available the food is to the plants. Good C:N ratios for plant growth are <15:1. The most ideal values for this ratio are between 8:1 and 15:1.

Soil Health Calculation: This number is calculated as 1-day CO2-C/10 plus WEOC/50 plus WEON/10 to include a weighted contribution of water extractable organic C and organic N. It represents the overall health of the soil system. It combines 5 independent measurements of the soil's biological properties. The calculation looks at the balance of soil C and N and their relationship to microbial activity. This soil health calculation number can vary from 0 to more than 50. This number should be above 7 and increase over time.

Some of the inter relationships between these variables are explored below

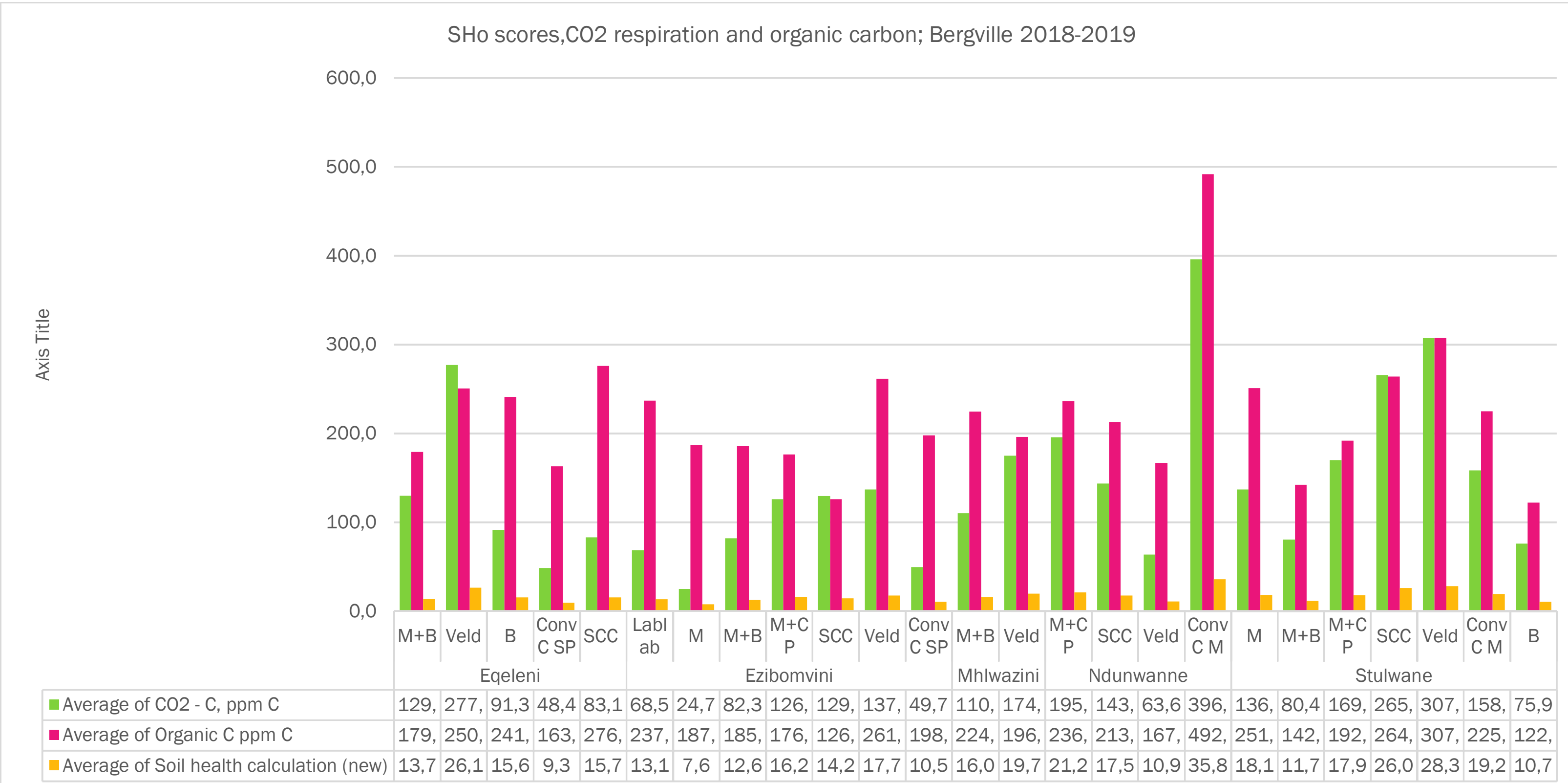


Figure 3: Comparison of the SH scores for Bergville participants (N=10) with microbial respiration and organic carbon.

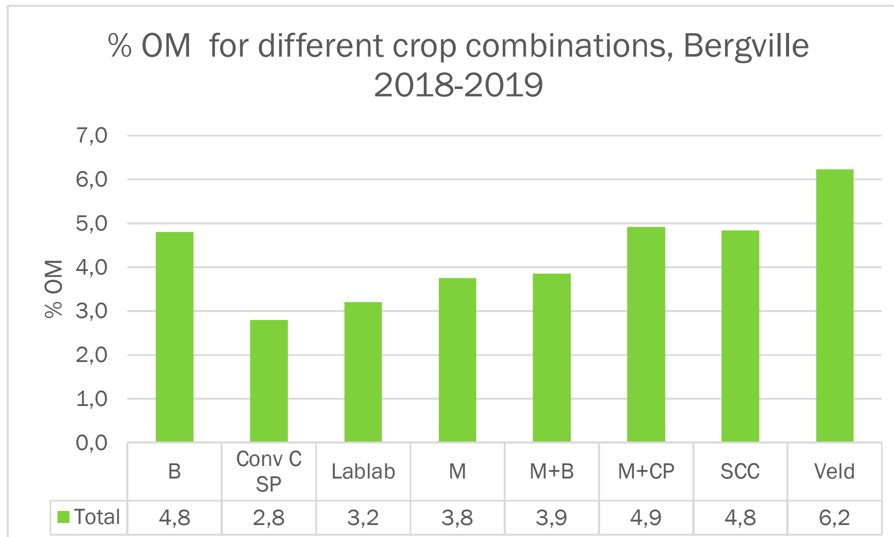
The general assumption here is that if the level of organic C in a plot is high, then the microbial respiration will also be high, as will the soil health scores and vice versa. This is not always the case, as the relationship is not necessarily a linear one.

The CO_2-C respiration also gives an indication of the potential mineralisation of N for the soil as well as organic matter content. The small table below indicates these relationships.

Test results ppm CO_2-C	N mineralisation potential	Biomass
>100	High-N potential soil. Likely sufficient N for most crops	Soil very well supplied with organic matter. Biomass>2500ppm
61-100	Moderately-high. This soil has limited need for N supplementation	Ideal state of biological activity and adequate organic matter
31-60	Moderate. Supplemental N required	Requires new applications of stable organic matter. Biomass <1200ppm
6-30	Moderate-low. Will not provide sufficient N for most crops	Low in organic structure and microbial activity Biomass <500ppm
0-5	Little biological activity; requires significant fertilisation	Very inactive soil. Biomass<100ppm. Consider long term care

For the above figure the following trends can be seen:

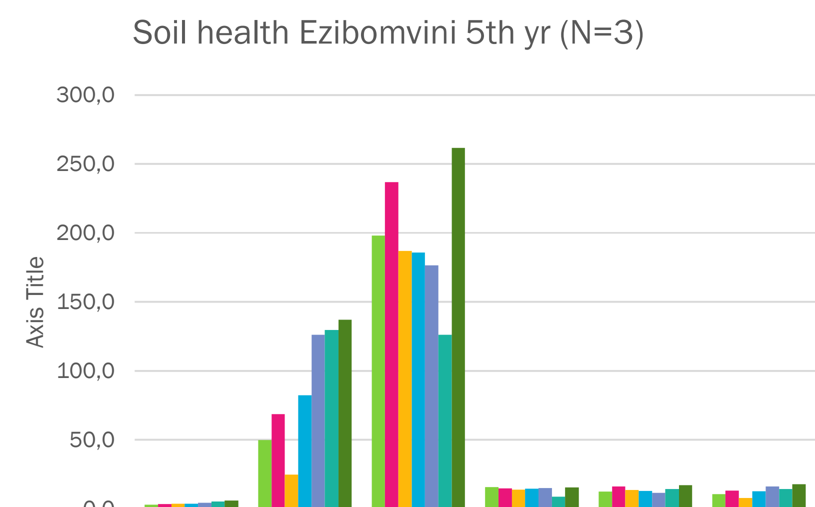
- All the CA samples for all five villages fall within the >100ppm and 61-100ppm $C0_2$–C respiration categories; indicating adequate to high levels of organic matter, an ideal state of biological activity and a moderate to high N- mineralisaton potential.
- The two Conventional tillage samples (sweet potato) fall within the moderate category where addition of organic matter is required as well as supplemental N. the Conventional maize control for Ndunwana however has extremely high respiration and organic carbon values – This value is somewhat of a mystery- as the benchmark veld samples for Ndunwana are quite low. The fact that it is a newly tilled plot, leading to very high microbial activity, especially bacteria, and the release of nutrients from the organic matter in the soil, might be the best explanation of the result.



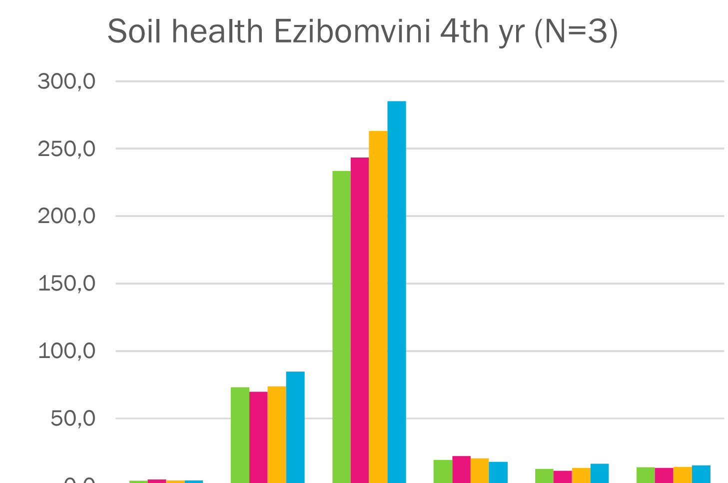
In conclusion the soil health status of the CA trial plots are moderately high to high, with good organic matter content and ideal states of biological activity, as indicated in the small figure alongside. The highest values for %OM are for the M+CP and SCC plots – which confirms the observations that these crop combinations are the best at improving soil health in the short term.

Figure 4: % OM for different CA crop combinations in Bergville; 2018-2019

Below is a comparison of the soil health status for Ezibomvini across two seasons.



	Average of % OM	Average of CO2 - C, ppm C	Average of Organic C ppm C	Average of Organic N ppm N	Average of C:N ratio	Average of Soil health calculati on (new)
Conv C SP	2,9	49,7	198,0	15,8	12,5	10,5
Lablab	3,2	68,5	237,0	14,7	16,1	13,1
M	3,6	24,7	187,0	13,8	13,6	7,6
M+B	3,6	82,3	185,7	14,4	12,8	12,6
M+CP	4,5	126,2	176,5	15,1	11,7	16,2
SCC	5,3	129,6	126,0	8,8	14,3	14,2
Veld	5,8	137,0	261,7	15,4	17,0	17,7



	Average of % OM	Average of CO2 - C, ppm C	Average of Organic C ppm C	Average of Organic N ppm N	Average of C:N ratio	Average of Soil health calculati on (new)
Cont M	3,8	73,1	233,5	19,1	12,6	13,9
M+B	4,7	69,9	243,5	22,2	11,2	13,2
SCC	4,0	73,7	263,3	20,3	13,1	14,0
Veld	3,9	84,8	285,3	17,8	16,3	15,2

Figure 5: Comparison of Soil health indicators for Ezibomvini across two cropping seasons; 2017/18 and 2018/19

Legend: CONV C SP - conventional control sweet potatoes, LabLab - Dolichos lab lab beans, M - Maize, M+B - maize and bean intercrop, M+CP - Maize and cowpea intercrop, SCC - summer cover crop mix (millet, Sunhemp and sunflower)

When comparing the two graphs (4th and 5th year) above, it can be seen that the soil health scores (SH) are comparable for the CA cropping options across the two seasons compared:

- SCC (5th); SH=14,2 and SCC (4th); SH =14,0
- M+B (5th); SH=12,6 and M+B (4th); SH=13,2

The SH score for the veld samples however differ quite a lot, mainly due to a difference in measured Organic C and Organic N. IN addition, these samples were not taken in exactly the same place every year – although they were taken in the veld directly adjacent to the homesteads. What this means, is that the soil health parameters vary in the veld as well, depending on where the sample was taken, also over a very small area. It is thought that these differences can be smoothed out by taking the veld samples in different places around the homestead and combining them into one sample. This will be attempted in future seasons.

In general, the Organic C and Organic N values for the 4th year are markedly higher than those measured for the 2018-2019 season. But the microbial respiration values for comparable CA samples (M+B and SCC) are markedly higher for the 5th year. While the flux and flow of organic nutrient availability and microbial growth are quite complex, with many interrelated parameters, the trends in decrease in organic C and N are considered to be related primarily to a slow, but definite drying of the soil profile over the last two years. The trend towards increased microbial activity in the multi-cropped (M+B, M+BP and SCC) and legume (Lab-Lab) plots in the 5th year clearly indicate the value of these practices for sustained soil health under conditions of climate variability (late onset of rain, variable rainfall and increased temperatures)

For 2018-2019 (5th year) the soil health results indicate the following trends:

- The average % OM is higher for all the CA cropping options when compared to the conventional control. Plot 1 (SCC CA treatment, 2018/19) has a value close to that of the natural veld sample, indicating the greatest build- up of organic carbon for this cropping system within a season. This trend was also noticed for the 2017-2018 cropping season (4th year), where the SCCs were planted in Plot 9
- The microbial respiration is highest for the SCC CA plot, followed by the maize and legume (cowpea, bean) intercropped plots and Lab-Lab beans and is lowest for the mono-cropped maize. A similar trend was noticed for the 2017-2018 cropping season (4th year).
- The average organic N is the highest for the three CA plots containing legumes (Lab-Lab, M+B and M+CP) (plots 10, 4 and 2 respectively). And lowest for the SCC plot. A similar trend was noticed for the 2017-2018 cropping season (4th year).
- A low C:N ratio is considered beneficial for nutrient availability for crop growth. The lowest values are found for the CA intercropped plots (M+B and M+CP), followed by the CA maize plot. Again the trend is similar to the 2017-2018 results

The Conventional control plot showed the highest average organic N value (15,8ppm).

As mentioned above in the discussions around soil water content and water holding capacity, finding appropriate controls to compare the CA results against, has been a challenge. This season a conventional control plot was chosen where increased tillage and mono-cropping is practiced. The plot was planted to sweet potatoes. We however, did not take into account the historical land use of this plot, so while the lower % OM and microbial respiration was expected, the higher levels of organic N were not. We have not compared the CA and conventional plots directly for this reason.

In addition, the CA maize plot for 2018-2019 (5^{th} year), shows a very low microbial respiration rate, despite having reasonably high organic C and Organic N values. The understanding here is that there are localised differences in soil quality between the 10x10m CA plots in Phumelele Hlongwane's field that have reduced these values considerably. These differences are not directly related to the multi-cropping and crop-rotation practices for the CA trial, but are more likely due to a lower microbial count, or localised soil pathogens. This was reported on in the 2016-17 report, where a supplementary soil pathogen study conducted by the ARC showed high levels of root and crown rot fungal species in her CA plots; notably Fusarium and Phoma species.[5]. The data indicated that the severity of root rots is higher in the CA plots than the conventionally tilled plots.

The local variations in soil health quality for different plots within the same field are due to soil management practices by the farmer prior to starting their CA experimentation combined with the combination of intercropping and crop rotation practices used during the CA experimentation process.

Repeat soil health samples are taken from the same plots within each participant's field. A sampling set of 15-20 cores is sued for each plot ; meaning that these 20 sub-sub samples per plot are combined to provide for one reading for the plot. As these participants use both intercropping and crop rotation, the crops in these specific plots are not the same every year. The assumptions used here are the following:

1. That a specific crop combination in a plot has an effect on the soil health; e.g. maize vs an intercrop or cover crops
2. That the history of the plot, in other words the rotations used also have an effect on the soil health and thus
3. That overtime the soil health scores across the plots will similar as they slowly increase.

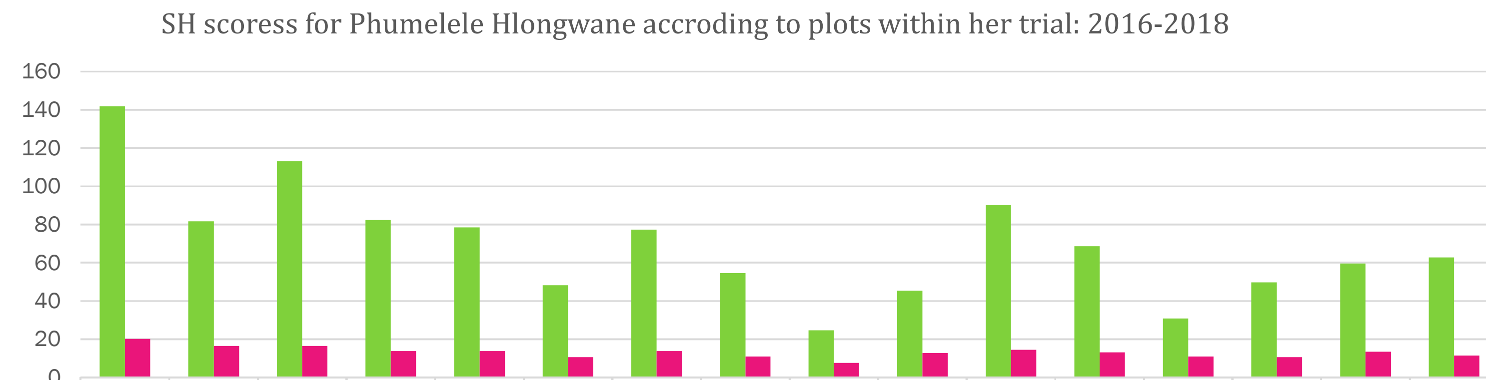
To date, there is however still a high level of variability between the plots. This is explored in a little more detail below.

The table below indicates Phumelele's rotations in the last four years.

[5] Agricultural Research Council. Plant Protection Research Institute. P/Bag X134, Queenswood, Pretoria 0121. Preliminary Consultation Report-Analyses Of Soil borne Diseases Of Maize, Soybean And Sunflower – Soil Health Project. Prepared by: Dr Sandra Lamprecht and Thabo Phasoana. Tel: (021) 887 4690 Fax: (021) 887 5096. Email: lamprechts@arc.agric.za

Plot no	2015/16	2016/17	2017/18	2018/19	Run off plots
1	M+B	M	M +WCC	SCC	Shaded cells indicate runoff plots
2	SCC	M	M+B	M+CP	Rotations have been done attempting to ensure a different crop/crop mix on each plot in each consecutive year. A further refinement of the schedule to be a 3- year rotation of; single crop – intercrop- cover crop, will be adhered to into the future
3	M+SCC+WCC	M+B	M	MCP	
4	M+B	LL	M	M+B	
5	LL	M	LL	M	
6	M+LL	SCC	M+CP	M+B	
7	M+CP	M	M+CP	M+B	
8	M+B	M+CP	B	M+B	
9	M+CP	M+B	SCC	M	
10	M+B	M+B	M	LL	
11?		CA Control: M	CA Control: M	CA Control M	
12?	Control: M (CA)		CA Control: M+B (CA)	Conventional control: SP	

If one now compares the soil health results for the specific plots within Phumelele's trial, across a number of seasons, it is expected that the soil health scores between the plots should even out and become more similar over time. These scores are also expected to increase over time. This is shown in the figure below



	Veld 2018	Veld 2017	Veld 2016	Plot 2 2018	Plot 2 2016	Plot 4 2018	Plot 4 2017	Plot 4 2016	Plot 5 2018	Plot 5 2017	Plot 5 2016	Plot 10 2018	Plot 10 2017	Cont M (ConvSP) 2018	Cont M (CA) 2017	Cont M (CA) 2016
CO2 - C, ppm C	141,8	81,6	113	82,4	78,4	48,3	77,4	54,5	24,7	45,5	90,2	68,5	30,8	49,7	59,6	62,7
SH	20,1	16,52	16,57	13,8	13,8	10,6	13,81	10,87	7,6	12,73	14,45	13,1	10,84	10,5	13,36	11,54

Figure 6: Soil health scores for a number of plots in Phumelele Hlongwane's CA trial between 2016-2018

From the figure above the following can be seen:

- The SH scores have not necessarily increased over the three seasons measured; it has increased for one of the plots (pot 10), decreased or another (Plot 5), stayed the same for another plot (Plot 2) and has been variable for another (Plot 4), with similar differences not in the microbial respiration.
- It the SH scores are average for the plots then the veld sample has the highest SH score (17,73), followed by plot 2 (13,8, with all other plots, including the control plots being in the range of 11,6-11,9. This does then indicate a tendency for the SH scores to even out between the plots over time.
- The fact that the CA control and Ca trial plot average soil health scores are the same; appears to indicate that the intercropping and rotations used have a smaller effect on soil health than the practice of CA (minimum tillage)

This means that the assumption that the soil health scores will even out over time is correct, but that there are local and seasonal variations that can mask this trend. Thus far the overall increase in soil health scores expected from the intercropping and crop rotation is not evident.

Using the soil health test results, it is also possible to explore the composition of the microbial population in the soil, looking at the different types of microorganisms and their prevalence using data from the PLFA test.

Generally, it is known that conventional tillage systems favour decomposer/saprophytic fungi, with small hyphal networks. These are important in soil fertility but play a very small role in carbon storage. Conservation Agriculture systems favour Mycorrhizal fungi which have large hyphal networks and play a major role in carbon storage. Mycorrhizal fungi get their energy in a liquid form, as soluble carbon directly from actively growing plant roots. They access and transport water - plus nutrients such as phosphorus, nitrogen and zinc - in exchange for liquid carbon from plant roots. Soluble carbon is also channelled into soil aggregates via the hyphae of mycorrhizal fungi and can undergo humification, a process in which simple sugars are made up into highly complex carbon polymers. Aggregate stability is thus an important emerging quality of the soil under CA. It is measured as % volumetric stability, as shown in the small table below.

Volumetric Aggregate stability %				
0 - 15 %	15 - 30 %	30 - 45 %	45 - 60%	> 60%
Very low	Low	Average	Good	Excellent

From the soil health, microbial respiration and organic carbon data for Ezibomvini and Ndunwana, the expectation is that aggregate stability will be good to excellent. This is indeed the case for Ndunwana (as shown in Figure 5), where the values range from 45-46,5%. For Ezibomvini however, there is a range of values from low, to average and good. This would mean, among other things, that the soil health status, including Mycorrhizal fungi populations in the Ezibomvini soils are not building up as expected and shows high variation between plots (within one field), as discussed in the section above.

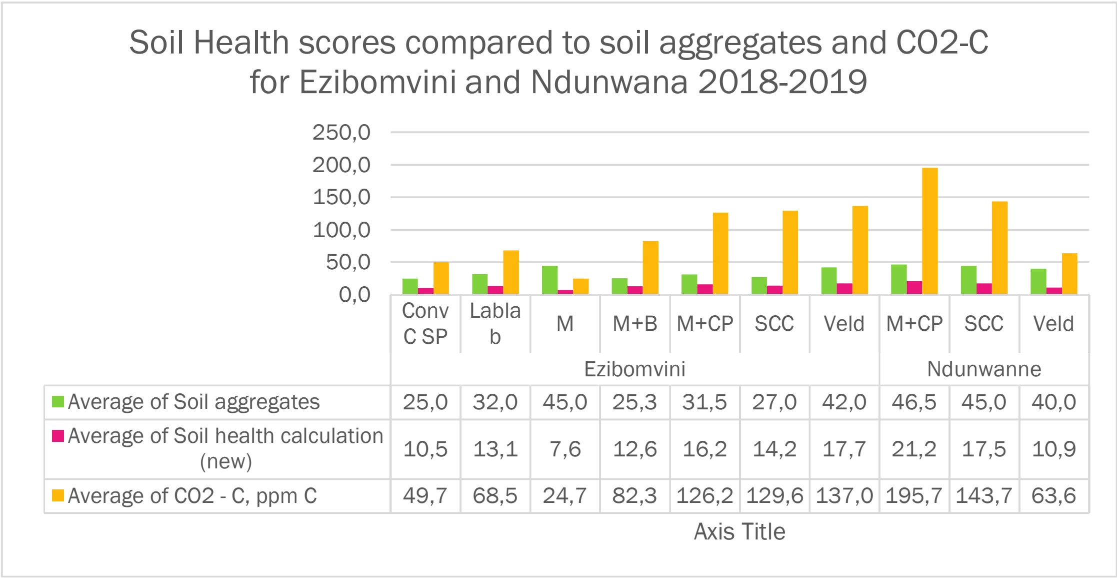
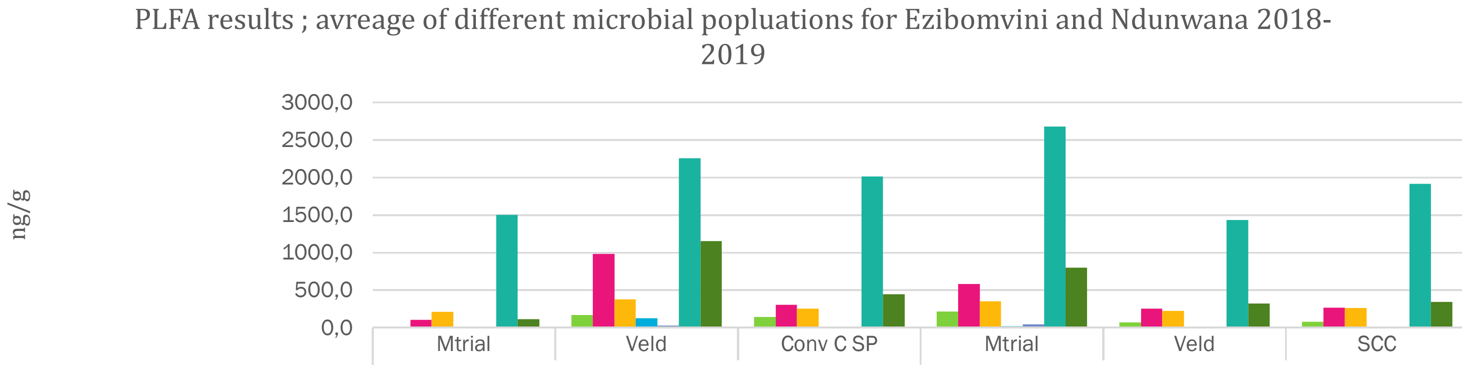


Figure 7: A comparison of % aggregate stability for soil health samples from Ezibomvini and Ndunwana

The PLFA analysis conducted and presented below, sheds some light on this.

PLFA analysis

PLFA (Phospholipid fatty acid) analysis of the microbial populations in the samples provides a breakdown (snapshot) of the type of organisms and their ratio's present, e.g. bacteria, fungi and protozoa, as well as their relative abundance. This is based on the different and distinguishable biochemical structures and processes for these organisms. Although this analysis can get very complex, two simplified snapshots of the process are provided in the figures below.



	Mtrial	Veld	Conv C SP	Mtrial	Veld	SCC
	Ezibomvini			Ndunwana		
Average of Arbuscular Mycorrhizal	9,4	170,8	140,9	217,4	68,1	79,4
Average of Saprophytes	104,6	982,4	305,3	581,5	253,7	264,1
Average of Actinomycetes biomass	208,4	376,7	253,2	352,8	223,5	259,4
Average of Rhizobia	0,0	126,0	0,0	21,3	0,0	0,0
Average of Protozoa biomass	0,0	29,7	17,9	44,7	13,0	8,8
Average of Bacteria biomass	1504,0	2257,3	2015,7	2679,2	1433,2	1917,0
Average of Fungi	114,0	1153,2	446,2	798,9	321,8	343,4

Figure 8: PLFA results for microbial populations from Ezibomvini and Ndunwana soil health samples; Bergville 2018-2019

From the above figure on PLFA results the following trends can be seen:

- Mycorrhizal fungi populations for the CA maize (Mtrial) in Ezibomvini are extremely low, when compared to the veld sample and the samples from Ndunwana; although the Mycorrhizal populations are quite small when compared to the overall microbial populations present in these sites.
- For the Ezibomvini samples the total microbial biomass for the Mtrial sample is lower than the Conventional control sample. This low microbial mass is not reflected in the %OM (3,65) or the organic carbon (187ppm) and organic nitrogen (13,8ppm) content of the plot; these values being quite high. This means that the microbial biomass in this particular plot is being dampened for another reason, the most likely being disease, shown in the 2nd graph in Figure 6 above. From this and other analyses done, it would appear that this situation is specific to this plot (and perhaps 2 others) in Phumelele Hlongwane's CA trail.
- Mycorrhizal fungi populations in the CA trial plots (Maize and SCC) are considerably higher than the veld benchmark for Ndunwana, indicating the expected build-up of these fungi in the CA cropping system

If is also possible to analyse the ratios of the different organisms to each other

Fungi:Bacteria; Bacteria tend to dominate in systems with fewer organic inputs or residues possibly leading to a lower C:N ratio. In addition, bacteria can be more prominent in the early spring or late fall as soil temperatures are usually cooler and vegetation is less active or absent. Dry conditions, or increased land disturbance through prolonged and extensive tillage, grazing, or compaction may also favour bacteria. While bacteria are important and needed in the soil ecosystem, fungi are desired and more often considered indicators of good soil health. Increased use of cover crops and/or other organic inputs and less soil disturbance should help the soil support more fungi.

Scale	Rating
< 0.05	Very Poor
0.05+ - 0.1	Poor
0.1+ - 0.15	Slightly Below Average
0.15+ - 0.2	Average
0.2+ - 0.25	Slightly Above Average
0.25+ - 0.3	Good
0.3+ - 0.35	Very Good
> 0.35	Excellent

Gram+ve:Gram-ve; Gram+ve bacteria typically dominate early in the growing seasons and/or following a fallow period. They also survive better under certain environmental conditions or stressors such as drought or extreme temperatures due to their ability to form spores. Therefore, it is common to see higher values when a community is coming out of dormancy or is stressed. These values will typically become more balanced as the soil conditions become more favourable throughout the growing season. A Gram-ve dominated soil may be due to anaerobic conditions or other stressors such as pesticide application or heavy metal contamination

Scale	Rating
< 0.5	Gram (-) Dominated
0.5+ - 1.0	Slightly Gram (-) Dominated
1.0+ - 2.0	Balanced Bacterial Community
2.0+ - 3.0	Slightly Gram(+) Dominated
3.0+ - 4.0	Gram(+) Dominated
> 4.0	Very Gram(+) Dominated

Predator:Prey; This ratio is also expressed as protozoa to bacteria. Protozoa feed on bacteria, which helps release nutrients, especially nitrogen. A higher ratio indicates an active community where base levels of nutrients are sufficient to support higher trophic levels of predators. However, this ratio will always be relatively low as prey generally greatly outnumber prey.

Scale	Rating
< 0.002	Very Poor
0.002+ - 0.005	Poor
0.005+ - 0.008	Slightly Below Average
0.008+ - 0.01	Average
0.01+ - 0.013	Slightly Above Average
0.013+ - 0.016	Good
0.016+ - 0.02	Very Good
> 0.02	Excellent

The figure below indicates these ratios for the soil health samples taken in Ezibomvini and Ndunwana

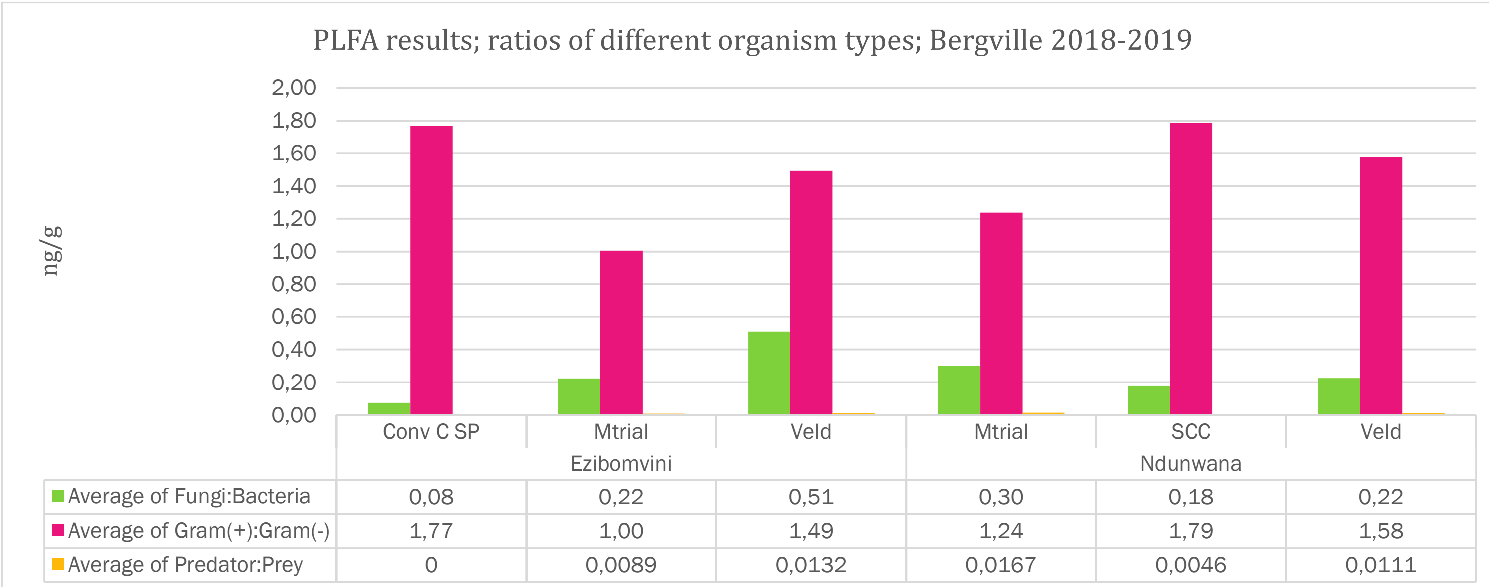


Figure 9: PLFA results; ratios of different types of organisms for Bergville 2018-2019

It can be seen that:

- The fungi:bacteria ratios for the CA Mtrial plots are above average to good. The low ratio for the Convention control plot (Conv C SP) is expected, given the lower organic matter content and tillage of this plot.
- The Gram+ve;Gram-ve ratios for all the samples veld control and trial plots fall between 1-2 and indicated a balanced bacterial community.
- The predator:prey ratios show some variation: From Phumelele Hlonwgane (Ezibomvini) the ratios for the M trial plot are average and those for her Conv C are very poor. This is also indicated in Figure 8 above showing very low populations of both rhizobia and protozoa in Phumelele's soil The occurrence of natural strains of Rhizobia in soils are affected by pH, tillage, high temperatures and chemical residues. As Phumelele has given attention to liming, reduced use of chemicals and has used CA now for 6 seasons running, it is unclear why these populations are so depleted. It is suggested that introduction of rhizobia strains for root nodulation and nitrogen fixation by legumes will have a highly beneficial effect.
- For Lethiwe Mofukeng (Ndunwana) both her Mtrial and SCC plots show a very good ratio.

Nitrogen

In the dryland cropping system around Bergville, as in most other dryland cropping areas in South Africa, supplementation with inorganic Nitrogen is considered an important strategy for optimal crop growth. In our CA study different crop combinations and cropping options are being explored to assess the potential of providing this nitrogen through improvement of natural nutrient flow cycles. Inorganic N, besides being expensive, also has been shown to dampen the natural microbial activity in the soil and can also be partially ineffective under extreme conditions of drought and heat.

An analysis of immediate release N has been done, as well as an estimation of the rand value of inorganic nitrogen saved /ha for different cropping options under CA. The immediate release N- is the water extractable organic Nitrogen, which is immediately available to the next crop.

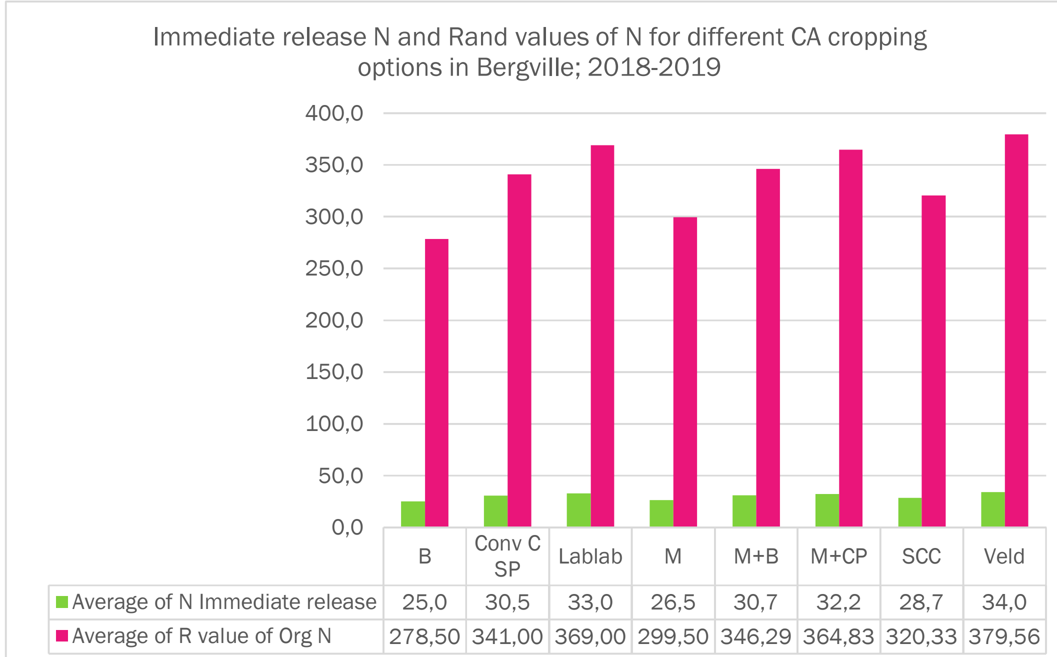
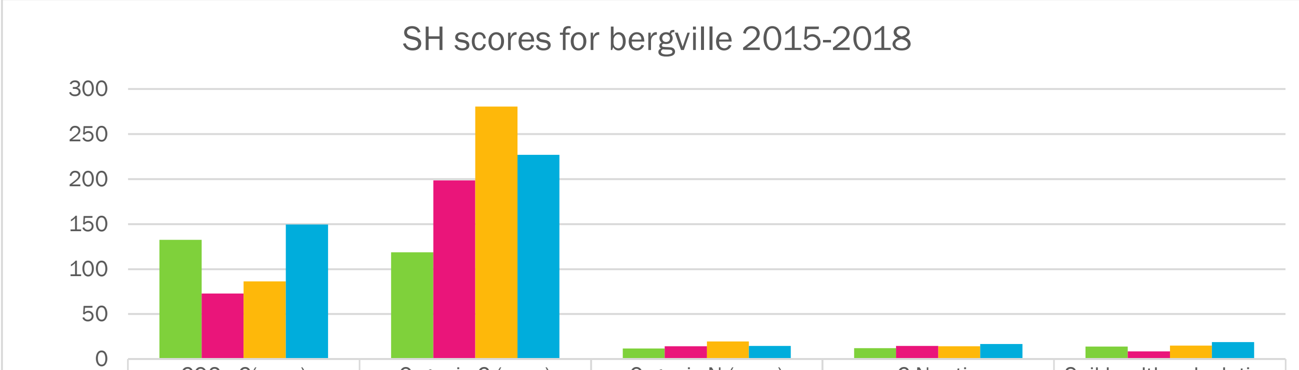


Figure 10:Comparison of immediate release N and Rand value of inorganic Nitrogen substituted for organic N for 5 villages in Bergville; 2018-2019

From this figure the expected progression of increase in available N from a CA maize monocrop – a summer cover crop mix to a maize and bean intercrop – a maize and cowpea intercrop is clearly visible. The CA beans only plot has a somewhat unexpectedly low result. On average the rand value of inorganic N saved in this process is R318/ha. If a recommendation of 60Kg/ha of N is used, this equates to a saving of around 47% on inorganic fertilizer – more specifically for the plots that integrate legumes (M+B, M+CP and Lab-Lab beans). The average rand value for inorganic N saved in the previous season (2017), was R393. It is assumed that this value is higher because of the higher soil water content (better soil water distribution in the soil profile throughout the season). This indicates the effect of heat and dry soil profiles on the ability of the soils to process and maintain nutrients.

Comparison of SH test results 2015-2018

One can compare the soil health data for the different participants over time to track improvement in soil health scores. The assumption is that soil health will improve over time with CA implementation. The figure below summarises the data for five participants between 2015/16 to 2018/19



	CO2 - C(ppm)	Organic C (ppm)	Organic N (ppm)	C:N ratio	Soil health calculation
2015	132,7	118,5	11,65	12,1	13,6
2016	72,95	198,55	14,025	14,55	8,525
2017	86,2	280,5	19,4	14,0	15,2
2018	149,68	227,02	14,62	16,58	18,74

Figure 11: Soil health data for 5 participants from Bergville;2015-2018

From the above figure the following trends are visible:

- Soil health scores have increased (although not linearly) between 2015-2018 and the average SH score for 2017/18 is 18,74.
- Despite the fluctuations in CO_{2_C} (microbial respiration) organic carbon and organic nitrogen in the four years of measurement, the overall values have increased substantially since 2015.

- Interestingly the C:N ratio has been systematically increasing – rather than the expected reduction. It indicates a higher proportional increase in organic carbon in the soil, as compared to organic nitrogen through the CA practices employed in the programme. It also shows that improvement of soil Nitrogen is still an issue, despite the legume based intercrops and cover crops that have been used.

The extreme climatic conditions in the area, including heat and dry soil profiles, reduces the soil health impact of the CA practices and also increases variability in the results for different seasons

Implementation snapshots across different villages

Information provided in the interim report is not repeated here. Snapshots are provided for a few of the different villages.

Ngoba

Ngoba is a village now in its fourth year of programme participation with eleven members in the group. The village practices crop rotation, intercropping and cover crop experimentation. Mam Vimbephi Dladla is one of the participants of the group. Her trial was planted 28 November 2018 and she shared that while her trial suffered during the drier period, the CA trial has thrived under the unexpected late rains in March-April 2019. She feels that one of the main reasons for this is the CA planting, that has helped crops to withstand these harsh conditions.

Thamela

Constance Hlongwane is the local facilitator for the Thamela learning group, which is now in their third year of programme participation. Her trial has performed poorly this season and she attributes this to both dry conditions and late planting. Her crops are characterized by stunted growth, yellowing and poor germination. She was unable to replant in plots where germination was poor due to lack of planting material.

Above Left & Centre- Pictures of Mam Constance fields showing signs of yellowing and stunted growth. Right- This plot has a contrast of yellowing and green leaves.

Ndunwana

The Seasonal conditions also caused a lot of late season weed growth, which some participants were unable to manage well. The pictures for Lethiwe Zimba below are indicative.


Above left and right; Weed infestation in Letiwe Zimba's trial plots for summer cover crops and maize.

Late beans

Farmers in the villages of Ndunwana, Thamela, Stulwane and Ezibomvini planted experiments of late beans in early March. They planter 200 m^2 plots, of which 100 m^2 was planted to dry beans PAN 148 with fertilizer (LAN) and 100 m^2 was planted incorporating both fertilizer and lime. Fertilizer was applied at a rate 40 kg/ha and lime at 1.7 t/ha.

*Table 18: **Showing participants for late bean experimentation***

Village	Participant name
Ndunwana	Lethiwe Zimba
Thamela	Constance Hlongwane
Ezibomvini	Nombono Dladla
	Zodwa Zikode
	Phumelele Hlongwane
	Landiwe Dlamini
Stulwane	Phasazile Sithebe
	Hluphizwe Zondo
	Dombi Dlamini

Constance Hlongwane – Thamela

Constance Hlongwane planted her late bean trial on the 7th of March 2019 and sprayed with Roundup the following day, due to high weed pressure. Monitoring showed even germination of the beans and subsequent better growth for the trial plot that included lime.

Right: Even germination for Constance's late bean trial

Lethiwe Zimba -Ndunwana

A similar result was found for other participants including Lethiwe Zimba from Ndunwana, although her germination was somewhat patchy. This is considered an effect of Roundup which can reduce germination of legumes, especially when sprayed after planting.

Right: Somewhat patchy germination of Lethiwe's late bean trial.

Cover crops

For the majority of participants who planted summer cover crops (around 56 participants), growth was compromised due to the weather conditions and late season infestation of weeds. Very few participants (around 8 in total) harvested seed from these and then only for the Sunhemp, fodder sorghum and millet (Babala). Sunflowers did not survive to maturity.

Right: Sunhemp and fodder sorghum cover crops seedinng in Ntombakhe Zikode's field (Eqeleni)
Far right: Millet seeding in Phumelele Hlongwane's field (Ezibomvini)

Legumes such as lab-lab (dolichos) and cowpea also fared reasonably well under these harsh conditions.

Winter cover crops were only attempted by a handful of participants this year. Those planted by Ntombakhe in Eqeleni did surprisingly well.

Right: Phumelele's Lab-Lab plot growing well and

Far right: Winter cover crops for Ntombakhe

Given the extremely erratic performance of the cover crops this season, obtaining of yield data has not been attempted.

Fodder production and supplementation

As mentioned in the interim report, most of the fodder species planted (including Lucerne, white and red clover and turnips) did not germinate. Only two participants managed a reasonable harvest of Teff, which was one of the few crops planted that grew.

Right: MT visitors standing on Ntombakhe's Teff plot, for which the grass was cut and put into bags for provision of fodder to livestock

In addition to attempting to grow different fodder crops, the learning group members have been provided with input on fodder supplementation and making of bales to improve their winter fodder supply for their livestock

During the fodder and supplementation learning workshop (April 2019) a number of topics were covered including:

- Why are livestock thin in winter and why does it matter
- What to feed and how much
- Supplementation
- How can we tell if it's making a difference (condition scoring sheet)
- Making hay
- Experimentation

Right; Participants in the fodder and supplementation workshop learn about using the condition scoring sheet to monitor their livestock and supplementation experiments.

The major issue in winter, or more generally is protein. Carbohydrates can be found in grass and maize. The type of grass makes a difference; Themida (Rooigrass) is good, other grasses such as Ngongoni (Aristida), Mtshiki and Uqunga are not very palatable. Urea supplementation can be done using a powder (Premix 450) or liquid (LS33) and protein licks.

Cutting of grass and making of hay bales was discussed and small mechanical balers were provided to the group for their experimentation process.

Right: the small balers to be used for making bales.

For the experimentation process participants undertook to do the following:

- Collect monies for the supplements
- Have these supplements, as well as rolls of twine for the bales available through the farmer centres
- Set up and participate in condition scoring days for the livestock; the first one in mid-End June and to
- Ensure that they have a viable experiment; cattle in the experiment and cattle not in the experiment

In Ezibomvini and Stulwane farmers have been preparing for the fodder supplementation experiments undertaken in early June. They have cut grass for baling and will now start to make bales, as the 2nd baler has been delivered; meaning there is one baler for each of the respective areas. The idea was the farmer centres in these two villages would procure and supply the premix and the LS33. This has worked well for the protein blocks as well. For the LS33, there was none available from their closest town for a period and thus they have only now bought this liquid supplement.

Right: Dried grass ready for baling at Phumelele Hlogwane's homestead.

Farmers have approached the experimentation process a little haphazardly – feeding all their cows every now and again, rather than having a more controlled experimentation process. The idea was thus re-introduced. There is also the issue that the few bales that they will be able to make (usually not more than 10 per participant), are not likely to last long, and thus their attempts at introducing the supplements directly. This will of course be rather difficult with the liquid version (LS33), but has in fact been working quite well with the pre-mix 450.

Right: Phumlele measuring out the Premix 450 to feed to her two cows directly.

The table below outlines the fodder and supplementation experiments now being undertaken .

Table 19: fodder experimentation participants from Stulwane, Ezibomvini and Eqeleni.

Experiment	Names	Comments
Bales with LS33	Mtholeni Dlamini Phumlani Dladla Mkhathini Dladla Phumelele Hlongwane Ntombenhle Hlongwane	They have now undertaken to feed 2-3 pregnant or lactating cows with the bales mixed with LS 33 and to have the rest of their hers as their control

	Ntombakhe Zikode	
Bales with Premix 450	Mtholeni Dlamini Dlezakhe Hlongwane Mkhathini Dladla Khulekani Dladla Phumelele Hlongwane Ntombakhe Zikode	They have now undertaken to feed 2-3 pregnant or lactating cows with the bales mixed with Premix 450 and to have the rest of their hers as their control
Teff Bales	Ntombakhe Zikode Mtholeni Dlamini	Baling of the Teff they have grown
Veld with protein blocks	Lungile Dladla Matholozane Gumbi Zodwa Zikode Phasazile Sitheb	Here it has been very difficult to allow for a control as all cattle in the kraal are given access to the block; it is thus a practice that is being introduced without conscious experimentation
Veld with Premix 450	Ntobmi Dlamini Fikile Hltashwayo Hlupizile Zondi Thulile Zikode Hlanganise Hlongwane Phumelele Hlongwane	They have now undertaken to feed 2-3 pregnant or lactating cows with the Premix 450 and to have the rest of their hers as their control

Yields; 2018-2019 planting season

Yields have been measured for around 50% of all participants, also focusing on villages where yield summaries were not done in the previous season.

Separation of the maize yields per plot of the trials has been an ongoing difficulty, although a number of participants in Stulwane managed this, due to the diligence of their local facilitator, Nelisiwe Msele. In addition, some participants combined their trial and control plot yields- in this case due to very low yields and these results could not be used.

An ongoing issue is the lack of appropriate storage options. In this season a number of 200l bins were bought by participants, with assistance by MDF.

Right: Decobbing and weighing maize yields separated per plot in Stulwane and Far right: Harvested maize piled up in a yard for final drying before storage. (Constance Hlongwane- Ndunwana)

This season also saw a much higher incidence of cob rots in harvested maize, due to the wet conditions towards the end of the season.

Right and Far Right: Examples of cob rot found in harvested maize.

These are likely caused by *Fusarium and Diplodia species* and carry the risk of mycotoxins. Participants have been strongly warned against consuming this maize and have been advised to remove the infected cobs from the rest of their harvest.

The table below provides a comparison between the 2018/19 season and the previous season 2017/18

Table 20: Yield summaries for Maize; 2017/18 and 2018/19 seasons, for a number of Bergville villages

Village	**2017/18 Maize (Trial) t/ha**	**2018/19 Maize (Trial) t/ha**	**2017/18 Maize (Control) t/ha**	**2018/19 Maize (Control) t/ha**	**2017/18 Beans (t/ha)**	**2018/19 Beans (t/ha)**
Stulwane	3,0	2,4	-	4,4	0,84	
Ndunwana	3,8	3,7	0,39	0,56	1,46	
Ezibomvini	8,1	2,6	7,5	2,2	1,62	
Eqeleni	4,4		3,7		1,37	0,6
Thamela	4,5		1,8		0,51	
Emabunzini	4,6	5,2	-	-	0,94	
Emazimbeni	7,9	4,4	-	-	1,28	
Vimbukhalo	7,9		-	-	1,29	
Emangweni-Emaqeleni	5,9	3,8	-	-	1,80	
Okhombe	3,5	2,3	-	-	-	0
Magangangozi	2,8	4,9	2,5	3,5	0,5	
Nsuka	2,8		-		-	
Thunzini	3,6	1,02	-	-	1,2	0
Ngoba	4,2		-		0,5	
Mhlwazini	6,6					
Emahlathini	5,9	3,6	-	-	1,09	
Emafafatheni	-	1,5	-	-		0,625
Emadakeni	-	4,4	-	-		0,45
Nsuka	-	5,6				
AVERAGE	**5,0 t/ha**	**3,5t/ha**	**3,4 t/ha**	**2,7t/ha**	**1,22 t/ha**	**0,56 t/ha**

NOTE: Grey blocks indicate villages where yield measurements are still being finalised. Green blocks indicate newer villages, where yields have been measured for the first time this season

The overall average yield for this season has been compromised due to the weather conditions and is 41% lower than 2017/18 for maize and 55% lower for beans.

Yields in intercropped and rotated plots

Maize yields for different plots within the experimentation regime were taken for a few of the participants and are summarized in the table below

Table 21: Maize yields measured per plot of the experimental fields for participants from Eqeleni, Stulwane and Ndunwana;

		2018/2019	Yield in kg										2018 / 19	2017 /18
Village	**Name and Surname**	**Trial description**	**PLOT 1**	**PLOT 2**	**PLOT3**	**PLOT 4**	**PLOT 5**	**PLOT 6**	**PLOT 7**	**PLOT 8**	**PLOT 9**	**PLOT 10**	**t/ha**	**t/ha**
Eqeleni	Ntombakhe Zikode	plt1(m),plt2(sccmix),plt3(m),plt4(b),plt5(m),plt6(m+LL),plt7(m+b),plt8(m+b),plt9(m+b),plt10(lab lab)	35,6	scc mix	22,8	beans	0,0	106,8	56,2	133,5	101,0	lab lab	7,6	4,9
Stulwane	Dlezakhe Hlongwane	plt1(m+b),plt2(m+c),plt3(sccmix),plt4(m+c),plt5(m),plt6(b),plt7(m),plt8(m+b),plt9(lb lab),plt10(m+c)	34,2	20,5	scc mix	11,9	65,6	beans	68,8		lab lab	12,7	3,7	4,2
	Khulekani Dladla	plt1(sccmix),plt2(m+b),plt3(m+c),plt4(m+b),plt5(b),plt6(m),plt7(lablab),plt8(m),plt9(b),plt10(m)	scc mix	53,2	54,0	33,1	beans		lab lab	25,2	beans	24,0	3,6	3,5
	Fikile Hlatshwayo	plt1(m+b),plt2(sccmix),plt3(m+b),plt4(lablab),plt5(m+c),plt6(b),plt7(m),plt8(b),plt9(m0,plt10(c)	39,0									16,1	1,3	
	Thulani Dlamini	plt1(sccmix),plt2(m+b),plt3(m+c),plt4(b),plt5(m+c),plt6(m),plt7(c),plt8(b),plt9(m),plt10(lab lab)	scc mix	23,2	34,5	beans	34,3	56,1	cowpeas	beans	31,7	lab lab	4,2	2,3
	Dombolo Dlamini	plt1(m+c),plt2(m+b),plt3(sccmix),plt4(m+c),plt5(m),plt6(b),plt7(m),plt8(c)plt9m),plt10(lab lab)	20,4	60,3	scc mix	0,0	35,8	beans	23,1	cowpeas	49,3	lab lab	3,6	2,7
	Nothile Zondi	plt1(sccmix),plt2(m+b),plt3(m+c),plt4(b),plt5(m),plt6(lablab),plt7(m),plt8(c),plt9(b),plt10(m)	scc mix	0,0	0,0	beans	14,8	lab lab	14,7	cowpeas	beans	29,5	1,7	2,1

	Matolozana Gumbi	plt1(m),plt2(b),plt3(m+b),plt4(sccmix),plt5(m+b),plt6(lablab),plt7(m+b),plt8(c),plt9(m),plt10(b)	41,7	beans	24,6	scc mix	0,0	lab lab	0,0	cowpeas	37,0	beans	2,4	4,5
	Mthuleni Dlamini	plt1(m+b),plt2(m+c),plt3(b),plt4(m),plt5(lablab),plt6(m),plt7(c),plt8(m),plt9(b),plt10(scc mix)	36,8	39,4	beans	81,2	lab lab	77,2	cowpeas	0,0	beans	Scc mix	5,3	0,7
	Cuphile Buthelezi	plt1(m+b),plt2(m),plt3(c),plt4(m),plt5(b),plt6(sccmix),plt7(m),plt8(b),plt9(m+c),plt10(lab-lab)	13,8	0,0	cowpeas	68,4	beans	scc mix	67,6	beans	14,3	lab lab	3,6	2,9
	Thembi Mpinga	plt1(m+b),plt2(m+c),plt3(m+b),plt4(m+c)	31,6	0,0	21,5	15,6							2,3	
Ndunwana	Boniwe Hlatshwayo	plt1(m+b),plt2(m+c),plt3(m+b),plt4(m+c)	42,4	51,4	33,3	16,9							4,8	10,9
	Shiyiwe Mazibuko	plt1(m+c)plt2(m+c),plt3(m+b),plt4(m+c)	13,9	5,5	20,4	9,4							1,6	2,5
	Matozo Zondo	plt1(m+b),plt2(m+c),plt3(m+b),plt4(m+c)	63,8	35,8	32,6	29,0							5,4	9,6
	Makhu Mdluli	plt1(m+b),plt2(m+c),plt3(m+b),plt4(m+c)	99,5	57,6	49,1	64,7							9,0	4,0
	Vayiswa Hlatshwayo	plt1(m+b),plt2(m+c),plt3(m+b),plt4(m+c)	40,9	21,3	21,1	20,6							4,0	
	Lethiwe Zimba	plt1(m+b),plt2(m+c),plt3(m+c),plt4(m),plt5(sccmix),plt6(m),plt7(lablab),plt8(m+c),plt9(m+b,plt10(m+b)	57,3	41,3	36,3	42,3	scc mix	55,5	lab lab	39,5	45,1	0,0	4,9	
												AVERAGE	**4,1**	**4,2**

From the above table it can be seen that overall the average yields in the experimental plots were in fact very similar for 2017/18 and the 2018/19 seasons, being 4,2 and 4,1 t/ha respectively. The other notable point is the continued large variation in yields between the different plots within each of the participants' fields. The expected evening out of yields between plots, due to the crop rotation and multi- cropping options, is not really happening. These yield differences are due in part to historical difference in land management, even at this micro-scale and partly due to different practices between plots- such as more meticulous weeding in some plots than others and livestock invasion only in parts of fields. It also points towards the confusion in soil health test results when trying to compare different cropping options in different plots within one field.

Bean Yields for the 2018/19 season

The 2018/2019 season has been a very difficult seasons for bean production; In a number of villages, no beans were harvested at all. Below an indicative summary is provided for three villages where bean harvests were recorded.

Village	% of participants who obtained a harvest	Average harvest (Kg	Yield (t/ha)
Eqeleni	55%	12,12kg	0,6
Emafefetheni (new)	44%	5kg	0,625
Emadakaneni (new)	63%	3,6kg	0,45
Average	**54%**		**0,56t/ha**

Right: A basin of beans being weighed at Emadakaneni during yield determinations

Farmer Centres

Case study 1: Ezibomvini Farmers Centre

Above left: Phumelele Hlogwnae making a sale of a bunch of spinach and Above right: A view of the farmer centre; which includes seed, fertilizer, pesticides, knapsack prayers, seedlings and 200l storage drums.

The Ezibomvini farmers centre is owned by Phumelele Hlongwane and Zodwa Zikode. It has been operating for 3 years, in Phumelele's homestead. The enterprise sells agricultural inputs and non-agricultural items including fertilizers (MAP and LAN), herbicides (Round up), knapsack sprayers, preservation pills, maize and bean seed, vegetables, seedlings, protein premix (fodder supplement) and 200l storage drums. She decided to include the non-farming items to sell during off-peak times. The agricultural inputs are sold to local farmers in the village and farms from surrounding villages. She obtained the initial investment from Mahlathini Development Foundation as a loan payable after three months. Subsequent investments were obtained from savings group and profits made through sales.

The incremental success of the farmers centre has continued to grow year after year since its inception. The owners are still as surprised by the success the business has generated over the years because they were 'venturing into something completely new and risky'. Local farmers and neighbours have continued to support the enterprise; fertilizers, seed and herbicides are still the most sold products by the centre. These sales are made mainly during the planting season. But over the years sales have also increased during off-peak times through the sale of non-farming items mentioned above. The inputs sold in small quantities have been the main attraction to the centre and the ability to purchase on credit on conditions specified by the owners. For example, customers are only allowed to buy on credit if they do not have existing debt or if there's enough stock.

We recommended that she start selling the fertilizer, maize seeds and other seeds, herbicide as a combo to local farmers. She added that this would be a great idea because some farmers end up planting late due lack of access to inputs when the rains start. This could ensure that the farmers have all the inputs they need to start planting immediately and increase her sales throughout the planting season. She will be working on what the combos will include, price and quantities of each time.

Case study 2: Thamela Farmers centre

Mam'Constance Hlongwane is the sole owner of the Thamela farmers centre which has been operating from December 2018. She sells LAN and MAP fertilizers, eggs and non-farming items such as candles and soap to boost sales during throughout the year. She purchased the inputs late in December during a dry and hot season, most farmers did not plant and most of those who planted had completed.

Right: The initial inputs purchased for the farmers centre.

She received her initial R1643.06 loan from Mahlathini Development Foundation. She bought the following inputs:

Item	Quantity	Price per item	Amount
MAP fertilizer	1	R447.01	R447.01
UERA	2	R350	R700
LAN	1	R284.05	R284.05
Round up	2	R106	R212
Total amount			R1643.06

During our visits we noticed that her confidence had decreased due to the low sales. We recommended that she may want to think of other items she could include. She later added some household items for sale. Subsequent investments were made using profits from sales and her own money to buy additional eggs and non-farming products such as candles and soaps. She had low confidence in the beginning that her enterprise could continue due to the low agricultural input sales in December due to the late purchase of the stock. After taking the recommendation to include other items that could be sold during off-peak times, she was regained her confidence and continued. Her sales are lower than expected but she has made personal investments to purchase more products to boost sales.

Case study 3: Ndunwana Farmers centre

The Ndunwana Farmers centre is owned by Lethiwe Zimba and Boniwe Hlatswayo. The enterprise operates from Boniwe Hlatshwayo's homestead. The owners are neighbours so customers can go to Mam' Zimba if Mam' Hlatshwayo is away. They received an initial loan of R2758 from Mahlathini Development Foundation to start the business. They both share the responsibility of paying back the loan. Subsequent investments have been made by Mam'Constance to purchase eggs and paraffin to boost sales during off-peak times.

Right: The owners of the farmers centre recording delivery of inputs

The following items were purchased using the loan:

Item	Quantity	Price per item	Amount
MAP fertilizer	2	R447.01	R894.02
UERA	3	R350	R1050
LAN	1	R284.05	R284.05
Round up	3	R176.64	R529.93
Total amount			R2758

It was recommended that they sell the eggs in smaller quantities, than the packs of 30 they were selling; given that this market is mostly available at month-end only and eggs would spoil if kept on the shelf for long periods.

Case Study 5: Stulwane Farmers centre

Nelisiwe Msele is the owner of the Stulwane Farmers Centre for about 2 months since 15 May 2019. Following the workshop on fodder production for the winter season, the facilitator suggested to the farmers to include protein supplements for livestock to sell to livestock farmers and preservation pill. She bought additional candles and salt sold at the farmers centre.

Right: Stulwane farmers centre

The initial investment was used to purchase the following items:

Item	Quantity	Price per item	Amount
Voermol Premix 450	4	R230	R920
Protein Block	2	R149.50	R299
Quick phos tab (pack)	1	R302	R302
Chemical measuring cup	4	R7.50	R30
TOTAL			R1551

She has made subsequent investments due to the increasing demand for Voermol premix 450. She initially thought people would not buy from her but we encouraged her to market her items more by spreading the word to her neighbours at all gatherings.

Case study 6: Emabunzini Farmers centre

Mam'Valindaba Khumalo also has a farmer centre in her homestead. The enterprise began operating from December 2018. She has knowledge of livestock vaccination due to her membership in the Executive Committee of the local dipping committee. In winter she plans to include livestock vaccines to her stock to sell to livestock farmers. She is the only one from the three other farmers centre opened in 2018 that was ready to return the loan to Mahlathini Development Foundation.

She visited her neighbours going from door to door marketing her products which was successful.

Right: Mrs Valindaba Khumalo's farmer centre and Far right: Phumzile sitting with her to consolidate her record keeping process.

The following inputs were purchased with the initial loam:

Item	Quantity	Price per item	Amount
MAP fertilizer	1	R447.01	R447.01
UERA	1	R350	R350
LAN	1	R284.05	R284.05
Round up	3	R106	R318
Total amount			R1399.06

Personal subsequent investments were used to purchase candles, salt and soap which were sold to increase profit and pay back the loan as soon as possible. Mam' Valindaba can't write so we devised a system with her that she could use to record. We offered her the opportunity to continue to use the initial investment to purchase livestock vaccines and other livestock items she had suggested.

Below is a table outlining the incomes for each farmer centre

Village	Initial loan	Items sold	Total	Profit
Stulwane	R1821	Premix 450, protein blocks, Quick phos tablets. Salt, britelit soap, Bulala Zonke	R6 237,50	R1 247,50
Eqeleni	R1 553	Protein block, premix 450	R1 523,75	R304,75
Thamela	R2 800	Urea, MAP, LAN, Roundup, paraffin, soap, snuff, eggs	R3 839,20	R778,64
Ezibomvini	-	Seed PAN 6671, Pan 413, PAN 53, Quickphos, Fert 2:3:2 (22), MAP Fert (33), Bulala Zonke, Blue death, seedlings, premix 450, protein blocks	R21 490,92	R4 958,40

Village Saving and Loan Associations

In the course of the month of April, the MDF team comprising of Mr Madondo, Tema and Nontokozo undertook a task to visit VSLA groups in Bergville. This was part of yearly group reviews with the aim to assess their progress and address any challenges. The groups visited by the team are situated in the villages of Vimbukhalo, Ezibomvini, Eqeleni, Ndunwana, Emabunzini, Stulwane and Bethany (Gudlintaba). MDF is currently supporting 15 groups in Bergville, 2 in Creighton and 1 in Nokweja area bringing the total number of groups to 18.

The groups are making good progress and all of them are fully operational. The oldest group is uMntwana Savings Group based in Stulwane Village which is saving for the seventh year this year. The majority of the groups have been operational for a period between three and five years.

Majority of the groups have a membership ranging from 20 to 30 members with 98 percent of the members being female. The groups consist of youth members, middle aged women as well as elderly women, most of whom are unemployed and rely on social and pension grants as well as remittances from family members residing outside Bergville.

Savings meetings are conducted monthly until the conclusion of the 13- month cycle where the group dissolves and starts again. Members who are not present at meetings can request someone to save on their behalf but must be present when borrowing to sign off their loans.

All of the groups have had their share-outs for the 2018/19 cycle. During the reviews, the groups were asked to talk about how the money from savings has made a difference in their lives and whether they save for agricultural inputs. The biggest items on which share-out money is utilized include furniture; fridges, wardrobes and televisions in particular which were mentioned by 95% of the members. Other uses include payment of school fees, groceries and household renovations which were also mentioned in more than 80% of the members of the savings groups. A small percentage (5-10 %) used the money to purchase agricultural inputs, i.e. fertiliser, seed and other agriculture related products such as meat and eggs.

Reasons for the aforementioned are that in most savings groups, up to half of the group members are not part of the CA programme, but joined the groups as they wanted to learn about savings hence their priorities lean more towards household consumption. However, even the participants who practice CA spend the majority of their savings on household needs.

The groups visited distributed a total of R 879 963.00 amongst 258 members *(see Table 22).* The majority of the groups had a share increase value ranging between 25 and 49 percent.

Right: A shar out session being conducted in Ngoba (Sakokuhle group)

The savings groups have been supported as an important element in the stability of the groups and in support of livelihoods in these rural communities.

There is no direct evidence that the hoped- for increase in savings for inputs and agricultural uses is materialising. Work with the VSLAs will thus no longer be consciously included as a part of this programme.

Table 22: Group Share-out Bergville, 2018/19

NO	Village	GROUP NAME	YRS	NO. OF MEMBERS	NEW SHARE VALUE	TOTAL AMOUNT SHARED OUT	MAX AMOUNT /MEMBER	MIN AMOUNT/ MEMBER	AVERAGE AMOUNT/MEMBER	USES
1	Vimbukhalo	Ukhamba	2	20	R130.00	R75,000	R8,000	R0.00	R1,300	Inputs, school fees, cutlery, blankets, renovations, furniture
2	Eqeleni	Masithuthuke	6	23	R130.00	R80,000	R7,800	R1,560	R3,680	Christmas and school clothes, new TV, tiles, renovations
3	Eqeleni	Masibambane	5	25	R136.00	R79,698	R8,000	R700	R4,000	Fertiliser, LAN, Maize seed, lounge suite, floor tiles
4	Stulwane	uMntwana	7	36	R130.00	R140,000	R7,500	R1,200	R3,200	Inputs, furniture, other household needs
5	Stulwane	Mbalenhle	2	20	R149.00	R108,000	R9,000	R1,600	R5,000	Electricity installation, furniture, serviced debts, business stock, groceries
6	Ngoba	Sakhokuhle	3	23	R145.00	R105,000	R8,000	R3,500	R3,500	smart phones, clothing, fertiliser, seed, wardrobe, building material, fencing
7	Ngoba	Isibonelo	3	30	R152.00	R100,000	R9,000	R1,200	R4,000	Wedding celebration, furniture, livestock, groceries, investments
8	Bethany	Gudlintaba	3	20	R161.00	R86,070	R9,600	R1,400	R4,500	New stock for meat business (tripe), eggs to sell, poultry, medical bills, College fees
9	Vimbukhalo	Inyonyana	3	20	R130.00	R41,210	R3,770	R780	R1,950	Furniture, groceries, school fees
10	Ezibomvini	Ukuzama	3	21	R125.00	R23,375	R3,375	R2,000	R2,000	Inputs, household needs
11	Ndunwana	Mphelandaa	3	20	R149.00	R41,610	R3,576	R700	R2,200	Christmas and school clothes, renovations
TOTAL				**258**		**R879,963**				

Stakeholder engagement

Maize Trust Board visit

6 Members of the Maize Trust Board, journeyed from Pretoria to the cathedral Peak area in Bergville for a smallholder conservation agriculture day hosted by the MDF team. The intention was to provide information and practical examples of the innovation development approach used for adaptive and participatory research into smallholder CA systems. Both this approach to research and the emphasis on livelihoods and adaptation were new to these important decision makers in the maize industry. The day was designed also to showcase some of the work smallholders have undertaken.

Below are a few illustrative photographs of the farmer visits.

Above Clockwise from top left: Visiting Ntombakhe Zikode's field in Eqeleni where a plot of winter cover crops is seen in the fore ground; Her maize crop maturing; the farmers' meeting with the board members and a view of a portion of the farmer centre for the village.

Issues, comments and suggestions

1. This season saw a dip in the number of CA trial participants, in addition to which those who did plant their subsidised trials for the most part did not plant the rest of their fields. This is a reasonably strong indication that these really poor smallholders use the subsidised CA production process as a risk management strategy for their cropping. This was not the intention, but the feeling is that the gains in food availability and food security, as well as general soil health are high enough to justify this "investment".
2. These seasons of high climate variability affect the ability of these smallholder farmers to crop in a commercially viable way, but the CA process has assisted to build resilience in the overall cropping system and improve the resilience of the livelihoods of these people.
3. Yields have decreased by around 40% in this season, primarily due to late seasonal rains and coupled with very high evapotranspiration rates in the hot summer months, despite overall rainfall being higher than last season.
4. The partnership with the KZNDARD Landcare unit is both rewarding and very frustrating. This season late and haphazard delivery of inputs from the Department led to a lot of time wastage and planting even later than needed. Thankfully the Department was very aware of this shortcoming and has initiated deliveries of inputs for the upcoming season already.
5. The local facilitators have played a much stronger role this season in organising monitoring and managing their learning groups. Their role will become more crucial in future as this responsibility will be handed to the groups themselves to free the MDF field staff up to focus on the research aspects of the programme
6. A focus on integration of livestock has been initiated and the initial fodder production and supplementation experimentation has been very interesting for all involved. This aspect is to be strengthened in the upcoming season through a partnership with the soil science division of KZNDARD at Cedara and AGT Food for supply of a range of different cover crop and fodder seed varieties.
7. A partnership also with a research process on mycotoxins through the ARC has been set in place for the upcoming season, as the slowly increasing prevalence of cob rots is of concern.
8. There has been a high turnover of interns at MDF and although this is to be expected, it is difficult to ensure quality of work and the monitoring these interns have undertaken. Although MDF is committed to this capacity building process, the resultant compromise in quality of data for some of the monitoring processes is seen as regrettable. The process of instituting an initial probation period of 1-3months, is now being held to more firmly.

Summary of annual expenses as on August 2019

Date of transaction	Type of transaction	Amount
2018/10/18	AGT FOODS : Seed	16 175,90
2018/10/18	AGT FOODS : Seed	1 932,00
2018/10/26	Monthly expenses	64 169,40
2018/12/11	Monthly expenses	52 358,17
2019/01/23	Monthly expenses	117 993,96
2019/02/28	Monthly expenses	75 295,69
2019/03/29	Monthly expenses	45 358,22
2019/04/30	Monthly expenses	55 445,11
2019/05/31	Monthly expenses	45 780,95
2019/06/28	Monthly expenses	65 330,30
2019/06/30	Monthly expenses	47 979,38
2019/07/31	Monthly expenses	48 490,22
2019/09/09	Monthly expenses	50 545,50
TOTAL AUG 2019		**636309,30**