ARC-Institute for Industrial Crops

Cotton Project Annual Progress Report

2016/2017

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Excellence in Research and Development

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PROJECT NUMBER	**:**	P08000011 (TK 208/16) – Part A
PROJECT TITLE	**:**	Minimum input – On farm demonstrations
REPORT YEAR	**:**	2016/2017
PROJECT MANAGER	**:**	HJ Steyn
CO-WORKERS	**:**	MS Magwaza MC Mkhwanazi BF Gumede C Ngwane

INTRODUCTION

The Makhathini Flats area of the Northern KwaZulu-Natal is very dry with an annual rainfall of 450 mm. The rainfall pattern is also very varied and erratic. Cotton is the only crop which can be grown successfully under these conditions without irrigation assistance. Research was done to determine which cultivation practice will be suitable for dryland cotton smallholder farmers in this area. It was determined that the most profitable production method under these climatic conditions is the double skip row - rip on the row method. In this production method no ploughing or discing is done but only a shallow 25 to 30 cm deep ripping action on the plant row. Two rows are ripped one meter apart and two rows skipped. This allows for roots to penetrate deep on the planting line as well as utilize moisture sideways in the open spaces. This method results in more moisture being available to the crop and results in higher yields. It also reduces the input cost drastically. Ploughing and discing are very costly practices. Planting double skip row also uses only half the quantity of diesel and seed used in planting inter row spacings of 1 meter resulting in a further reduction of input costs. The fact that there is only half the usual amount of planted lines also results in spraying only half the amount of pesticides. A big challenge is that farmers are very reluctant to practice this very effective dryland cotton production method on their own farms.

OBJECTIVE

The objective of these dryland cotton, double skip row - rip on the row on-farm trials was to demonstrate to dryland cotton farmers on their own farms and on three different soil types that this method is superior to other dryland cotton production methods on the Makhathini Flats.

EXPERIMENTAL PROCEDURES

The aim was to plant these three on-farm demonstrations on three different soil types before 15 December 2016. The planting furrows on the sandy soil in the Bhiva area were drawn on 11 November 2016. The Bhiva demonstration was planted on 11 November 2016. Roundup was sprayed on the trials at the Cotton Gin and Bhiva on 17 November 2016. The planting furrows on the Red soil at the Cotton Gin and the Dark clay soil in the Gugulesizwe area were drawn on 16 November 2016. The two demonstrations at the Cotton Gin and the Gugulesiswe areas were planted in dry soil on 24 and 25 November respectively. Unfortunately, from 16 November until 10 December 2016 it only rained 12.4 mm with the biggest shower of 5 mm resulting in very poor germination. The two demonstrations at the Cotton Gin and Gugulesiswe areas had to be replanted on 04 January 2017. The rainfall improved a little but the germination was only about 50 to 60 percent.

RESULTS AND DISCUSSION

The Bhiva area where the sandy soil cotton demonstration was planted received a bit higher rainfall than the other two areas and the plant stand was about 90 percent. The two demonstrations on the red and dark clay soil did not geminate well and the follow up rains were not good .The full row spacing where the rows were 1 meter apart, yielded 670 kg (Table 2) of seed cotton per hectare. The double skip rows where two rows were planted one meter apart and then two rows skipped, yielded 508 kg of seed cotton per hectare. It must be kept in mind though that although the yield of the double skip row method was little lower, the inputs were also much lower (Table 3).

Table 1. Total rainfall in mm from November 2016 until June 2017

Nov 2016	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	June 2017	Total
100.4	35.4	51.6	79.8	47.6	11.2	16.0	0.0	**342**

Table 2. Seed cotton yield of trial planted on sandy soil in kg/ha, 2016/2017 season

Treatment	Yield (kg/ha)
Full Rows 1 m spacing	670
Double Skip row	508
Average	**589**

Table 3. Comparison of Input costs and profit per hectare, sandy soil - 2016/2017 season

Treatment	Cultivation /ha	Seed cost /ha	Pesticides /ha	Labour /ha	Income/ha at R6.00/kg	Input Cost /ha	Profit /ha in Rand	Return/rand invested/ha
Full Rows 1 m spacing	R215.00	R1 144.00	R365.00	R2 530.00	R4 020.00	R4 254.00	-R234.00	R0.94
Double Skip row	R105.00	R572.00	R283.00	R1 980.00	R3 048.00	R2 940.00	R108.00	R1.04

The total input cost per hectare for the full rows was **R4 254.00** and for the double skip row it was **R2 940.00**. The input cost for the double skip row was, therefore, **R1 314.00** less per hectare. The double skip row had an income of **R3 048.00/ha** which was **R972.00/ha** lower than the **R4 020.00/ha** of the full rows, but the input costs per hectare was **R1 314.00/ha** less than that of the full rows resulting in **R342.00** more profit per hectare for the double skip row method. The full rows showed a loss of **R234.00 /ha** and the double skip rows showed a profit of **R108.00/ha.** The return for every rand invested /ha for the full rows was **R0.94** and for the double skip rows **R1.04**.

Table 4. Seed cotton yield of trial planted on red soil in kg/ha, 2016/2017 season

Treatment	Yield (kg/ha)
Full Rows 1 m spacing	406
Double Skip row	405
Average	**405.5**

Table 5. Comparison of Input costs and profit per hectare, red clay soil - 2016/2017 season

Treatment	Cultivation /ha	Seed cost /ha	Pesticides /ha	Labour /ha	Income/ha at R6.00/kg	Input Cost /ha	Profit /ha in Rand	Return/rand invested/ha
Full Rows 1 m spacing	R215.00	R1 144.00	R365.00	R1 742.00	R2 436.00	R3 466.00	-R1 030.00	R0.70
Double Skip row	R105.00	R572.00	R283.00	R1 363.00	R2 430.00	R2 323.00	R 107.00	R1.05

The total input cost per hectare for the full rows was **R3 466.00** and for the double skip row it was **R2 323.00**. The input cost for the double skip row was, therefore, **R1 143.00** less per hectare. The double skip row had an income of **R2 430.00/ha** which was **R6.00/ha** lower than the **R2 436.00/ha** of the full rows, but the input costs per hectare was **R1 143.00/ha** less than that of the full rows resulting in **R1 137.00/ha** more profit per hectare for the double skip row method. The full rows showed a loss of **R1 030.00 /ha** and the double skip rows showed a profit/ha of **R107.00/ha.** The return for every rand invested /ha for the full rows was **R0.70** and for the double skip rows **R1.05**.

Table 6. Seed cotton yield of trial planted on dark clay soil in kg/ha, 2016/2017 season

Treatment	Yield (kg/ha)
Full Rows 1 m spacing	473
Double Skip row	402
Average	**438**

Table 7. Comparison of Input costs and profit per hectare, dark clay - 2016/2017 season

Treatment	Cultivation /ha	Seed cost /ha	Pesticides /ha	Labour/ha	Income/ha at R6.00/kg	Input Cost /ha	Profit/ha in Rand	Return/rand invested/ha
Full Rows 1 m spacing	R215.00	R1 144.00	R365.00	R1 881.00	R 2 838.00	R3 605.00	-R 767.00	R0.79
Double Skip row	R105.00	R572.00	R283.00	R1 472.00	R 2 412.00	R2 432.00	-R20.00	R0.99

The total input cost per hectare for the full rows was **R3 605.00** and for the double skip row it was **R2 432.00**. The input cost for the double skip row was, therefore, **R1 173.00** less per hectare. The double skip row had an income of **R2 412.00/ha** which was **R426.00** lower than the **R2 838.00** of the full rows, but the input cost per hectare of the double skip rows was **R1 173.00** less than that of the full rows resulting in **R747.00** more profit per hectare for the double skip row method. The full rows showed a loss of **R767.00 /ha** and the double skip rows showed a loss of **R 20.00/ha.** The return for every rand invested /ha for the full rows was **R0.79** and for the double skip rows **R0.99**.

Table 8. Comparison of the average values of the three soil types - 2016/2017 season

Treatment	Yield in kg/ha	Total input cost/ha	Income/ha at R6.00/kg	Profit/ha in Rand	Return/rand invested/ha
Full Rows 1 m spacing	516	R3 775.00	R 3 176.00	-R 599.00	R 0,84
Double Skip row	438	R2 565.00	R 2 630.00	R 65.00	R 1.03

CONCLUSION

The yield was very low this season due to the very low rainfall, yet the average profit/ha for the double skip-row rip-on-row method for the three soil types combined was **R65.00** per hectare and for the full row method the average loss/ha for the three soil types combined was **R599.00/ha**. The input cost per hectare of the double skip row method was **R1 210.00** less than the full row method. Therefore, it is a lower risk production method.

The return for every rand invested per hectare was R 0.19 more for the double skip rows than for the full rows. Therefore, it seems that the double skip row method has the promise of being the better investment option. The average profit/loss for the three soil types shows that the double skip row rip on the row system was the only system of the two which could show a profit on all soil types.

The Makhathini Flats area is a very dry area which creates the need of a dryland cotton production method that can use every millimetre of rain effectively but has minimum input costs, thus also lowering risk and giving a higher profit than more traditional dryland cotton production methods.

NEXT SEASON

Due to fact that farmers are reluctant to switch from their traditional production methods, the double skip row – rip on the row method will only be planted at the Makhathini Experimental Station for demonstration purposes during a farmers' day.

ACKNOWLEDGEMENTS

The cooperation of the Department of Agriculture and Environmental Affairs, KwaZulu-Natal, is gratefully acknowledged.

PROJECT NUMBER	**:**	P08000011 (TK 208/16) – Part B
PROJECT TITLE	**:**	Minimum input – Nitrogen Fertilization
REPORT YEAR	**:**	2016/2017
PROJECT MANAGER	**:**	HJ Steyn
CO-WORKERS	**:**	MS Magwaza MC Mkhwanazi BF Gumede C Ngwane

INTRODUCTION

The Makhathini Flats area of the Northern KwaZulu-Natal is very dry with an annual rainfall of 450 mm. The rainfall pattern is also very varied and erratic. Cotton is the only crop which can be grown successfully under these conditions without irrigation assistance. Research was done to determine which cultivation practice will be suitable for dryland cotton smallholder farmers in this area. It was determined that the most profitable production method under these climatic conditions is the double skip row - rip on the row method. In this production method no ploughing or discing is done but only a shallow 25 to 30 cm deep ripping action on the plant row. Two rows are ripped one meter apart and two rows skipped. This allows for roots to penetrate deep on the planting line as well as utilize moisture sideways in the open spaces. This method results in more moisture being available to the crop and results in higher yields. It also reduces the input cost drastically. Ploughing and discing are very costly practices. Planting double skip row also uses only half the quantity of seed used in planting inter row spacing of 1 meter resulting in a further reducing of Input costs. The fact that there is only half the usual amount of planted lines, also results in spraying only half the amount of pesticides. The question arose, that seeing that there is now more moisture available to the plants, will a nitrogen topdressing result in a further economic benefit to the farmer and if so at what quantity must it be applied.

OBJECTIVE

The objective of this dryland cotton, double skip row - rip on the row nitrogen trial was to determine if nitrogen applied as a topdressing would have an economical benefit to the farmer.

EXPERIMENTAL PROCEDURES

The results of this trial in previous two seasons showed that the history of the soil of the trial block negatively affected the trial results. For that reason, a new trial block was used to do the trial in the 2016/2017 season.

From 06 to 15 November it rained 85 mm which enabled the drawing of the plant furrows. The plant - furrows for the experiment was drawn in the double skip row – rip on the row method. The trial was planted on the ripped furrows on 23 November 2016. Gramoxone was sprayed directly after plant to control all weeds present.

A Youden Square Design was used with 6 treatments that were replicated 3 times. Six different nitrogen levels were applied on 10 February 2016. These levels were:

1. 0 kg N/ha
2. 10 kg N/ha
3. 20 kg N/ha
4. 30 kg N/ha
5. 40 kg N/ha
6. 50 kg N/ha

The cotton variety PM 3225 B2RF from Monsanto/Deltapine was used. The first spray of Roundup Power Max was done on 19 January 2017. The second Roundup Power Max spray was applied on 04 March 2017.

Scouting for pests was done on 06 February 2017, 13 February 2017, 20 February 2017, 27 February 2017 and 03 March and 20 March 2017. Mospilan was sprayed for aphids on 07 February 2017; Mospilan and Abamectin for red spider mite and Fastac for leaf eating worms on 28 February 2017. Mospilan and Karate were sprayed for aphids, jassids and worms on 15 March 2017. Mospilan and Talstar were sprayed for aphids, red spider mite and worms on 22 March 2017. The trial was affected by drought as it rained only 241 mm from 23 November 2016 until 30 June 2017.

Table 1. Total rainfall in mm from November 2016 until June 2017

Nov 2016	Dec 2016	Jan 2017	Febr 2017	March 2017	Apr 2017	May 2017	June 2017	Total
100.4	35.4	51.6	79.8	47.6	11.2	16.0	0.0	**342.0**

The first pick was harvested on 06 April 2017, the second on 03 May 2017, the third on 29 May 2017 and a fourth on 20 June 2017.

RESULTS AND DISCUSSION

The 2016/2017 cotton season was dry. The rainfall was low and no significant differences showed, but very interesting observations were made.

Table 2. Average values for yield, plant height and bolls/plant, 2016/2017 season

Treatment	Yield (kg/ha)	Plant height (cm)	Bolls/plant (7 plants)
0	1831,3	83	20
10	1919.3	90	23
20	1929.5	84	18
30	1480.3	79	14
40	1754.0	88	22
50	1775.8	96	24
Average	**1781.7**	**86.6**	**20.1**
CV	**26.5**	**13.54**	**38.45**

No significant differences

Yield

The average yield for the trial was 1781.7 kg of seed cotton per hectare with the highest treatment yield average coming from 20 kg of Nitrogen applied per hectare, giving 1 929 kilograms of seed cotton per hectare. There were no significant differences between the treatments.

Plant height

The plant height was the highest with the 10, 40 and 50 kg N/ha treatments but no significant differences were observed.

Bolls/plant

The average bolls per plant was the highest with the 50 kg N/ha treatment but no significant differences were observed.

FIBRE QUALITIES

Table 3. Average values for fibre qualities - Pick 1, 2016/2017 season

Treatment	Length (mm)	Strength (g/tex)	Micronaire
0	28.2	32.35	4.30
10	28.4	33.21	4.28
20	28.7	33.12	4.12
30	28.7	32.21	4.14
40	28.9	32.32	4.19
50	28.1	32.14	4.17
Average	28.4	32.56	4.19
CV	3.19	4.2	7.21

No significant differences

Length

The average length was 28.4 mm with the longest fibre coming from the treatment of 40 kg N/ha that measured 28.9 mm. No significant differences were observed.

Strength

The average strength measured was 32.56 g/tex with the treatment of 10 kg N/ha as the highest at 33.21 g/tex. The lowest strength value came from the 50 kg N/ha and was 32.14 g/tex. No significant differences were observed.

Micronaire

The average Micronaire measured was 4.19. The treatment of 0 kg N/ha gave the highest Micronaire value of all the treatments at 4.3 and the lowest micronaire value was 4.12 given by the 20 kg N/ha treatment.

TRIAL RESULTS FOR THE THREE SEASONS OF 2014/15, 2015/16, 2016/17 COMBINED

Table 4. Average values for yield, plant height and bolls/plant, combined seasons.

Treatment	Yield (kg/ha)	Plant height (cm)	Bolls/plant (7 plants)
0	1279	71	14
10	1379	75	15
20	1384	74	13
30	1178	73	12
40	1294	76	15
50	1377	77	16
Average	**1315**	**74.1**	**14.3**
CV	**23.96**	**12.61**	**33.4**

No significant differences

FIBRE QUALITIES

Table 5. Average values for fibre qualities, combined seasons.

Treatment	Length (mm)	Strength (g/tex)	Micronaire
0	28.0	33.0	4.4
10	27.9	33.2	4.4
20	27.8	33.4	4.3
30	28.0	32.6	4.2
40	28.3	33.1	4.3
50	28.1	32.9	4.4
Average	28.0	33.0	4.3
CV	2.96	4.6	6.2

No significant differences

DISCUSSION

2016/2017 season

The cotton season in 2016/17 received 100 mm of rain more than the cotton season of 2015/16 resulting in an increase of yield/ha of 915 kg/ha, an increase in plant height of 17 cm/plant and an increase in bolls per plant of 9 bolls/plant higher than the previous season.

In spite of receiving 100 mm's more rain than the previous season the 2016/17 season was still fairly dry, but the average trial yield was good for dryland produced cotton showing the higher yield potential of the applied production method. The change of field unfortunately influenced the result as it takes several seasons for the rip on row skip row method to show it is higher yield and profit potential.

COMBINED SEASONS - 2014/15, 2015/16 AND 2016/17

The highest yield/ha measured over the combined seasons were given by the 20 kg N/ha treatment producing 1 384 kg of seed cotton per ha.

The highest plant height of 77 cm's and the highest amount of bolls per plant was given by the 50kg N/ha treatment.

The longest fibre was produced by the 40 kg N/ha treatment, the strongest fibre strength by the 20 kg N/ha treatment and the lowest micronaire value by the 30 kg N/ha treatment.

CONCLUSION

The double skip row - rip on the row dry land cotton production method, is a very effective method to produce cotton in areas where the rainfall during the cotton production season is low.

From the combined seasons results it shows that 20 kg N/ha is the optimum level of producing cotton with this method.

The combined seasons results shows the treatment of 20 kg N/ha gave an average of 105 kg seed cotton per hectare more than the 0 kg N/ha treatment shows promise and at a price of R6.00 per kg of seed cotton it means the farmer gets an extra income of R630.00 per hectare.

The cost of 20 kg of N in the form of LAN (28%) is R392.00/ha and when deducted, results in a higher income of R238.00 per hectare. Transport, handling and application costs must also still be deducted which could nullify the profit shown.

NEXT SEASON

The trial will be repeated on the new block to determine the long-term effects and also compare the effect of 1 m row spacings.

ACKNOWLEDGEMENTS

The cooperation of the Department of Agriculture and Environmental Affairs, KwaZulu-Natal, is gratefully acknowledged.

PROJECT NUMBER	**:**	P08000015 (TK 208/20)
PROJECT TITLE	**:**	High temperature tolerance in cotton
REPORT YEAR	**:**	2016/2017
PROJECT MANAGER	**:**	MM van der Westhuizen
CO-WORKERS (Internal)	**:**	P Maja N Schwan
CO-WORKERS (External)	**:**	Prof DM Oosterhuis * Dr J Berner * Dr D Loka * Dr TR FitzSimons *

* Department of Crop, Soil and Environmental Sciences, University of Arkansas. Fayetteville.

ABSTRACT FROM THESIS

Cotton (*Gossypium hirsutum* L.) is sensitive to heat stress (HS) during reproductive development. The objective of this study was to evaluate different screening methods for identification of heat tolerance in cotton genotypes. Three growth chamber studies and four field trials were conducted from 2014 to 2017 using genotypes Arkot 9704, VH260, DP 210 B2RF and DP393. Measurements were made of membrane leakage (ML), chlorophyll fluorescence (ChlF), glutathione reductase (GR), and sucrose concentration. In the growth chambers, measurements were made at 30 and 40°C and at 2, 4 and 6 hours of HS, as well as 3 and 7 days after HS and 7 days after recovery. Both ML and ChlF were decreased at 40°C and genotypic difference were detected, with DP393 the least affected indicating heat tolerance. Arkot 9704 was affected the most indicated sensitivity to HS. The small genotypic responses to HS was related to modern genotypes having less tolerance to HS than older obsolete genotypes and wildtype cotton. Glutathione reductase was increased by HS and VH260 and DP393 increased the most in the growth chamber but not in the field studies. Sucrose concentrations were decreased by HS with no genotypic differences. Analysis of the fluorescence transient after HS was imposed showed that maximum fluorescence intensity, plant performance index (PI_{ABS}) and electron transport flux (ET/CS) provided more intrinsic quantitative measurements of the effect of HS on PSII function. For both ML and ChlF, for a

one day heat stress period, measurements could be made at 2 hours, but for a longer heat stress, parameters should be measured 7 days after stress. The method of measuring genotype response to HS in the field by comparing cool versus hot days was not sufficiently accurate. A new method of comparing early morning cool 6.00 AM measurements versus hot midday measurements, showed genotypic increases in ML, but for ChlF only on clear, high radiation days. Differential genotypic responses to HS can be detected by ML and particularly by ChlF for ease of use and accuracy, with an analysis of the fluorescence transient responses to HS providing a clear means of differentiating between genotypes for thermotolerance. This project is concluded, but will be used as an example to test for drought tolerance of eight different cotton cultivars.

This 161 page dissertation is available from tillap@arc.agric.za or the libraries of Cotton SA and ARC-IC.

PROJECT NUMBER	:	P08000016 (TK 208/21)
PROJECT TITLE	:	Evaluation of planting date on production of cotton cultivar
REPORT YEAR	:	2016/2017
PROJECT LEADER	:	CE Fourie
ADDRESS	:	ARC-Institute for Industrial Crops, Loskop Research Farm, Groblersdal
CONTACT DETAILS	:	FourieCE@arc.agric.za
CO-WORKERS	:	KC Phalane GV Matlala

INTRODUCTION

Obtaining a vigorous and optimal stand is the first step for profitable cotton production. The use of appropriate cultivars and agronomic practices in suitable environmental factors is a prerequisite for such success. Environmental factors such as soil temperature determines the time of planting cotton.

In South Africa, the window for sowing cotton is very narrow and has a major influence on the yield and fibre qualities. Finding the most suitable cultivar for a particular planting date can help to widen the window period for sowing and ultimately optimize the total yield and quality of fibre.

OBJECTIVE

The objective of the trial is to determine which cultivar is most suitable for a particular planting date. The effect on plant growth, yield, fibre qualities and the degree of whiteness (colour values) of the different cotton cultivars was determined at various planting dates.

LOCALITY

Groblersdal: ARC-Loskop Research Farm

The locality presents one of the eight different climatic zones experienced for cotton production in South Africa.

PLANTING DATES

A field trail was conducted at ARC-Loskop Research Farm, Groblersdal, by planting different cotton cultivars over a period of eight weeks to determine which cultivar is most suitable for a particular planting date. These planting dates were:

1. 07 October 2016 (PD 1)
2. 14 October 2016 (PD 2)
3. 21 October 2016 (PD 3)
4. 28 October 2016 (PD 4)
5. 04 November 2016 (PD 5)
6. 11 November 2016 (PD 6)
7. 18 November 2016 (PD 7)
8. 25 November 2016 (PD 8)

CULTIVARS

Cotton cultivars planted under irrigation consisted of six entries namely:

1. Delta12BRF (standard)
2. DP1541 B2RF
3. DP1240B2RF
4. CandiaB2RF
5. DP1531 B2RF
6. DP210BRF (standard)

EXPERIMENTAL PROCEDURES

The trial was conducted under irrigation conditions, following practices that are commonly used in commercial cotton production systems. The effect on planting time on plant growth, yield, fibre qualities and the degree of whiteness (colour values) of the different cotton cultivars was determined.

Each planting date trial was planted in a randomized block design with four replicates, and plots consisted of 2 rows of 5 m lengths, at an inter-row spacing of 90 cm and intra-row spacing of 15 cm.

ENVIRONMENTAL CONDITIONS

Temperatures

Warm and consistence air- and soil temperatures with more rain benefited all the cotton cultivars in the 2016-17 growing season.

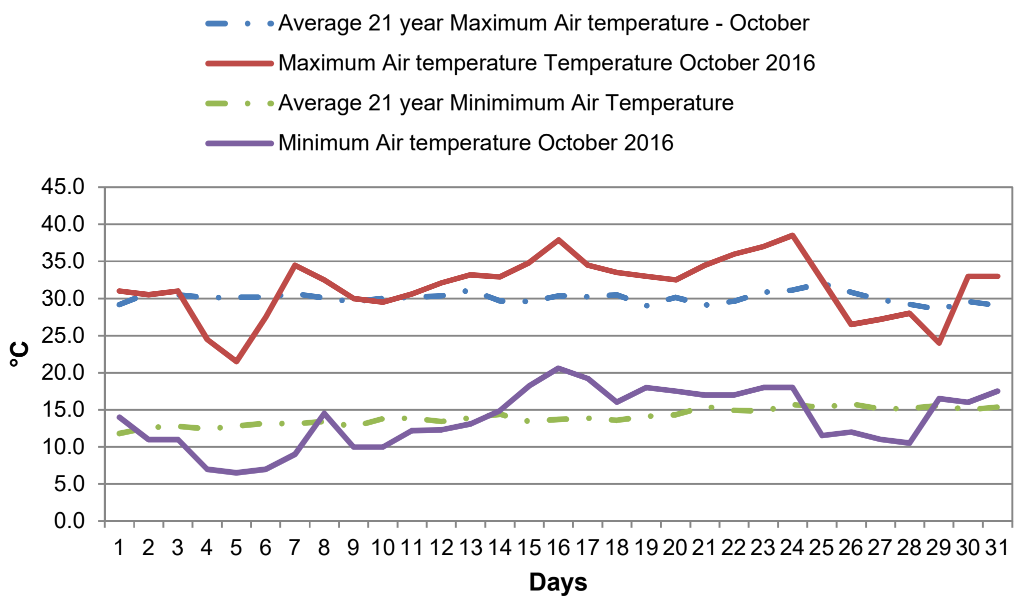

Figure 1. Air Temperature – October 2016 (°C)

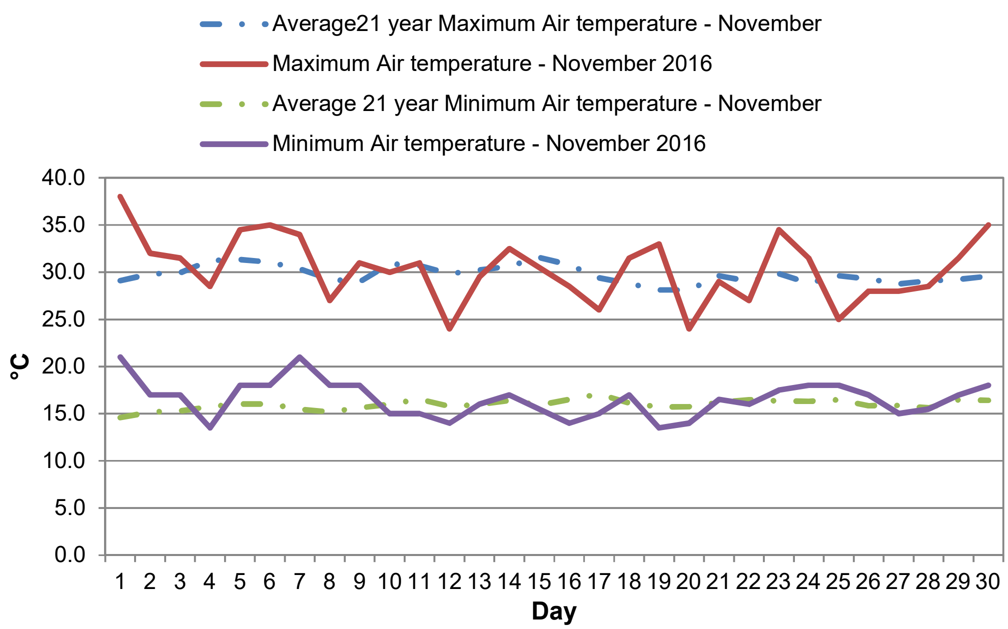

Figure 2. Air temperature – November 2016 (°C)

Soil temperature

A soil temperature meter was installed on 30 September 2015 to record soil temperatures during sowing season of the eight planting dates. A cold front moved over South Africa on 08 October 2016 resulting in soil temperature dropping below 15 °C.

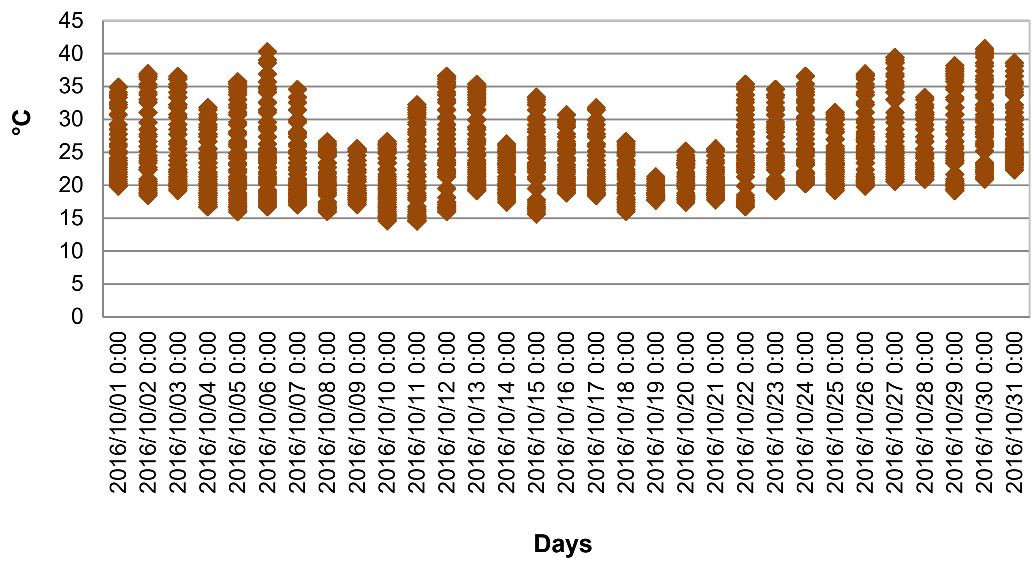

Figure 3. Soil temperatures – October 2015 (°C)

November 2016 – Soil temperatures

Soil temperatures for mid November 2016 were sufficiently high for sowing of cotton. Five days were recorded ≥ 40°C.

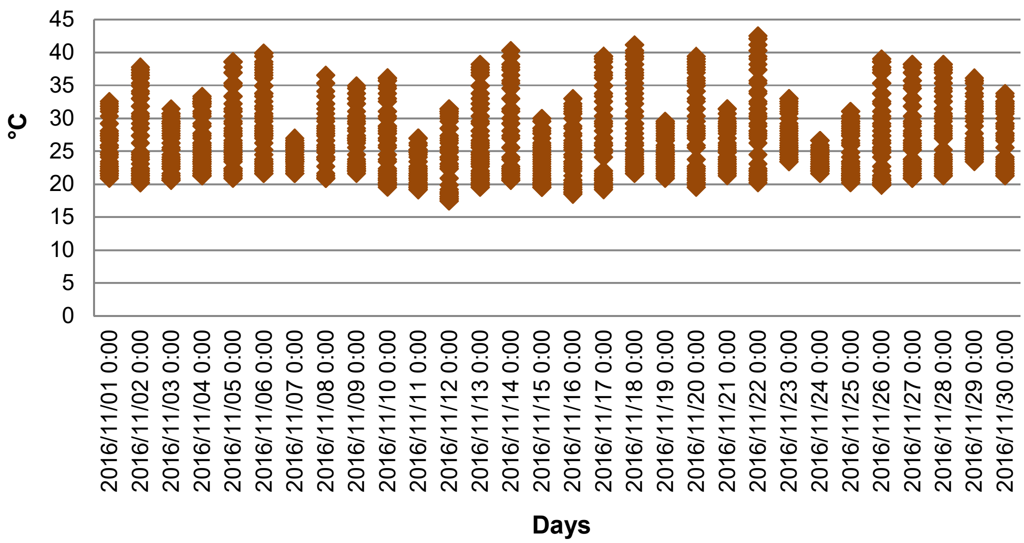

Figure 4. November 2015 Soil temperatures (°C)

Day Degree (base 15.6°C)

The growth of the cotton plant is temperature dependent. If daily temperatures fall below the critical threshold of 15.6 °C, growth ceases. As temperatures rise above the critical threshold, growth-rate of the plant increase again.

The relationship between growth and temperature is used to predict the timing of various development stages of the cotton plant. Day degree accumulation evolved to monitor crop development because it took accumulation of heat over time. One degree-day is defined as the amount of heat that accumulates during a 24-hour period when the average temperature is 16.6 or 1° above the development threshold. The formula use to calculate degree-days:

Degree days = [(Maximum temperature + Minimum temperature) ÷ 2] - 15.6

If cotton seed does not experience favourable temperature within 5 days of planting, seedling emergence will be delayed, plant stand reduced and yield loss will occurred.

From the day of planting, a cotton seed needs 50 degree-days to emerge from an optimum depth. If cotton emerges from the soil in less than 10 days, the plant has experience ideal soil and daily temperatures of 5 of more degree-days. When more than 10 days are required for seedlings to emerge, this indicates less-than-ideal temperatures has occurred.

PD 1 (7/10/2017) resulted in low germination percentages which were caused by low soil, (≤ 16 °C) and low daily temperatures of 28.4 degree-days. PD 2 (14/10/2017) and PD 3 (21/10/2017) were the only two Planting dates that had ideal growing condition. The rest of the Planting dates had less than 50 degree-days but soil temperatures were higher than 16 °C and thus resulted in good germination percentages.

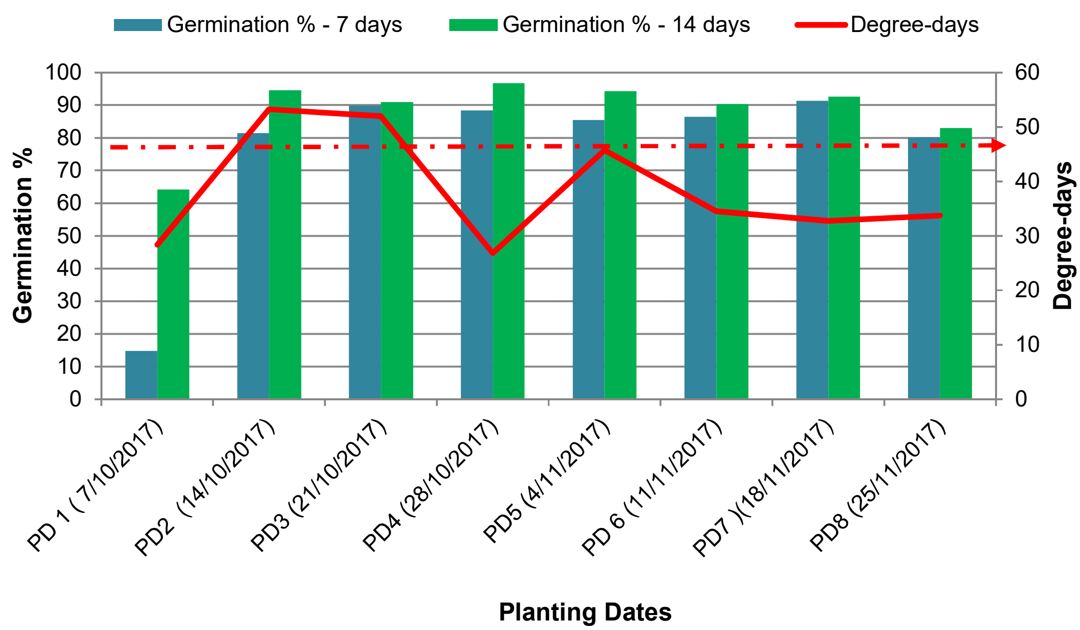

Figure 5. Germination (%) compared to Degree-days

2016/17 Rainfall (mm) compared to 2015/16 Rainfall (mm)

A total of 614 mm rainfall was measure for the 2016/17 cotton growing period. This is 37 % more rain than the very dry 2015/16 cotton growing period. This higher rainfall did benefit the cotton growing season. Above normal rainfall of 177 mm was recorded for January 2017.

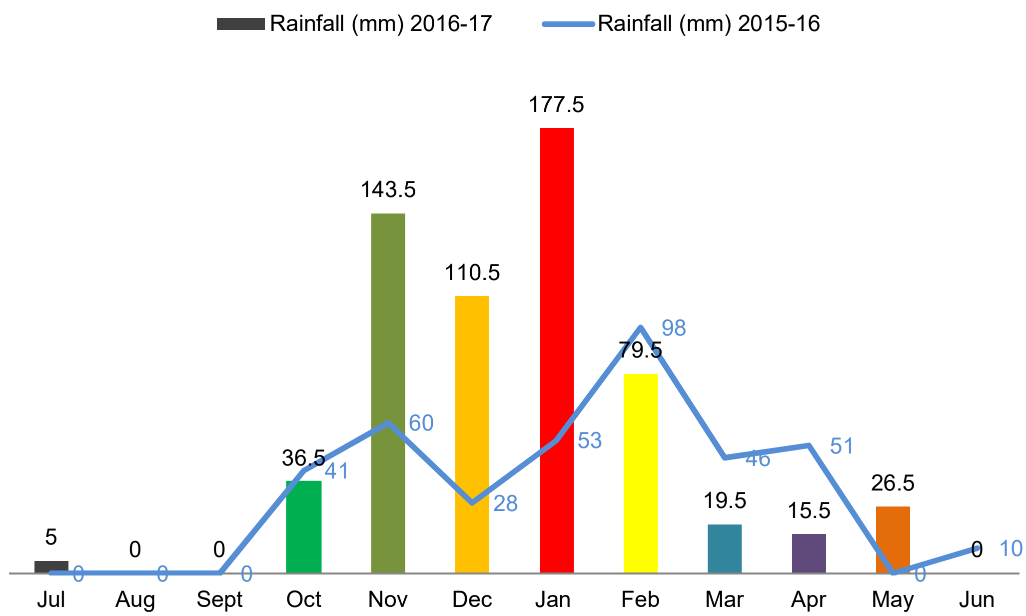

Figure 6. Rainfall (mm)

PLANT GROWTH

Germination (%)

Cool soil temperatures below 16°C and low daily temperatures of 28.4 degree-days on 08 to 10 October 2016 had an effected on Plant Date 1 planted at 07 October 2017.

Soil temperatures indicated that the soil was warm enough from the second Planting date in October until the end of November. Germination percentages were higher than 90 % at 14 days after germination. Cool daily temperatures of 33.2 could have played a part in plant stand at the last Planting date at 25/11/2016.

Table 1. Germination percentage 7 days after planting

Cultivar		Planting dates								Average Germination % - 7 Days after plant	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	6.0	54.3	69.0	59.8	56.9	62.4	74.5	45.5	53.5	5
2	DP1541 B2RF	5.0	93.1	93.1	96.0	89.8	93.1	95.5	83.1	81.1	4
3	DP 1240 B2RF	6.2	82.9	95.7	94.8	92.6	92.6	94.3	92.4	81.4	3
4	Candia B2RF	15.2	85.0	93.6	92.6	90.7	89.8	94.5	87.4	81.1	4
5	DP1531 B2RF	23.8	84.0	95.2	91.9	95.0	90.5	94.5	86.4	82.7	2
6	DP210BRF	32.6	89.3	92.7	95.5	87.6	90.5	94.5	86.4	83.6	1
Average		14.8	81.4	89.9	88.4	85.4	86.5	91.3	80.2		
Ranking		8	6	2	3	5	4	1	7		
CV %		8.4218									
LSD_t(0.05)(PD x Cult)		3.2528									
LSD_t(0.05)(Cult x PD)		1.9799									

Table 2. Germination percentage 14 days after planting

Cultivar		Planting dates								Average Germination % - 14 Days after plant	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	62.6	82.9	72.4	85.2	82.9	64.8	76.2	52.9	72.5	6
2	DP1541 B2RF	46.4	99.3	94.3	99.8	94.5	97.6	96.2	86.7	89.3	5
3	DP 1240 B2RF	50.5	91.9	96.0	99.3	95.7	96.7	96.7	94.0	90.1	4
4	Candia B2RF	61.2	97.1	93.8	98.8	96.9	95.2	94.5	89.0	90.8	3
5	DP1531 B2RF	70.7	97.9	96.2	98.3	99.3	94.0	96.0	87.9	92.5	2
6	DP210BRF	93.8	98.1	93.1	99.0	96.4	94.0	96.0	87.9	94.8	1
Average		64.2	94.5	91.0	96.7	94.3	90.4	92.6	83.1		
Ranking		8	3	5	1	2	6	4	7		
CV %		6.074674									
LSD_t(0.05)(PD x Cult)		3.1591									
LSD_t(0.05)(Cult x PD)		2.7359									

Final Plant Mapping data

Final Plant mapping data were made to assist in explaining the influence of the cultivar adaptation and climatic conditions. The growth of the cotton plant is temperature dependent.

For every Planting Date trial five plants per cultivar in each replication were evaluated.

The Final Plant Mapping data included the following:

a. Plant height
b. Number of vegetative nodes
c. Number of fruit branches
d. Height-to-node ratio
e. Bolls/plant
f. Boll Retention at 95 % zone

Plant height at Final Plant Mapping

Figure 7 indicates that the November plantings resulted in significantly taller plants. This result may be related to the fact that later plantings develop during warmer weather, resulting in faster vegetative growth, but with less total development time.

The cultivars 13P3001B2R2 and 13P3005B2R2 resulted in significantly taller plants at the 5th Planting Date with heights of 138.2 cm and 137.5 cm respectively. The cultivar Candia B2RF resulted in significant shorter plants over all the planting dates with an average plant height of 99.6 cm (Table 6). The shorter plants of Candia B2RF could be cultivar related.

Table 3. Plant Height at Final Plant Mapping

Cultivar		Planting dates								Average Plant height (cm)	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	103.6	107.1	124.0	121.6	118.2	103.8	101.8	90.0	108.7	5
2	DP1541 B2RF	107.9	123.7	144.7	140.0	127.1	130.9	118.7	99.0	124.0	3
3	DP 1240 B2RF	113.2	130.0	137.3	137.1	124.9	129.1	113.7	98.7	123.0	4
4	Candia B2RF	96.7	102.0	119.2	115.8	107.1	102.1	93.5	73.3	101.2	6
5	DP1531 B2RF	113.2	126.7	150.2	145.5	133.7	119.4	121.3	90.8	125.1	2
6	DP210BRF	121.3	133.1	141.7	148.8	132.3	119.4	121.3	90.8	126.1	1
Average		109.3	120.4	136.2	134.8	123.9	117.4	111.7	90.4		
Ranking		7	4	1	2	3	5	6	8		
CV %		6.810808									
LSD_t(0.05)(PD x Cult)		4.0035									
LSD_t(0.05)(Cult x PD)		4.6229									

Number of vegetative nodes

The number of vegetative nodes produced before the first fruiting branches are formed depends on the variety and the environment.

Candia B2RF resulted in a lower number of vegetative nodes of 4 per plant.

Table 4. Number of vegetative nodes

Cultivar		Planting dates								Average Number of Vegetative nodes above cotyledons (count)
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016	
1	Delta 12 BRF	4	5	4	5	4	5	5	4	5
2	DP1541 B2RF	5	5	5	5	4	5	5	5	5
3	DP 1240 B2RF	6	5	4	5	5	5	5	6	5
4	Candia B2RF	4	4	5	4	4	4	6	4	4
5	DP1531 B2RF	5	5	5	4	5	5	4	5	5
6	DP210BRF	5	5	5	5	4	5	4	5	5
Average		5	5	5	5	4	5	5	5	
CV %		9.354796								
LSD_t(0.05)(PD x Cult)		0.2172								
LSD_t(0.05)(Cult x PD)		0.2508								

Fruit Branches

The number of fruit branches decreased significantly in the end of the November plantings (Table 5). This may be related to the fact that later plantings develop during warmer weather, resulting in faster vegetative growth.

The cultivar, CandiaB2RF, resulted in significantly lower fruiting branches over all the planting dates.

Table 5. Number of fruit branches

Cultivar		Planting dates								Average Number of fruit nodes (count)
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016	
1	Delta 12 BRF	20	17	20	22	20	17	17	14	18
2	DP1541 B2RF	20	19	22	21	21	21	17	16	20
3	DP 1240 B2RF	21	19	22	23	22	19	19	17	20
4	Candia B2RF	19	18	20	20	18	18	16	13	18
5	DP1531 B2RF	17	19	23	23	21	19	18	19	20
6	DP210BRF	18	19	22	22	20	19	18	19	20
Average		19	19	21	22	20	19	17	16	
CV %		11.58056								
LSD_t(0.05)(PD x Cult)		1.036								
LSD_t(0.05)(Cult x PD)		1.2744								

Height-to-node ratio (HNR)

The height-to-node ratio is a simple determination of the plant's vigour or growth potential. It reflects the degree of stress that plants experience throughout the season. This is the numeric equivalent to the average distance between nodes and is called internode length. The formula used:

Height-to-node ratio = Plant height (cm) ÷ total number of nodes on main stem (vegetative nodes and fruit branch nodes)

Cooler temperatures and regular rainfall patterns during January 2017 and February benefitted Planting Dates 2 to 6. Plants were growing more vigorously and the internode lengths (cm) were all longer (>5.0 cm).

Cultivar DP210BRF had the longest internode of 5.2 cm but is not available anymore, thus, Cultivar DP1541 B2RF and DP1531 B2RF had the longest internode lengths of 5.1 cm. . The two cultivars are both strong growers and improved management of these cultivars is needed. CandiaB2RF had the shortest internode length of 4.6 cm.

Table 6. Height-to-node ratio of cotton cultivars planted at different dates

Cultivar		Planting dates								Average HNR (Calculated)
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10 /2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016	
1	Delta 12 BRF	4.2	4.8	4.7	4.7	4.9	4.9	4.5	5.1	4.7
2	DP1541 B2RF	4.6	5.3	5.3	5.3	5.2	5.0	5.5	4.7	5.1
3	DP 1240 B2RF	4.4	5.5	5.3	4.9	4.7	5.7	4.9	4.4	5.0
4	Candia B2RF	4.1	4.7	4.9	4.9	4.9	4.7	4.4	4.2	4.6
5	DP1531 B2RF	5.3	5.3	5.0	5.6	5.3	5.0	5.5	3.8	5.1
6	DP210BRF	5.4	5.5	5.2	5.5	5.5	5.0	5.5	3.8	5.2
Average		4.7	5.2	5.1	5.1	5.1	5.0	5.1	4.3	
CV %										
LSD_t(0.05)(PD x Cult)		ns								
LSD_t(0.05)(Cult x PD)		ns								

Bolls per plant

Stress to plants reduces early leaf area, resulting in a smaller and older leaf area during boll set. Cultivar DP210BRF had the highest average bolls per plant with 25 bolls per plant. Although not significant, Plant date 3 had the highest average number of boll per plant of 27.

Table 7. Number of boll per plant

Cultivar		Planting dates								Average Bolls per plant (count)	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	25.4	20.8	28.3	24.3	22.5	26.8	30.1	21.9	25.0	1
2	DP1541 B2RF	17.8	20.7	26.3	22.8	22.3	27.8	19.9	27.0	23.1	3
3	DP 1240 B2RF	22.8	22.5	24.8	28.6	25.8	17.3	23.7	16.4	22.7	4
4	Candia B2RF	20.4	24.9	23.8	24.3	21.9	21.4	22.0	15.7	21.8	5
5	DP1531 B2RF	15.8	19.8	26.5	26.4	24.6	24.0	21.0	14.2	21.5	6
6	DP210BRF	21.8	25.3	35.6	26.5	22.8	24.0	21.0	14.2	23.9	2
Average		20.6	22.3	27.5	25.5	23.3	23.6	23.0	18.2		
Ranking		7	4	1	2	4	3	6	8		
CV %		4.78288									
LSD_t(0.05)(PD x Cult)		ns									
LSD_t(0.05)(Cult x PD)		ns									

Boll retention 95% zone

Cut-out occurs when the boll load consumes all the carbohydrates produced by the leaves. This is affected by both the early boll load and the quantity of leaf area to sustain the boll load. Final plant mapping data was used to determine when cut-out occurred. Plants were considered to reach cut-out when 95 percent of the harvested bolls at the first position have already been set.

Planting Date 7 on 18 November 2016 significantly retained more bolls at the 95 percent zone of 84.9 %. The cultivar Candia B2RF retained the highest number of bolls at the 95 percent zone of 79.0 %.

Figure 8. Boll retention 95 % zone

Cultivar		Planting dates								Average retention 95 % bolls (calculated)	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	69.5	67.8	68.1	81.1	65.9	87.5	87.1	72.3	74.9	4
2	DP1541 B2RF	49.4	80.2	72.4	69.1	71.4	70.6	87.3	83.9	73.0	5
3	DP 1240 B2RF	70.6	82.8	74.0	81.1	78.6	76.7	83.6	84.2	79.0	1
4	Candia B2RF	66.8	78.2	78.7	72.4	77.0	69.8	89.6	86.7	77.4	2
5	DP1531 B2RF	89.2	77.5	70.6	71.3	65.4	79.0	81.0	65.4	74.9	4
6	DP210BRF	75.1	82.7	79.7	74.3	69.0	79.0	81.0	65.4	75.8	3
Average		70.1	78.2	73.9	74.9	71.2	77.1	84.9	76.3		
Ranking		8	2	6	5	7	3	1	4		
CV %		17.1171									
LSD_t(0.05)(PD x Cult)		6.43									
LSD_t(0.05)(Cult x PD)		7.4247									

YIELD AND FIBRE QUALITIES

Cotton Stainer (*Dysdercus nigrofasciatus*)

Every season seems to throw new challenges to produce cotton.

After conducting a 3 year study on planting dates, results of the 2016-17 Plant Dating trials showed grayish and stained cotton fibres but it is not cultivar related but due to the insect, *Dysdercus nigrofasciatus*.

Cotton strainers are rarely a problem in cotton because they are controlled by broad spectrum insecticides. They cannot survive temperature higher than 40°C and need free standing water to be present.

Enough moisture from rainfall and irrigation was present from December until February for the insect to thrive. These mild conditions in combination with a low broadcast of insecticides on neighboring ratoon cotton fields presented a very high infestation of cotton strainers on the Planting Date trials.

As an occasional pest, there are only a few products registered for their control. Weekly applications, as weather permitted, with synthetic pyrethroid lambda cyhalothrin (Karate and Lambda) and deltametrin and methomyl (not register) could not control the high infestation of cotton strainers until middle March 2017.

Lastly, the reduced insecticide used against bollworms and the large cultivation of Bt-transgenic cotton has led to an increase in populations of these red cotton bugs. Cotton stainers only attack bolls and will have no effect on the growth of cotton.

Damage they caused

They start attacking the bolls from an early stage until cotton is hanging from the bolls. The cotton stainer sucks out the juices from green bolls. When bolls open, they lay their eggs and the nymphs and adults suck their nourishment from immature seeds that do not ripen, remaining light weight. Vitality of the plant is lowered in general. Affected bolls open badly with the lint stained with the yellow excreta or body juices.

Quality of the fibre is affected and the attacked seeds become unfit for either sowing or oil extraction. Boll rot is caused by secondary infection due to bacteria wherein rotting of the entire contents of the boll occur following the initial discoloration of the lint to yellow or brown. Adults found in lint get crushed during the ginning process, emitting a bad odour and stain the fibre.

Seed Cotton Yield

When cotton stainer feeds on young bolls, it caused the bolls to abort and shed. This insect pieced the bolls and feeds on developing seeds, resulting in tight locking around the seeds. They are also able to feed on bolls during later stages of development. As the bolls open, the cotton stainers feed on mature seeds, resulting in bald patches that came more evident when cotton starts to fluff out.

All the Planting Dates resulted in very low seed cotton yield. Cotton strainers destroyed the yield of the Plant Date 6 that was planted on 11 November 2016. This Planting date resulted in a seed cotton yield of 651.2 kg/ha.

Table 9. Yield (kg/ha)

Cultivar		Planting dates								Average yield (kg/ha)	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	1633.3	2194.6	1907.4	1536.8	1104.7	650.1	1184.0	622.5	1354.2	6
2	13P3001B2R2	2380.1	2800.6	1945.1	1933.6	1335.4	641.3	1155.9	1653.7	1730.7	3
3	DP 1240 B2RF	2439.4	2796.2	2380.9	1799.0	1208.6	687.5	1225.6	1520.3	1757.2	2
4	Candia B2RF	5502.6	2413.7	2078.8	1854.7	1134.4	503.6	976.7	935.6	1925.0	1
5	13P3005B2R2	2014.7	2698.8	2072.5	1862.9	1230.4	876.5	1441.6	1315.5	1689.1	5
6	DP210BRF	2576.7	2700.2	1990.0	1682.6	875.8	548.4	1242.0	2001.3	1702.1	4
Average		2757.8	2600.7	2062.4	1778.2	1148.2	651.2	1204.3	1341.5		
Ranking		1	2	3	4	6	8	7	5		
CV %		0.0751									
LSD_t(0.05)(PD x Cult)		Ns									
LSD_t(0.05)(Cult x PD)		?									

Estimate Yield

Cotton strainers only damage mainly seeds and fibre of cotton, the average number of bolls have been used to calculate the estimate yield. Average boll weight used was 5.5 g. The formula used

*Estimate Yield = [(Bolls per plant * 5.5 g)*germinated plants at 14 days after plant * 555.5]/1000*

Damage percentage

The damage percentage was calculated to see what impacted cotton strainers could have on yield. The formula used:

*Damage % = (Yield 2016/17 ÷ Estimate Yield) * 100*

Table 10. Estimate Yield (kg/ha)

Cultivar		Planting dates								Average yield (kg/ha)
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016	
1	Delta 12 BRF	3434.3	3681.5	4366.5	4390.4	4010.5	3781.4	4932.2	2625.0	3902.7
2	DP1541 B2RF	2128.8	4385.9	5287.9	4868.6	4479.5	5795.6	4254.0	4946.9	4518.4
3	DP 1240 B2RF	2057.0	4409.2	5087.8	6077.0	5236.7	3576.8	4089.5	3336.5	4233.8
4	Candia B2RF	2292.0	5157.0	4777.5	5143.0	4544.0	4351.5	3683.2	3013.7	4120.2
5	DP1531 B2RF	2663.7	4135.3	5452.3	5559.3	5216.6	4838.2	3324.1	2674.4	4233.0
6	DP210BRF	3552.7	5294.3	7095.4	5615.2	4707.1	4838.2	4107.6	2674.4	4735.6
Average		2688.1	4510.5	5344.6	5275.6	4699.1	4530.3	4065.1	3211.8	
CV %		0.0218								
LSD_t(0.05)(PD x Cult)		ns								
LSD_t(0.05)(Cult x PD)										

Table 11. Cotton Stainer Damage (%)

Cultivar		Planting dates								Average yield (kg/ha)
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016	
1	Delta 12 BRF	47.6	39.5	55.3	64.0	70.1	79.7	73.5	70.7	62.5
2	DP1541 B2RF	27.6	35.3	61.8	58.0	70.7	89.3	59.1	66.2	58.5
3	DP 1240 B2RF	28.3	35.3	50.5	69.4	76.5	80.6	59.3	48.7	56.1
4	Candia B2RF	23.6	51.7	55.9	63.6	75.2	87.3	58.3	67.3	60.4
5	DP1531 B2RF	28.8	34.4	61.2	66.0	73.5	82.0	59.2	49.2	56.8
6	DP210BRF	33.1	49.0	71.0	67.6	80.2	82.0	69.5	49.2	62.7
Average		31.5	40.9	59.3	64.8	74.4	83.5	63.1	58.5	
Ranking		1	2	4	6	7	8	5	3	
CV %		0.0218								
LSD_t(0.05)(PD x Cult)										
LSD_t(0.05)(Cult x PD)										

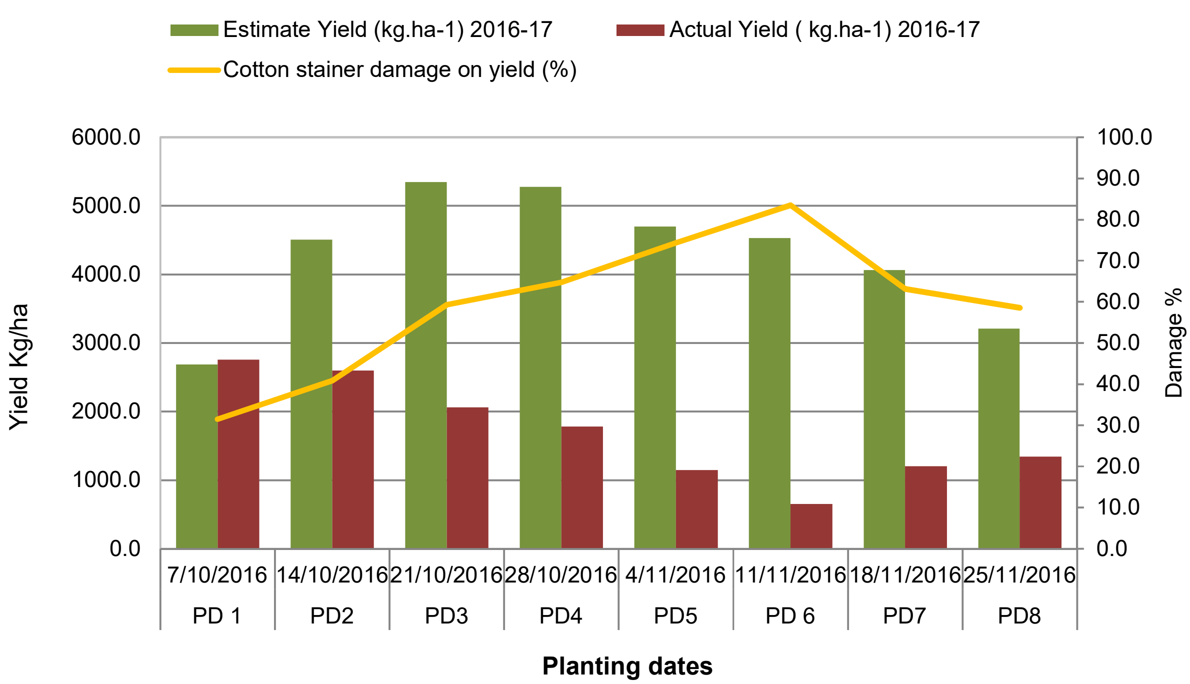

Figure 7. Combined graph for Yield and Cotton Stainer damage

Fibre percentage

Fibre percentages were not greatly influenced by the planting dates but cotton strainers damage fibres in the 5th and 6th Planting dates. Fibre percentages are cultivar related. The cultivars Candia B2RF and DP1531 B2RF resulted in the highest fibre % of 43.1 and 42.6 respectively.

Table 12. Fibre (%)

Cultivar		Planting dates								Average Fibre %	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	39.4	39.8	39.2	37.5	36.8	34.7	39.0	39.9	38.3	6
2	DP1541 B2RF	43.0	44.2	42.9	40.9	37.2	36.2	41.8	42.5	41.1	3
3	DP 1240 B2RF	41.1	40.6	39.4	38.9	37.3	38.1	40.7	40.7	39.6	5
4	Candia B2RF	45.7	46.0	44.3	38.9	39.4	41.7	43.7	44.7	43.1	1
5	DP1531 B2RF	44.1	46.7	41.8	41.0	41.4	39.0	43.8	42.9	42.6	2
6	DP210BRF	40.3	46.1	40.1	38.0	35.2	32.7	38.5	38.7	38.7	4
Average		42.3	43.9	41.3	39.2	37.9	37.1	41.3	41.6		
Ranking		6	5	4	1	4	2	1	3		
CV%		3.156374									
LSD_t(0.05)(PD x Cult)		0.3307									
LSD_t(0.05)(Cult x PD)		0.6328									

Boll size

Cotton stainers feed on young bolls and this causes a reduction in size. All the Planting dates resulted in small bolls, less than 4.3 grams per boll. The smallest bolls were obtained from Plant dates 4, 5, and 6.

Table 13. Boll size (g)

Cultivar		Planting dates								Average Boll size (g)	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	4.0	4.1	5.1	3.6	3.8	3.5	4.0	3.6	3.96	4
2	DP1541 B2RF	4.3	5.0	3.9	3.7	3.4	3.1	4.4	4.3	3.99	3
3	DP 1240 B2RF	4.4	4.6	5.3	3.6	3.7	3.6	4.7	4.5	4.31	1
4	Candia B2RF	3.8	4.2	3.6	3.4	2.8	3.9	3.9	3.6	3.65	6
5	DP1531 B2RF	3.8	4.0	3.9	3.4	4.1	4.1	4.6	4.3	4.02	2
6	DP210BRF	3.9	3.8	4.8	3.4	3.3	3.1	4.4	4.3	3.87	5
Average		4.0	4.3	4.4	3.5	3.5	3.6	4.3	4.1		
Ranking		4	2	1	6	6	5	2	3		
CV %		9.620815									
LSD_t(0.05)(PD x Cult)		0.1882									
LSD_t(0.05)(Cult x PD)		0.2173									

Fibre length

Fibre length is largely controlled by variety, although weather and management can also influence the final fibre length.

There were no significant differences between the October plantings and the November planting dates.

The cultivar, DP1541 B2RF resulted in the longest average fibre length of average 29.0 mm followed by Candia B2RF with a fibre length of 28.8 mm. From the combined analysis for planting dates over planting dates, in Planting Date 2 the cultivar DP1541 B2RF resulted in a significantly higher fibre length of 30.0 mm.

Table 14. Fibre length (mm)

Cultivar		Planting dates								Average Length (mm)	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	28.4	29.2	28.9	27.8	27.4	27.1	27.4	26.8	27.9	6
2	DP1541 B2RF	29.8	30.0	28.5	28.7	28.7	29.0	28.6	28.5	29.0	1
3	DP 1240 B2RF	29.1	28.7	29.3	29.1	28.2	28.7	28.1	27.8	28.6	4
4	Candia B2RF	29.3	29.3	28.0	28.7	28.2	29.9	28.2	28.4	28.8	2
5	DP1531 B2RF	28.9	29.6	28.8	27.7	28.2	28.0	27.8	27.3	28.3	5
6	DP210BRF	29.3	28.3	27.7	28.1	29.1	29.3	29.0	28.8	28.7	3
Average		29.1	29.2	28.5	28.4	28.3	28.7	28.2	27.9		
Ranking		2	1	4	5	6	3	7	8		
CV %		2.5814									
LSD_t(0.05)(PD x Cult)		0.3638									
LSD_t(0.05)(Cult x PD)		1.0294									

Uniformity index

Uniformity index is minimally affected by cotton variety. Field weathering and ginning have a more dramatic effect on uniformity.

The uniformity index values were slightly lower than the 83 to 85 norm that indicated a high degree of uniformity. This could be the result of the cotton strainers damaging the bolls.

Table 15. Uniformity index

Cultivar		Planting dates								Average Uniformity	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	82.89	82.5	83.3	82.1	81.8	82.0	82.2	80.9	82.2	4
2	DP1541 B2RF	83.73	84.3	82.6	82.8	82.2	83.1	83.1	83.5	83.2	4
3	DP 1240 B2RF	83.92	83.2	82.3	83.3	83.6	83.4	82.5	81.8	83.0	1
4	Candia B2RF	82.50	82.8	82.5	82.0	82.1	84.0	81.4	81.5	82.3	3
5	DP1531 B2RF	82.91	82.4	82.2	82.1	83.7	82.9	82.0	81.7	82.5	2
6	DP210BRF	82.46	82.2	82.2	80.8	82.2	83.0	82.4	81.5	82.1	5
Average		83.1	82.9	82.5	82.2	82.6	83.1	82.3	81.8		
Ranking		1	2	4	6	3	1	5	7		
CV %		1.296648									
LSD_t(0.05)(PD x Cult)		0.5285									
LSD_t(0.05)(Cult x PD)		0.6102									

Fibre strength

Variety is by far the most dominant factor in fibre strength**.** Environment has a small effect on fibre strength.

The cultivar Delta1240B2RF significantly gave the strongest fibres of 28.1 g/tex. From the combined analysis for planting dates over cultivars, no significant differences were obtained. Planting Date 6 resulted in the strongest fibres of 27.9 g/tex.

Table 16. Fibre strength (g/tex)

Cultivar		Planting dates								Average Fibre Strength (g/tex)	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 4/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	25.53	26.2	27.2	25.3	25.5	26.5	25.3	24.5	25.8	4
2	DP1541 B2RF	27.23	28.6	28.5	25.8	26.6	27.4	27.8	27.4	27.4	2
3	DP 1240 B2RF	27.83	28.5	26.0	28.3	28.3	28.9	29.2	27.3	28.1	1
4	Candia B2RF	24.88	26.9	26.7	25.0	23.0	29.3	25.7	23.8	25.7	5
5	DP1531 B2RF	26.47	28.9	26.3	26.1	27.8	27.5	27.0	26.7	27.1	3
7	DP210BRF	26.48	27.1	25.5	25.0	25.4	27.7	28.0	26.8	26.5	6
Average		26.4	27.7	26.7	25.9	26.1	27.9	27.2	26.1		
Ranking		5	2	4	7	6	1	3	6		
CV %		3.7359									
LSD_t(0.05)(PD x Cult)		0.3638									

Elongation

No water stress occurred during the elongation phase of the fibre. Planting Date 7 and 8 resulted in significantly higher fibre elongation of 10.8 and 10.3, respectively. The cultivar Candia B2RF resulted in the highest fibre elongation of 9.4.

Table 17. Elongation

Cultivar		Planting dates								Average fibre elongation	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	6.74	9.0	8.7	10.1	9.7	10.1	11.2	12.1	9.7	1
2	DP1541 B2RF	6.99	8.1	9.0	8.7	8.9	8.6	9.3	8.8	8.6	5
3	DP 1240 B2RF	7.20	7.8	8.7	9.0	8.3	8.2	10.1	10.7	8.7	4
4	Candia B2RF	6.79	9.5	8.8	10.1	10.2	7.7	10.8	11.3	9.4	2
5	DP1531 B2RF	7.62	8.4	9.3	9.6	8.3	8.4	10.0	10.8	9.0	3
7	DP210BRF	6.98	9.7	9.7	10.9	9.5	9.1	10.5	11.1	9.7	1
Average		7.1	8.7	9.0	9.7	9.1	8.7	10.3	10.8		
Ranking		8	7	5	3	4	6	2	1		
CV %		5.1372									
LSD_t(0.05)(PD x Cult)		0.16244									
LSD_t(0.05)(Cult x PD)		0.1929									

Micronaire

The damage caused by cotton stainers on the lint could be seen in Table 18. All cultivars and Planting Dates resulted in very low micronaires, less than 3.6 µg.

Table 18. Micronaire (µgrams)

	Cultivar	Planting dates								Average Micronaire (µg)	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	3.4	3.6	3.0	2.8	2.9	3.1	3.7	3.1	3.2	2
2	DP1541 B2RF	3.2	3.4	3.1	2.6	2.6	2.4	3.7	3.5	3.1	3
3	DP 1240 B2RF	3.5	3.6	2.8	2.7	2.6	2.6	4.0	3.5	3.2	2
4	Candia B2RF	3.0	3.1	3.2	2.5	2.2	2.7	3.2	2.8	2.8	4
5	DP1531 B2RF	3.7	3.3	2.5	2.9	3.8	3.1	3.7	3.5	3.3	1
6	DP210BRF	2.9	3.4	3.2	2.2	2.4	2.1	3.2	2.8	2.8	4
	Average	3.3	3.4	3.0	2.6	2.7	2.7	3.6	3.2		
	Ranking	3	2	5	7	6	6	1	4		
	CV %	32.26									

Yellowness and Degree of reflectance

Each planting date trial was hand pick when ready and cotton fibres were not exposed too long to field weathering.

The effect of discolouration of fibres could be seen in Table 20 where the degree of reflectance for all planting dates and cultivars is less than 75. Cotton fibres were greyish and yellowed stained by the cotton strainers and thus resulted in +b to be higher than 9.

Table 19. Yellowness (+b < 9)

Cultivar		Planting dates								Average Yellowness (+b < 9)	Ranking
		PD 1 07/10/2016	PD 2 14/10/2016	PD 3 21/10/2016	PD 4 28/10/2016	PD 5 04/11/2016	PD 6 11/11/2016	PD 7 18/11/2016	PD 8 25/11/2016		
1	Delta 12 BRF	9.9	9.8	11.6	12.3	12.3	12.8	9.0	8.1	10.7	1
2	DP1541 B2RF	10.5	11.0	12.5	12.7	13.5	13.3	9.6	9.2	11.5	4
3	DP 1240 B2RF	11.0	10.7	12.0	13.5	13.6	13.7	8.8	9.2	11.6	5
4	Candia B2RF	10.5	10.7	11.9	13.2	13.6	13.0	10.9	9.1	11.6	5
5	DP1531 B2RF	10.4	10.4	12.5	12.4	12.1	12.3	9.5	9.4	11.1	2
6	DP210BRF	11.4	10.4	11.7	12.7	12.7	13.1	9.4	9.6	11.4	3
Average		10.6	10.5	12.0	12.8	13.0	13.0	9.5	9.1		
Ranking		3	4	5	6	7	7	2	1		
CV %		6.4232									
LSD_t(0.05)(PD x Cult)		ns									
LSD_t(0.05)(Cult x PD)		ns									

Table 20. Degree of reflectance (RD ≥75)

Cultivar		Planting dates								Average Degree of reflectance (RD ≥ 75)	Ranking
		PD 1 07/10/ 2016	PD 2 14/10/ 2016	PD 3 21/10/ 2016	PD 4 28/10/ 2016	PD 5 04/11/ 2016	PD 6 11/11/ 2016	PD 7 18/11/ 2016	PD 8 25/11/ 2016		
1	Delta 12 BRF	70.5	70.48	69.3	67.3	70.8	71.5	73.7	75.3	71.1	2
2	DP1541 B2RF	70.7	69.47	67.2	68.1	67.2	71.0	74.1	74.6	70.3	4
3	DP 1240 B2RF	68.1	69.94	68.3	65.7	67.3	70.4	72.8	72.8	69.4	6
4	Candia B2RF	70.3	70.09	68.5	66.1	65.3	70.9	71.0	74.0	69.5	5
5	DP1531 B2RF	70.8	70.45	68.4	67.5	73.1	73.2	72.7	74.1	71.3	1
6	DP210BRF	70.2	70.61	68.6	67.2	69.5	73.1	73.8	74.2	70.9	3
Average		70.1	70.2	68.4	67.0	68.9	71.7	73.0	74.2		
Ranking		5	4	7	8	6	3	2	1		
CV %		2.4441									
LSD_t(0.05)(PD x Cult)		ns									
LSD_t(0.05)(Cult x PD)		ns									

CONCLUSION

In the 2016/17 growing season the number of days in the high 30s was below average for the past 3 years and none were over 40°C.

Cotton planted before 14 October could have a plant stand reduction due to varying soil temperatures and less-than-ideal daily temperatures of less than 50 degree-days.

As seen in the results presented, when environmental conditions are favorable to cotton stainers damage can impact yield production through-out the cotton growing season. A yield loss of 31.5 % was obtained in the early planting date (07/10/2017). Yield loss increased rapidly with each planting date until it reached 83 % when cotton was planted in mid November 2017.

Yield and fibre qualities were greatly effected by the cotton strainers and this resulted in huge loss in gross income for a farmer.

Cotton stainer is partly blamed for a decreasing in whiteness and brightness of the fibres. Wet weather and long exposure to environmental conditions could also result in grayish cotton colour. Grayish cotton is not cultivar related.

Farmer, extension officers and researchers have to take care of this natural fibre and they must not allow this pest to become an economic problem.

PROPOSED RESEARCH FOR 2017/18

In the four years that this cotton trial was conducted, this is the first year grey cotton fibres were noticed. This trial will have to be repeated to look into the reasons and possible solutions facing the cotton industry as far as grey cotton is concern. The trial will be planted at Groblersdal: ARC-Loskop Research Farm.

PROJECT NUMBER	:	P08000013 (TK 205/29)
PROJECT TITLE	:	Organic insecticides & nematicides for SMF farmers
SUBPROJECT TITLE	:	Biological control of cotton bollworms and leafhoppers in South Africa
REPORT YEAR	:	2016/2017
PROJECT MANAGER	:	LN Malinga

INTRODUCTION

South Africa is one of only a few developing countries that have adopted genetically modified crops for commercial and small-scale production. Cotton has been an important crop in the socio-economic development of South Africa. However, cotton production is of an intensive cost and any yield less than an optimal has a direct impact on the profitability of the farming. Cotton is susceptible to a wide range of insect pests that have significant impact on the yield and quality of the fibre. Smallholder farmers, in particular, struggle with the cost of agrochemicals for the control of these pests and frequently suffer severe losses due to them.

Organic insecticides have become an attractive alternative to inorganic insecticides. The use of organ insecticides could form part of a broader IPM system to be used by small-scale cotton farmers. If these natural and organic insecticides can be successfully integrated into their management system, the farmers' input costs can be lowered and therefore the profit margin will increase. The objective of this study was to compare novel treatments versus current insecticides for control of insects in cotton.

AIM AND OBJECTIVES

The aim of these studies was to develop an integrated pest management programme to control cotton pests using biological agents. The specific research objectives of the studies are:

- An evaluation of the potential of biological control agents on cotton bollworm management in the field.

- An evaluation of the potential of biological control agents on cotton jassids management in the field.

RESEARCH LAYOUT

The studies were conducted in Rustenburg to evaluate the efficacy of different biological control agents against the bollworm and jassids.

The following treatments were used in the bollworm study:

1. Insecticide – pyrethroid : lambda-cyhalothrin (Karate)
2. Biocontrol 1 – Eco-Bb
3. Biocontrol 2 – Bb endophyte
4. Biocontrol 3 – nuclear polyhedrosis virus, Bolldex
5. Biocontrol 4 – Bt kurstaki
6. Untreated control

Spraying of all the treatments was administered weekly.

The Neonicotinamide, imidacloprid (Bandit), was applied every second week to all treatments for control of jassids.

The following treatments were used in the jassid study:

1. Insecticide 1 – neonicotinamide: imidacloprid (Bandit)
2. Insecticide 2 – pyrethroid: lambda-cyhalothrin (Karate)
3. Insecticide 3 – organophosphate (Chloryphos)
4. Biocontrol 1 – Eco-Bb
5. Biocontrol 2 – Eco-Bb endophyte
6. Biocontrol 3 – Eco-Bb 2
7. Untreated control

The nuclear polyhedrosis virus, Bolldex, was applied on all treatments for control of bollworms.

REPLICATES

Each treatment was replicated four times. Each replicate consisted of 5 m x 6 rows (approximately 20 plants/row) with 2 m borders.

CROP

The DeltaPine non-GM Cotton cultivar, Delta 18, was planted.

EXPERIMENTAL PROCEDURES

The bollworm trial was planted on 24 October 2016. Treatments were started at 12 weeks and continued weekly. Weekly evaluations were done from Week 11 for insects counts and crop damage. The trail was harvested on 22 – 23 May 2017.

The jassid trial was planted on 15 November 2016. Treatments were started at 9 weeks and continued weekly. Weekly evaluations were done from Week 8 for insects counts and crop damage. The trial was harvested on 19 – 23 June 2017.

EVALUATION PARAMETERS

1. Insects counts in each plot
2. Damage index in each plot
3. Yield of cotton

ANALYSIS

Data analysis for ANOVA and LSD using GenStat.

RESULTS AND DISCUSSION

Bollworm trial

The overall average from Week 15 of insect scouting showed that the Karate and Bolldex treatments had a lowest number of African bollworm during the 2016/17 season (Table 1). The untreated control had the highest significant incidence of African bollworm compared the Karate treatment. While considering the economic injury levels of the different bollworms, the results shows that American bollworm larvae exceeded the threshold level of 5 bollworms for all the treatments except for the Karate and Bolldex treatments. The lowest number of spiny bollworm larvae were recorded in the plots that were treated with Bolldex and Karate. However, they did not differ significantly from the untreated control (Table 2). No red bollworm larvae were recorded throughout the season. The results in Tables 3 revealed that plots that were treated with Eco-Bb had the lowest number of damaged bolls when compared to the other treatments. However, there were no significant differences among all the treatments.

Karate treatment has the least significant number of aphids on different treatments compared to the Bolldex and the untreated control (Table 4). The Eco-bb plots exhibited the highest number of thrips but did not differ significantly from all the other treatments (Table 5). The results in Table 6 indicated that Karate treatment had a significant effect on the whiteflies compared to the untreated control. Table 7 shows that there were no significant differences in the spider mites population amongst all the treatments. The lowest population of jassids was observed in the plots treated with Karate, which differed statistically from the untreated control (Table 8). The highest average number of jassids recorded was 2 jassids per plot. This may be due to the application of neonicotinamide imidacloprid (Bandit) on all the treatments to suppress the jassids population.

An average of less than 2 tons/ha was recorded during the season, except for the Karate treatment. All the plots that were treated with biocontrol agents gave lower yields than the control. Significant high seed cotton yield of 5.1 tons/ha was found in the plots that were treated with Karate (Table 9). This may be because all the plots that were treated with Karate had their boll opening earlier than the other treatments (Figure 1).

In summary, during the 2016/17 season, the biological control agents gave control of bollworms when compared with untreated control. Bolldex exhibited a good reduction of bollworms compared to the other treatments except to the Karate treatment. This study suggests that bollworm reduction through the use of biological control agents are likely to be achieved through continued integration of the agents in cotton pest control. The trial will be repeated during the 2017/18 season to verify the current findings.

Table 1. The average number of African bollworms on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb	5.2941 **ab**
Bolldex	4.3077 **bc**
Bt kurstaki	5.2093 **ab**
Bb endophyte	5.4615 **ab**
Karate	3.8919 **c**
Untreated Control	5.5946 **a**
LSD $_{(5\%)}$	**1.2459**
CV%	**1.97160**

[1] Means with the same letter are not significantly different.

Table 2. The average number of spiny bollworms on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb	1.0000 **a**
Bolldex	1.0000 **a**
Bt kurstaki	1.4000 **a**
Bb endophyte	1.4000 **a**
Karate	1.3333 **a**
Untreated Control	1.4444 **a**
LSD $_{(5\%)}$	**0.5764**
CV%	**2.22814**

[1] Means with the same letter are not significantly different.

Table 3. The average number of bollworm damage on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb	2.400 **a**
Bolldex	3.000 **a**
Bt kurstaki	5.118 **a**
Bb endophyte	3.200 **a**
Karate	6.111 **a**
Untreated Control	7.375 **a**
LSD $_{(5\%)}$	**6.9473**
CV%	**2.14479**

[1] Means with the same letter are not significantly different.

Table 4. The average number of aphids on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb	12.10 **bc**
Bolldex	63.86 **a**
Bt kurstaki	17.00 **bc**
Bb endophyte	14.17 **bc**
Karate	7.82 **c**
Untreated Control	35.00 **b**
LSD $_{(5\%)}$	**23.973**
CV%	**2.14479**

[1] Means with the same letter are not significantly different.

Table 5. The average number of thrips on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb	4.667 **a**
Bolldex	1.500 **a**
Bt kurstaki	3.333 **a**
Bb endophyte	4.000 **a**
Karate	2.500 **a**
Untreated Control	2.500 **a**
LSD $_{(5\%)}$	**3.2137**
CV%	**3.18245**

[1] Means with the same letter are not significantly different.

Table 6. The average number of whiteflies on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb	5.0556 **ab**
Bolldex	4.9259 **ab**
Bt kurstaki	3.9375 **ab**
Bb endophyte	4.1250 **ab**
Karate	3.4000 **b**
Untreated Control	5.6538 **a**
LSD $_{(5\%)}$	**1.7579**
CV%	**2.13145**

[1] Means with the same letter are not significantly different.

Table 7. The average number of spider mites on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb	8.00 **a**
Bolldex	2.00 **a**
Bt kurstaki	3.75 **a**
Bb endophyte	26.00 **a**
Karate	10.00 **a**
Untreated Control	6.43 **a**
LSD (5%)	**40.115**
CV%	**2.57058**

[1] Means with the same letter are not significantly different.

Table 8. The average number of jassids on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb	1.7143 **ab**
Bolldex	2.0000 **ab**
Bt kurstaki	1.7143 **ab**
Bb endophyte	1.6250 **ab**
Karate	1.0000 **b**
Untreated Control	2.2500 **a**
LSD (5%)	**1.1367**
CV%	**2.26216**

[1] Means with the same letter are not significantly different.

Table 9. Seed yields obtained from the different treatments during the 2016/2017 season

Treatment	Mean (kg/ha)[1]
Eco-Bb	1018.3 **c**
Bolldex	1538.3 **bc**
Bt kurstaki	1174.2 **bc**
Bb endophyte	1033.3 **c**
Karate	5133.3 **a**
Untreated Control	2084.2 **b**
LSD $_{(5\%)}$	**1003.9**
CV%	**2.10092**

[1] Means with the same letter are not significantly different.

Figure 1. Arial view of the trial showing the rate of boll opening for the plots that were treated with Karate

Jassid trial

The highest numbers of jassids were recorded from the plots that were treated with Endo Bb 1, which was significantly higher than Endo Bb 2, Chloryphos and untreated control (Table 13). During the season, all the treatments significantly reduced the mean number of cotton stainers compared to the untreated control (Table 14). The lowest number of cotton stainers was recorded on the plots that were treated with Endo Bb 1.

The highest number of aphids were recorded in the plots that were treated with Endo Bb 1, however, they did not differ significantly from the Karate treatment (Table 10). Chloryphos treatment had the highest number of whiteflies while Karate had the lowest population. However, there were no significant differences in all the treatments (Table 11). Besides the Bandit and Karate, plots that were treated with Chloryphos exhibited the highest significant number of spider mites compared to Endo Bb 1, Endo Bb 2, Eco Bb and untreated control (Table 12). No cotton bollworm larvae or damage were recorded throughout the season. This may have been due the spraying of Bolldex on all the treatments to suppress the populations.

There were no significant differences on the populations of beneficial insects (Tables 15 and 17) except for ants, which the populations were significantly low in plots that were treated with Chloryphos and Karate compared to Eco Bb (Table 16).

The highest cotton seed yield of 5981.7 kg/ha was recorded on the plots that were treated with Karate, while the Chloryphos has the lowest yield of 5020.8 kg/ha (Table 18).

In summary, during the 2016/17 season, the biological control agents showed no effect on the control of jassids when compared with untreated control. The populations of beneficial insects were very low during the season. An average of more than 5 tons/ha was recorded during the season, however, there were no significant differences in all the treatments. The trial will be repeated during the 2017/18 season to verify the current findings.

Table 10. The average number of aphids on different treatments during the 2016/2017 season

Treatment	**Mean [1]**
Eco-Bb1	113.91 **a**
Bb endophyte 2	32.65 **dc**
Chloryphos	32.53 **dc**
Bb endophyte 1	70.94 **bc**
Karate	82.32 **ab**
Bandit	22.23 **d**
Untreated Control	22.23 **d**
LSD (5%)	**40.658**
CV%	**2.10092**

[1] Means with the same letter are not significantly different.

Table 11. The average number of whiteflies on different treatments during the 2016/2017 season

Treatment	**Mean [1]**
Eco-Bb1	6.606 **a**
Bb endophyte 2	6.611 **a**
Chloryphos	10.03 **a**
Bb endophyte 1	7.552 **a**
Karate	5.541 **a**
Bandit	5.842 **a**
Untreated Control	7.865 **a**
LSD (5%)	**5.8525**
CV%	**2.10092**

[1] Means with the same letter are not significantly different.

Table 12. The average number of spider mites on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb1	5.333 b
Bb endophyte 2	9.800 b
Chloryphos	27.533 a
Bb endophyte 1	9.000 b
Karate	13.125 ab
Bandit	16.824 ab
Untreated Control	11.500 b
LSD $_{(5\%)}$	**14.915**
CV%	**2.13145**

[1] Means with the same letter are not significantly different.

Table 13. The average number of jassids on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb1	4.000 a
Bb endophyte 2	1.0000 b
Chloryphos	1.0000 b
Bb endophyte 1	2.3333 ab
Karate	2.3333 ab
Bandit	1.5000 ab
Untreated Control	1.0000 b
LSD $_{(5\%)}$	**2.6582**
CV%	**2.677645**

[1] Means with the same letter are not significantly different.

Table 14. The average number of cotton stainers on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb1	2.500 b
Bb endophyte 2	3.556 b
Chloryphos	3.000 b
Bb endophyte 1	2.571 b
Karate	2.750 b
Bandit	3.571 b
Untreated Control	7.429 a
LSD $_{(5\%)}$	**3.8053**
CV%	**2.14479**

[1] Means with the same letter are not significantly different.

Table 15. The average number of bees on different treatments during the 2016/2017 season

Treatment	**Mean** [1]
Eco-Bb1	1.500 a
Bb endophyte 2	1.400 a
Chloryphos	1.3333 a
Bb endophyte 1	1.2222 a
Karate	1.0000 a
Bandit	1.3333 a
Untreated Control	1.0000 a
LSD $_{(5\%)}$	**2.17881**
CV%	**0.959**

[1] Means with the same letter are not significantly different.

Table 16. The average number of ants on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb1	1.6667 ab
Bb endophyte 2	1.6667 ab
Chloryphos	1.2500 b
Bb endophyte 1	2.2000 a
Karate	1.0000 b
Bandit	1.3333 ab
Untreated Control	1.3333 ab
LSD $_{(5\%)}$	**0.9216**
CV%	**2.26216**

[1] Means with the same letter are not significantly different.

Table 17. The average number of ladybirds on different treatments during the 2016/2017 season

Treatment	Mean [1]
Eco-Bb1	2.6667 **a**
Bb endophyte 2	1.0000 **a**
Chloryphos	1.0000 **a**
Bb endophyte 1	1.3333 **a**
Karate	1.2000 **a**
Bandit	*
Untreated Control	1.2500 **a**
LSD $_{(5\%)}$	**0.9216**
CV%	**2.26216**

[1] Means with the same letter are not significantly different.

Table 18. Seed yields obtained from the different treatments during the 2016/2017 season

Treatment	Mean (kg/ha)[1]
Eco-Bb	5964.2 **a**
Bb endophyte 1	5826.7 **a**
Chloryphos	5020.8 **a**
Bb endophyte 2	5595.8 **a**
Bandit	5822.5 **a**
Karate	5981.7 **a**
Untreated Control	5306.7 **a**
LSD $_{(5\%)}$	**989.88**
CV%	**2.07961**

[1] Means with the same letter are not significantly different.

PROJECT NUMBER	**:**	P08000018 (101795)
PROJECT TITLE	**:**	Biological control of nematodes on cotton
SUBPROJECT TITLE	**:**	Evaluation of environmental friendly products for control of *Meloidogyne* sp. on cotton in South Africa
REPORT YEAR	**:**	2016/2017
PROJECT LEADER	**:**	SC Khuzwayo
CO-WORKERS	**:**	LN Malinga

INTRODUCTION

The root-knot nematode (RKN), especially *Meloidogyne javanica*, is by far the most important nematode pest of cotton worldwide. Root-knot nematodes, in particular *Meloidogyne incognita* race 4 is the predominant nematode species and race that adversely affects the production of cotton in South Africa and thus result in substantial yield losses (De Beer, 2010). Other nematodes, such as *Pratylenchus* spp and *Trichodorus* spp are widely found but not of economic importance in cotton. *Meloidogyne* spp. are widespread and attack a wide range of hosts, both cultivated and uncultivated.

Following the 2005 international withdrawal of methyl bromide (MB) technique in management of plant-parasitic nematodes due to its eco-unfriendliness (Johnson *et al.* 2012.) *Meloidogyne* spp became increasingly the most debilitating nematode genus which left producers have been left with limited options. There are no commercial cotton varieties resistant to root-knot nematodes and the limited availability of nematicides needs carefully evaluation to be conducted for farmers to use products that will produce better yield and good quality. It is therefore imperative to evaluate some of the available nematicides and biological agents.

OBJECTIVES

To evaluate the effect of nematicides and biological agents for the management of nematodes in a cotton farming system under field and greenhouse conditions.

EXPERIMENTAL DESIGN

A glasshouse experiment was conducted in Rustenburg ARC-Industrial crops in the North West Province of South Africa. The following treatments were evaluated in the study:

i. Untreated control,
ii. Standard Nematicide (Oxamyl) 10l/ha at planting
iii. Seed Treatment (Clothianidin) prepared by Bayer personnel
iv. OR_079 + Standard nematicide (10% Pressed orange oil + Oxamyl) 7 days before planting and standard nematicide at planting
v. OR_079 (10% pressed orange oil) 100g/l applied 7 days before planting and at planting
vi. OR_079 10% pressed orange oil 100g/l applied 7 days before planting and at planting + OR_151 plant derived flavonoids in an organic carbon complex 250ml/ha of OR_151 applied at 14days after planting and 28 days later

Mixed growth medium and sand soil were sterilised to remove any pathogens in the soil. The soil was transferred to pots in glasshouse. Tomatoes roots infested with the root knot nematodes *Meloidogyne incognita* and *Meloidogyne javanica w*ere incorporated to the soil to establish nematode population.

Soil samples were taken for analysis of nutrients. Planting date was 13 February 2017. During the trial, 20g/l cypermethrin was sprayed to control aphids.

The experiment comprised of a randomized block design with six treatments, replicated 6 times in separate 3kg pots with three plants each. Candia B2RF cotton cultivar was used for study. Two plants were used for nematode assessments during season and one used for harvest end of season. Nematodes were extracted according to the procedure of Jenkins (1964) from one 250-ml sub-sample taken from the composite sample from each plot for identification and quantification of all plant parasitic nematodes (PPN) present. Then nematode samples (for soil and roots) counting were done before planting (soil only), 6 weeks after planting and 12 weeks after planting. To determine nematode root infestation, one randomly selected plant from the each pot was sampled at 6 and 12 weeks after planting. Nematodes were extracted from the excised roots by maceration and sugar-centrifugal flotation (Coolen and D'Herde, 1972) for identification and quantification of all PPN present. The nematode data will be loge (no. + 1) transformed for analysis (Van Ark, 1981). Data will be analysed using Genstat and subjected to an analysis of variance. Means were compared by Tukey's multiple range test ($P \leq 0.05$).

RESULTS AND DISCUSSION

95% of the seedlings develop sufficient root/stem systems that ensured adequate number of test plants per pot. Moreover, sampling was destructive by uprooting the whole plant system to allow root and soil around root system to be assayed.

The initial population of nematodes in soil showed no significant difference in each pot for each treatment (Table 1). Although the untreated control had higher number of nematodes counted in the soil compared to other treatments, there was no significant difference in the number. At week six *M. javanica* population in soil showed significant difference among treatments. Untreated control had significantly higher number of nematodes in soil compared to standard nematicide and seed treatment. In addition, standard nematode and seed treatment had no significant difference with other treatment except for untreated control.

At week 12 nematode count in soil for *M. javanica* showed significant difference amongst treatments. OR_79 had highly significant number compared to standard nematicide, OR_79 + standard nematicide and seed treatment, which were lower and not different to other treatments

Table 1. Effects of each treatment in nematode population in soil: *Meloidogyne incognita* and *Meloidogyne javanica*

A	***Meloidogyne javanica* in soil**	***Meloidogyne javanica* in soil**	***Meloidogyne javanica* in soil**
Treatments	**Mean (Week 0)**	**Mean (Week 6)**	**Mean (Week 12)**
Untreated control	1.3 **a**	5.0 **a**	2.3 **ab**
Standard Nematicide	0.8 **a**	1.2 **b**	1.0 **b**
Seed Treatment	1.2 **a**	1.7 **b**	1.3 **b**
OR_079 + Standard nematicide,	1.2 **a**	2.5 **ab**	1.3 **b**
OR_079	0.2 **a**	2.7 **ab**	4.5 **a**
OR_079 + OR_151.	1.0 **a**	2.5 **ab**	2.3 **ab**
	LSD 1.4745	*LSD 3.0042*	*LSD 3.0979*

B	***Meloidogyne incognita* in soil**	***Meloidogyne incognita in soil***	***Meloidogyne incognita in soil***
Treatments	**Mean (Week 0)**	**Mean (Week 6)**	**Mean (Week 12)**
Untreated control	3.7 **a**	2.8 **a**	4.0 **a**
Standard Nematicide	0.7 **a**	2.2 **a**	2.5 **ab**
Seed Treatment	1.7 **a**	2.0 **a**	1.8 **ab**
OR_079 + Standard nematicide,	1.8 **a**	2.7 **a**	2.7 **ab**
OR_079,	3.5 **a**	3.2 **a**	2.2 **ab**
OR_079 + OR_151.	3.5 **a**	1.5 **a**	1.0 **b**
	LSD 3.3183	*LSD 2.8416*	*LSD 2.8738*

Initial population for *M. incognita* showed no significant difference among counts in each pot for each treatment (Table 1: B). At week six, treatments showed no statistically difference in the number of nematode counts in the soil. With OR_79 number of nematodes present in the soil increased compared to untreated control, which had high number at planting.

Twelve weeks after planting soil samples were taken again for *M. incognita* counts. The untreated control had the highest number compared to OR_79 + OR_151 statistically but no significant difference compared to four other treatments.

Table 2. Effects of each treatment in nematode population in roots of *Meloidogyne incognita* and *Meloidogyne javanica*

A	***Meloidogyne javanica* in Roots**	***Meloidogyne javanica in Roots***
Treatments	**Mean (Week 6)**	**Mean (Week 12)**
Untreated control	3.0 **ab**	2.2 **ab**
Standard Nematicide	0.3 **c**	0.8 **b**
Seed Treatment	2.5 **ab**	1.2 **b**
OR_079 + Standard nematicide	1.5 **abc**	1.5 **ab**
OR_079	3.3 **a**	4.2 **a**
OR_079 + OR_151	1.2 **bc**	1.8 **ab**
	LSD 2.1655	*LSD 2.825*

B	***Meloidogyne incognita* in Roots**	***Meloidogyne incognita in Roots***
Treatments	**Mean (Week 6)**	**Mean (Week 12)**
Untreated control	2.8 **a**	3.2 **a**
Standard Nematicide	0.8 **b**	0.7 **b**
Seed Treatment	0.8 **b**	2.2 **ab**
OR_079 + Standard nematicide	0.7 **b**	0.8 **b**
OR_079	1.0 **b**	3.7 **a**
OR_079 + OR_151	0.7 **b**	1.0 **b**
	LSD 1.3247	*LSD 1.7516*

Six weeks after planting, roots sample were taken for analysis of nematode infestation (Table 2). At six weeks, *M. javanica* counts in roots showed significant difference amongst treatments.

OR_79 had the highest counts statistically compared to standard nematicide that had the lowest number. In addition, OR_79 + OR_151 and OR_79 + standard nematicide had no significant difference compared to standard nematicide. At 12 weeks, OR_79 also had highest number, which is significantly different to standard nematicide that had the lowest number of *M. javanica* in roots. However, the untreated control had no signicant difference with all other treatments including standard nematicide except with OR_79, which was significantly different.

Meloidogyne incognita root analysis also took place at week 6 (Table 2: B). Only the untreated control was significantly different from all other treatments with highest number of nematodes counted in the roots of cotton plants. At 12 weeks after planting, OR_79 and the untreated control had the highest number of nematodes compared to standard nematicide statistical.

CONCLUSION

Plant parasitic nematodes are important cotton pests. They can be equally damaging in sandy soils and warm regions, yet the damage inflicted by nematodes is easily confused with damage from other pests and pathogens. Examining soil and root systems provided the confirmation of nematode presence and damage. Population counts were important in determining efficacy of treatments for management of nematodes.

Although few nematicides are available for the control of *Meloidogyne spp* nematodes on cotton, Oxamyl still performed best compared to other environmental friendly product currently available. More research needs to done in order to enhance these product for efficacy on cotton and any other crops.

NEXT SEASON

Experiment will be repeated next season in two localities Rustenburg and Northern Cape for field trials and one glass house trial in Rustenburg.

ARC-Institute for Industrial Crops

Cotton Project Annual Progress Report

2016/2017

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PROJECT NUMBER	**:**	P08000013 (TK 205/29)
PROJECT TITLE	**:**	Organic insecticides & nematicides for SMF farmers
SUBPROJECT TITLE	**:**	Survey on the current status of pests on cotton and production practises in South Africa
REPORT YEAR	**:**	2016/2017
PROJECT MANAGER	**:**	LN Malinga

INTRODUCTION

Cotton remains the most versatile crop, however, South Africa's production of cotton is far below the domestic demand (DAFF, 2011). This is due to, amongst other things, that cotton production is of an intensive cost and any yield less than an optimal have a direct impact on the profitability of the farming. Cotton is susceptible to a wide range of insect pests that have significant impact on the yield and quality of the fibre (Manjunath, 2004). The damage by these organisms is more severe on farmers in developing countries who lack the knowledge of these pests and are limited with their control inputs and availability of options compared to the ones from first world. Efficient integrated pest management (IPM) has long been proposed as the future for cotton production. However, the concept requires new interventions devised through a thorough knowledge of biological interactions and information on the crop and on the surrounding environment (Prudent et al., 2007).

Although incidences of pests is not new in South African cotton farmers, there is no recent information that reflects the current status on cotton. The last survey conducted to deal with these issues was performed more than 13 years ago. The current pest control strategy has contributed to an increase in cotton yield and production. However, socio-economic issues and production problems experienced over the last decade require further changes in pest management to improve the cotton production system further. An important component in achieving this is to obtain an insight into farmers' needs, as acceptance of any pest management innovation must meet the needs of the customer (Mumford and Norton, 1993). With the introduction of new cultivars by some of the leading seed companies in South Africa, the relevance of pests and the damage associated with them might have changed. Hence, it is imperative that such a survey is conducted to provide more information on the existing farmers' knowledge and perceptions about the most important cotton pests in different areas.

This survey would also give a relevant information especially on the agronomic and other activities of the farmers on the dynamics of the pests and diseases and its management. Information needs to be obtained to appreciate cotton farmers' practices and to assess opportunities as well as constraints for decision-making at the farm level (Ochou et al., 1998). This study was conducted to survey the farmers' knowledge of cotton pests, their farming activities/practices, control measures that they use, and their challenges.

AIM AND OBJECTIVES

The aim of this study is to develop an integrated pest management programme to control cotton pests using biological agents. The specific research objective to be evaluated in this study will be as follows:

- To conduct a survey on the current status of pests on cotton and production practises in South Africa.

EXPERIMENTAL PROCEDURES

The survey involved both electronic and manual survey of all cotton producers, both commercial and smallholder, to determine the current status and knowledge on pests and diseases, as well as production practices being used which could influence these. The study was based on a questionnaire survey from randomly selected farmers. Questionnaires were distributed to cotton farmers in Mpumalanga, KwaZulu-Natal, Limpopo and Northern Cape. The questionnaire for the survey has been developed in collaboration with Cotton SA. The survey was be conducted in languages that are spoken by the cotton farmers and translated to English. Data were collected using a self-administered questionnaire, which included demographic conditions, questions on cotton production practises, pests and diseases. Overall, 140 cotton farmers were interviewed.

EVALUATION PARAMETERS

Pest and disease status
Cultivation practices
Climate conditions

ANALYSIS

The results were subject to Chi-square test.

RESULTS AND DISCUSSION

The initial sample consisted of 500 farmers from five cotton-producing areas, but only 140 questionnaires were returned. The results are based on the sample of the completed forms that were returned. A total of 122 (87.14%) farmers are planting dryland cotton while the rest have some irrigated cotton field.

Of the 100 farmers who specified the soil type of their cotton fields, 16%, 22%, 3%, 56%, 3% of them have clay, loam, loam clay, sandy, sandy loam soils respectively. Regarding the practice of conservation agriculture, most of them, 131 (94.93%), are currently not implementing it on cotton production. A majority of the participants (86.96%) does not conduct soil analysis prior to planting their fields. Hundred and thirty-eight (98.57%) of the participants harvest their cotton by hand picking. An average yield of 530 kg/ha, ranging between 120 kg/ha and 1 800 kg/ha, were reported by 34 participants. PM 3225 B2RF is the cotton variety that 123 (89.13%) participants are currently planting. However, all the farmers are currently planting genetically modified cotton and only 3 farmers reported that they do not apply chemicals to control the pests.

When inquired about the knowledge on insect and disease resistance of the planted varieties, 126 (91.30%) and 102 (73.38%) participants, respectively, were not aware of the resistance of those varieties. Out of the 140 participants who took part in the survey, only 96 (68%) responded on the resistance of the varieties against pests and diseases of which 78.13% cited that the GM crops that the varieties they plant is resistant to bollworms. Twenty six percent of the participants also mentioned that the varieties they plant is resistant to *Verticillium* wilt.

Most of the farmers 116 (90.63%) obtained their cotton seed from the seed company and only 20 (14.49%) of them used the seed from the previous year. Majority of the farmers receive mentoring and support from the extension officers 113 (81.88%) followed by seed companies 19 (13.77%) and only 2 (1.45%) farmers indicated that they received support from the ARC. Also, only 32 (23.02%) of the participants had a visit by an agricultural scientist in the past.

With regards to the awareness of diseases and pests, 88.57% (124) of the farmers knew more about bollworms compared to nematodes (11.76%), *Fusarium* wilt (8.15%) and *Verticillium* wilt (9.56%). Majority of the participants in Makhathini indicated that there is a high prevalence of mealybugs on cotton in the area. A total of 137 (97.86%) farmers use chemical application as a means to control cotton pests and diseases while only 20 (14.29%) farmers also use biological control methods. Of the 121 participants who answered the question on yield limiting factors, 118 participants cited the climate as the major limiting factor for a good yield. This may be due to the climate change that has shifted the planting season. The farmers identified difficulties in controlling weeds, especially the morning glory 32 (33.33%) and the nutsedge 21 (21.88%).

The areas of cotton production that the participants were keen to see more research being done, was on mechanical harvesting, pest and weed control, soil analysis and development of new cultivars. Table 1 below presents the summary of the findings based on the numbers of the participants who responded to the questions from the survey questionnaire.

CONCLUSION

The results of the survey suggest that there is a need for the following:

- Improved cotton varieties to control more pests and diseases
- Research on the control of mealybug and weeds
- Farmer awareness on nematodes and diseases
- Increase on the use of biocontrol methods to reduce the use of chemical control measures
- Empowering the farmers on the application of conservation agriculture
- Encourage farmers to conduct soil analysis that with assist on increasing the yield
- Frequent visits by the agricultural scientists to advise and mentor the farmers
- Research on the climate change that will result on cotton varieties that will adapt to the new conditions

Table 1. Summary of the knowledge, attitude and practice of participants

Variables	n = 140 (%)
Soil type	
Clay	16 (16.00%)
Loam	22 (22.00%)
Loam clay	3 (3.00)
Sandy	56 (56.00%)
Sandy loam	3 (3.00%)
Practice of conservation agriculture	
No	131 (94.93%)
Yes	7 (5.07%)
Use of soil analysis	
No	120 (86.96%)
Yes	18 (13.04%)
Harvest mechanism	
Handpick	138 (98.57%)
Machine	2 (1.43%)
Varieties that the farmers are planting	
18 + 12B RF	13 (9.42%)
Candia + 1541+ DP1	1 (0.72%)
DP1240	1 (0.72%)
PM 3225 B2RF	123 (89.13%)
Knowledge on disease resistance of the planted variety	
No	6 (4.32%)
Yes	31 (22.30%)
Do not know	102 (73.38%)
Knowledge on insect resistance of the planted variety	
No	8 (5.80%)
Yes	4 (2.90%)
Do not know	126 (91.30%)
Cottonseed supplier	
Cooperative	10 (6.81%)
Loskop gin	1 (0.78%)
Cooperative	1 (0.78%)
Seed company	116 (90.63%)

Use of cottonseed from the previous year	
No	118 (85.51%)
Yes	20 (14.49%)
Advice on variety to plant	
ARC	2 (1.45%)
Chemical agents	1 (0.72%)
Extension officer	113 (81.88%)
Farmer	2 (1.45%)
Other	1 (0.72%)
Seed company	19 (13.77%)
Field visits by a researcher	
No	107 (76.98%)
Yes	32 (23.02%)
Awareness of diseases and pests	
Verticillium wilt	No: 123 (90.44%)
	Yes: 13 (9.56%)
Fusarium wilt	No: 124 (91.85%)
	Yes: 11 (8.15%)
Nematodes	No: 120 (88.24%)
	Yes: 16 (11.76%)
Bollworms	No: 16 (11.43%)
	Yes: 124 (88.57%)
Management strategies to control cotton pests and diseases	
Farming practices	3 (2.14%)
Chemical application	137 (97.86%)
Use of resistance cultivars	100 (71.43%)
Biological control	20 (14.29%)
Factors limiting cotton yield	
Climate	118 (97.51%)
Insect	51 (42.14%)
Labour	106 (87.59%)
All factors	10 (8.26%)
Weed Control	
Morning glory	32 (33.33%)
Nutsedge	21 (21.88%)