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Research Article

EVALUATING THE PERFORMANCE OF SHORT STATURED COTTON GENOTYPES UNDER VARIOUS PLANT DENSITIES

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ABSTRACT

Extensive research has demonstrated that proper planting density is the most critical factor for establishing an optimal canopy structure depending on the specific cotton variety. A research was done at Cotton Research Institute (CRI) in Zimbabwe where the aim was to evaluate the performance of Turkish cotton genotypes against local genotypes under various densities from a period between 2018 to 2021season. Based on the finding, there were highly significant differences (P<.001) on seed cotton yield. At a plant density of 44444 plants ha^{-1}, CRIMS3 had highest seed cotton yield of 2233 kg ha^{-1}. At a density of 74000 plants ha^{-1} May 505 had a highest yield of 2163 kg ha^{-1} . On boll mass, CRI MS1 and CRIMS3 had comparable results with heavier bolls (6.159g and 6.093g) respectively, however Turkish varieties had less boll weights with average mass of (5.051g and 4.967g) respectively. On the number of bolls, plant density of 33333 plants ha^{-1} had highest number of bolls with 11 and the least number of bolls was on plant density of 74000 plants ha^{-1} however with less bolls (6 bolls). Taller plants were also observed on CRIMS1 and CRIMS3 whereas Turkish varieties had shorter plants. According to the findings, CRIMS3 and CRIMS1 had the highest seed cotton yield at a plant density of 44 444 plants ha^{-1} whereas May505 and May344 had the highest yields at a plant density of 74000 plants ha^{-1}. Turkish genotypes performed well at a plant density of 74000 plants ha^{-1}.

INTRODUCTION

Growing cotton at an optimum plant density is an effective agronomic practice for promoting productivity. Investigation of new cotton (Gossypium hirsutum) alternative planting patterns in conjunction with high plant density could be essential to improve cotton yields and profitability[2]. These planting patterns have been found to be beneficiary in cotton production. In research done elsewhere, compact plants grown at high populations were found to result in higher quality cotton and earlier harvest. The propose of spacing and planting density for crops in general and for cotton in particular, has tried to meet the specifics needs of cultivating methods and productivity improvement. Theoretical advantages of Ultra narrow row (UNR) cotton include: earlier crop cover, earlier season radiation interception, increased shading of germinating weeds, better sunlight interception under adverse conditions like poor soils, smaller compact plants with less second positions bolls and increased earliness. Extensive research has demonstrated that proper planting density is the most critical factor for establishing an optimal canopy structure consisting of a good Leaf Area Index (LAI) and porosity, which is an important parameter to describe the light transmission capacity of the canopy, Ali. *et al* [1]. On this research work, it was once conducted by the Cotton Research Institute under breeding programme between 2017 to 2020 season where local varieties and short-statured Turkish varieties were evaluated on field performance and fibre quality whilest using only one plant density of 33333 plants ha^{-1} . The recommendation that was made at the end of the experiment was that the genotypes needed to be evaluated at different plant densities. Therefore, this study to sought to evaluate the performance Turkish genotypes under different plant densities in Zimbabwe, and was carried out in two different sites for three seasons.

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Objective

To evaluate the performance of Turkish cotton genotypes against local genotypes under various plant densities in Zimbabwe.

MATERIALS AND METHODS

Experimental locations

The study was carried out at two sites namely Tokwane and

Dande from 2019 to 2022 season. Tokwane is situated near Triangle in Natural Agro-ecological Region IV on latitude 25° 47' South and longitude 31° 15' East. The altitude is 1087m and the type of soil is sandy clay. Dande is in Natural Agro-ecological Region IV on latitude 16° 33' South and longitude 30° 58' East. The altitude is 369m and the soil type is rhizoidal.

Table 1 Ecological Characteristics of the Experimental Locations.

Management activity	Dande	Tokwane
Soil type	Rhizoidal soils	Black soils
Natural region	4	4
Altitude	369m above sea level	1087m above sea level
Latitude	16°33'south	25° 47'south
Longitude	30°58'east	31° 15'east
Average rainfall (mm) per three seasons	690.5	729.9

Treatments

The experiment had four treatments for Main plots and four treatments for Sub plots as follows**.**

Table 2 Treatments.

Whole - Plot factor- Variety	Sub-Plot factor – Plant density
1. CRI MS 1 (local check)	33333
2. CRI MS 3 (local check)	44444
3. May 344 (Turkish)	55555
4. May 505 (Turkish)	74000

Experimental Design and Plot Sizes

The treatments were laid in a Split Plot Design with four replications. The gross was $35m^2$. The net plot was $15m^2$.

Measurements and Statistical Analysis

Seed cotton yield was measured. Data for average boll mass, boll number per plant and plant height were collected for the purpose of explaining the performance of treatments in respect of seed cotton output. Analysis of data for the dependant variable was done using GenStat software 18th edition. In the final season an across seasons analysis of data was performed after aggregating the data for three seasons. Means were separated using Fisher's Protected LSD at 5%.

RESULTS AND DISCUSSIONS

Seed Cotton Yield (kg/ha)

Analysis of variance (Table 3) on across season below shows that there were no significant differences (P≥0.05) on the effect of variety on seed cotton yield, the seed cotton yield results were comparable. Variations on cotton varieties had no influence on the seed cotton yield. However, there were highly significant differences (P≤.001) recorded on the effect of plant density on seed cotton yield where highest yield of 2093 kg ha $^{-1}$ was obtained from a high plant density of 74000 plants ha^{-1} . This was due to high number of plants per unit area which contributed to a greater number of bolls. A plant density of 55555 plants ha^{-1} also produced higher seed cotton yield where 1975 kg ha^{-1} was realised and this yield result was also influenced by number of plants as earlier alluded to. Plant density of 44444 plants ha^{-1} had 1962 kg ha $^{-1}$ and from this recorded yield, it is evident that the yield was now slightly decreasing as number of plants were also decreasing. The least yield of 1860 kg ha $^{-1}$ was obtained from a plant density of 33333 plants ha $^{-1}$. Basing on the results obtained, it clearly shows that plant population per unit area can influence the final yield. This result was in unison with Dai *et al.*[3] ; Keshavarz *et al*[7], where they came up with research finding where cotton growth and development is highly affected by genetic and environmental factors. One of these factors affecting cotton quality and yield is optimum plant density, and the determination of a suitable plant population differs by environment, cultural practices and cultivar. Usually, producers and farmers choose plant density based on tradition rather than variety requirement, potentially resulting in yield losses. Further researches were made by Li *et al.* [11]; Keshavarz *et al*.[7] , where they emphasised that high plant density can prolong the vegetative phase, delay plant maturity and decrease net photosynthesis due to lower chlorophyll content and RUBP carboxylase enzymes activity . Therefore, the total number of the cotton plants per unit area, the boll number per plant, boll quality can be coordinated to produce higher seed cotton yield Dong *et al*[4].; Li *et al*.[11] However, the suitable planting density is always different for different cotton varieties under different ecological conditions, so the optimum planting density must be determined by field experiments for each variety. In this regard, the suitable planting density will be determined by different cotton varieties under different ecological conditions as seen on Matikwa and Dande, hence the different sites had to be established in order to ascertain whether a plant density can be influenced by different locations besides varieties. An appropriate plant density may not only maximize cotton yield and fibre quality for a given cultivar but also reduce inputs by minimizing seed use without sacrificing yield.

Boll Mass(g)

According to Liu HYPERLINK "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8645204/"et alHYPERLINK "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8645204/". HYPERLINK "https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8645204/"11 cotton bolls located at different fruiting branch positions experience different climate conditions and boll weight differ at different fruiting boll positions. According to the results obtained, cotton genotypes had an influence on the boll mass, therefore significant differences were observed amongst cotton genotypes where CRIMS1 and CRIMS3 had comparable results where they exhibited heavier bolls (6.159g and 6.093g) respectively, however these two genotypes were local checks. Turkish varieties also had comparable boll weights, where an average mass of (5.051g and 4.967g) was recorded respectively. According to Dai HYPERLINK "https://www.ocl-journal.org/articles/ocl/full_html/2023/01/ocl230007/ocl230007.html"etHYPERLINK"https://www.ocl-journal.org/articles/ocl/full_html/2023/01/ocl230007/ocl230007.html"

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Plant Height (cm)

There was high significant difference recorded (P≤.001) on the influence of variety on plant height (Table 3) below, where tall plants were recorded on CRIMS1 and CRIMS3 which both were comparable with (141.2cm and 143.7cm) respectively, this was attributed to that they are both semi-determinate genotypes. Turkish genotypes also had comparable results where May 505 and May 344 exhibited shorter plants with (126.7cm and 117.0cm) respectively. Generally, on plant height Turkish varieties had short statured plants whereas CRIMS varieties were a bit taller. On the effect of plant density on plant height, cotton grown at 33333 and 44444 plant density ha^{-1} produced taller plants and high number of bolls per plant as this was influenced by number of fruiting branches per plant. It was further observed that CRIMS1 and CRIMS3 produced taller plants (141.2 and 143.7 cm) respectively, whilest shorter plant heights were recorded on May 505 and 344 (126.7 cm and 117.0cm) respectively. However, this latest finding gives a contrast to the research finding by Kumar[10] and Sharma[14], where they reported that the closer the plant spacing, the increase on the height of the plants. In this regard, this latest result is consistent with the research made by Khan *et al* [9], MacDonald *et al* [6] who argued that planting density has a certain influence on plant height, where a plant height tends to decrease with the increase of density. In their findings, the main reason for the difference of plant height between the two cotton varieties is where they were affected by planting density and more so Wankemian-1 is an infinite fruit branch with a large area per plant, so the increase of density significantly affects the plant growth, and the plant height decreases with the increase of density, while the Wanmian-191 belongs to a finite fruit branch, which each plant occupies a small area, so the plant growth was not significantly affected by the density. So, coming back to this latest research finding, it carries the same narrative where it is also being attributed to the genetic make-up of the material (Turkish and CRIMS) varieties. CRIMS varieties plant heights had a bearing on the influence of the final seed cotton yield, as plant height increased the number of fruiting branches where cotton bolls developed also increased. Furthermore, there were significant differences on the effect of plant density on plant height where 33333 plants ha^{-1} and 44444 plants ha^{-1} had taller plants with 136.8cm and 135.1cm respectively, whereas the plant density of 55555 plants ha^{-1} and 74000 plants ha^{-1} had shorter plants which were also comparable. As the plant density increased, the height was decreasing. Low plant density of 33333 and 44444 plants ha^{-1} produced taller plants which were due to less competition on sunlight, water and nutrients, this made the plants to grow freely without any hindrance, however on high plant density, plants were competing for nutrients and this compromised growth and development. There was no interaction between variety and plant density on plant height, this means that there was no specific variety which was compatible to a certain plant density which resulted to the influence of plant height.

Boll counts

According to results obtained, there were no significant differences recorded on average boll number in relation to different genotypes. Varieties had no influence to the number of bolls (P≥0.05), results were all comparable**.** On the effect of plant density on boll counts, there were highly significant differences (P≤.001) which were recorded where low plant density of 33333 plants ha^{-1} had highest number of bolls with 11 per plant, this was attributed to tall plants (138.8cm) as this contributed to more fruiting branches where bolls were formed. The second-high number of bolls was recorded on 44444 plants ha^{-1} with 9 bolls. Plant density of 55555 plants ha^{-1} had an average of 7 bolls and the least number of bolls was for 74000 plants ha^{-1} with 6 bolls. As the number of bolls increased, the plant density was decreasing. The results were in unison with the findings made by Luo *et al*.,[12]; Li *et al*.,[11] under a high density, the number of fruit branches, boll quality and lint percentage per plant were decreased, and the number of buds and bolls per plant were also decreased, and thus caused a decrease in the economic yield of cotton. Boll retention rate varied in different plant densities being attributed to number of fruiting branches per plant which was depended upon the plant height. Increasing plant density resulted in a decreased boll retention rate. High boll retention rate was observed where plant density was low as fruiting branches fully exploited their maximum nodes where bolls were formed. As plant population increases, the number of bolls (cotton fruit) produced per individual cotton plant tends to decrease. This is due to increased competition for limited resources like nutrients, water, and light as the plants get more crowded, Suminarti *et al* [15]. Each plant has a finite capacity to produce bolls, so higher populations mean fewer bolls per plant. Boll retention rate decreased as plant population increased this relationship was inversely related. There was no interaction between varieties and plant spacing on number of bolls.

Table 3 Summary table: Across season analysis 2019 to 2021

Treatments	Yield(kg/Ha)	ABM(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	1855	6.159b	7	141.2c
2. CRIMS3	2019	6.093b	9	143.7c
3. MAY344	1788	5.051a	8	117.0a
4. MAY505	1868	4.967a	8	126.7b
P-Value	0.337	<.001	0.221	<.001
LSD	287.0	0.2	3.6	5.8
Plant Density				
1. 33 333	1860a	5	11c	136.8b
2. 44 444	1962c	5	9b	135.1b
3. 55 555	1975b	5	7a	131.1a
4. 74 000	2093d	5	6a	128.2a
Grand mean	1882	5	8	132
P-Value	<.001	0.149	<.001	0.014
LSD	105	0.1	1.8	5.0
Variety x Density	0.013	NS	NS	NS
CV (%)	7.1	13	18.1	9.9

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD

ABM-average boll mass, ABN-average boll number

4.5 Relationship between Variety and Plant Density on Seed Cotton Yield (kg/ha)

According to the results on (Figure 1) below, there was interaction (P≤.0.05) between variety and plant density on seed cotton yield where CRIMS3 performed well at a plant density of 44444 plants ha^{-1} where seed cotton yield of 2233 kg ha^{-1} was recorded. Apart from having performed extremely well on that particular plant density, CRIMS3 also performed well on 33333 plants ha^{-1} with 2088 kg ha^{-1} and also on 74000 plants with 2035 kg ha^{-1}, however the results were not convincing. But from this narrative, basing on the results, CRIMS3 is an all-rounder as it is compatible to all the plant densities as it performed well. However, to be more precise; it performed well on plant density of 44444 plants ha^{-1}. CRIMS1 also performed well at 44444 plants ha^{-1} where highest yield of 1999 kg ha^{-1} per that specific genotype was realised. Therefore, the CRI varieties from Zimbabwe are well suited to a low plant population due to their plant architecture. Turkish varieties also performed well in specific areas. May 505 performed well at a plant density of 74000 plants ha^{-1} with a yield of 2163 kg ha^{-1}. May344 performed well on the same plant density of 74000 plants ha^{-1} where seed cotton yield of 1873 kg ha^{-1} was obtained. From the different results obtained on different plant densities and varieties, it clearly indicates how a certain plant density on a particular variety can influence yield. When a certain type of variety is exposed to a certain plant density it can fully exploit itself. Turkish varieties are more compact and determinate and can tolerate higher plant populations, while Zimbabwean CRI varieties require more space as they are semi-determinate. The other issue which made these varieties to differ was that Turkish varieties are determinate, hence they could suit high plant population, assimilates will be channelled to boll maturation after the terminal bud , in this regard determinate varieties tend to have a more limited fruiting period and may be more sensitive to plant density. whereas CRI varieties are semi-determinate, they exhibit more plasticity in their response to plant population, plants keep flowering as they keep produce bolls, hence they require more space for extensive growth.

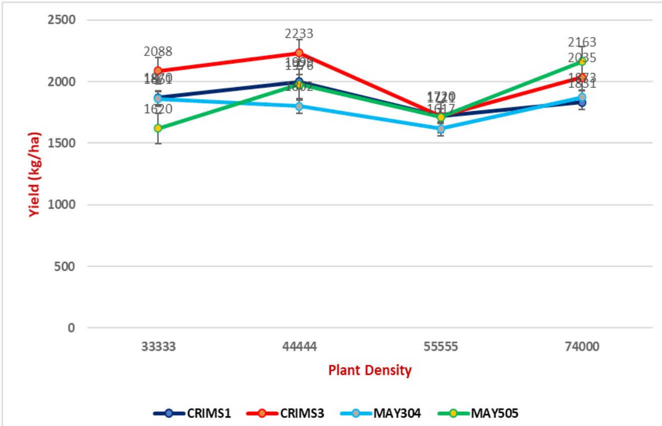

Figure 1 Interaction between plant density and genotypes for three seasons (P≤0.05).

CONCLUSION

According to the analysis on this this latest research finding, the results indicate that CRIMS3 produced highest yield of 2233 kg ha^{-1} at a plant density of 44444 plants and CRIMS1 also performed well at a plant density of 44 444 plants ha^{-1} with a yield of 1999 kg ha^{-1} whereas May 505 performed well at a plant density of 74000 where a yield of 2163 kg ha^{-1} was recorded. May 344 also had its highest yield of 1873 kg ha^{-1} on the same plant density of 74000 plants ha^{-1}. CRIMS1 and CRIMS3 produced heavier bolls than the Turkish varieties as this was attributed to plant height since CRIMS varieties had taller plants whereas Turkish varieties had short statured plants. The other key aspect which contributed to variations on plant height was the issue of plant density, as the plant density increased, the plant height was decreasing. The number of bolls were also influenced by plant height, highest boll retention was realised on plants which were tall especially on low plant density of 33333 plants. Having gone through this experiment, it is evident that careful variety selection and matching with the appropriate plant population is crucial for optimizing cotton yields and fibre quality. Growers must experiment and fine-tune plant densities for their specific conditions and the cotton cultivars they are using. Extension services and research trials can provide guidance on recommended plant populations for various cotton varieties in different production environments. Overall, the relationship between cotton varieties and optimal plant population is a complex, location-specific factor that cotton growers must manage to achieve the best possible outcomes. There are several key factors that influenced the optimal plant population for Turkish cotton varieties and Zimbabwean CRIMS varieties which include growth habit, indeterminate against semi-determinate where it involved growth patterns. Semi-determinate varieties tend to have a more limited fruiting period and may be more sensitive to high plant populations, that is compact against spreading plant architecture. The other reason was on compactness on Turkish varieties which can generally tolerate higher populations than the CRI varieties which are spreading and branching types (compact against spreading plant architecture).

RECOMMENDATIONS

The local bred CRIMS1 and CRIMS3 can be grown under a low plant density of 44444 plants ha^{-1}. Turkish varieties (May344 and May505) are recommended to be grown under a high plant density of 74000 plants ha^{-1} so that the best yields can be realised on a particular genotype, however all these tested varieties can be grown in any environment across Zimbabwe where cotton is cultivated. However, some certain consideration has to be taken care of which include environmental factors where soil fertility is paramount importance hence the trials were done on two sites which is Tokwane and Dande which have different soil types, (Table 1) above. Higher fertility soils can support higher plant populations before nutrient deficiencies occur. Moisture availability especially on irrigated environments generally allow for higher optimal plant populations compared to dryland conditions. Temperature and solar radiation also play a significant part where warmer, higher-light environments may favour higher plant densities. Lastly, management practice where row spacing and plant arrangement with narrow rows and more uniform spatial distributions can increase the optimal plant population. The interplay of these factors means the ideal plant population can vary significantly between cotton growing regions and individual farm conditions. Careful testing and adaptations are required to determine the optimal population for each cotton variety.

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Appendices

Table 4 Dande 2020/21 season

Treatments	Yield(kg/Ha)	ABM(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	3693	5.975b	20a	148.8c
2. CRIMS3	3835	5.842b	22ab	152.7c
3. MAY344	3552	4.808a	26b	117.7a
4. MAY505	3698	4.763a	27b	130.9b
P-Value	0.446	<.001	0.029	<.001
LSD	394.2	0.16	4.686	8.9
Plant Density				
1. 33 333	3716b	5.2	19a	132
2. 44 444	3293a	5.4	22ab	140
3. 55 555	4073c	5.4	25bc	138
4. 74 000	3696b	5.4	28c	140
Grand mean	3695	5.3	24	138
P-Value	<.001	0.169	0.02	0.261
LSD	256.7	0.15	4.225	9.6
Variety x Density	S	NS	NS	NS
CV (%)	8.2	3.3	21.3	8.3

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

Table 5 Tokwane 2020/21 season

Treatments	Yield (kg/Ha)	ABM(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	1694	5.458b	13a	101.3
2. CRIMS3	2047	5.496b	18c	107.4
3. MAY344	1656	4.454a	14b	88.2
4. MAY505	1743	4.458a	14b	92.3
P-Value	0.503	<.001	<.001	0.429
LSD	658.	0.4	6.3	28.96
Plant Density				
1. 33 333	2045b	5	12	93.0
2. 44 444	1618a	5	12	93.7
3. 55 555	1766a	5	15	99.2
4. 74 000	1711a	5	18	103.4
Grand mean	1785	5	15	97.3
P-Value	0.018	0.247	0.163	0.057
LSD	266.2	0.2	2.0	8.47
Variety x Density	NS	NS	NS	NS
CV (%)	17.7	4.4	16.1	10.3

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

Table 6 Dande 2019/20 season

Treatments	Yield (kg/Ha)	ABM(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	333ab	3.9b	8	87.8b
2. CRIMS3	546b	4.0b	10	83.8b
3. MAY344	315a	3.1a	6	72.2a
4. MAY505	316ab	3.1a	6	69.9a
P-Value	0.044	0.006	0.069	0.021
LSD	173.1	0.48	3.6	11.31
Plant Density				
1. 33 333	509c	3.6	7	77.7
2. 44 444	373b	3.5	7	76.8
3. 55 555	401b	3.5	9	81.2
4. 74 000	227a	3.4	7	78.0
Grand mean	377	3.5	8	78.4
P-Value	<.001	0.409	0.370	0.605
LSD	98.8	0.25	1.7	7.00
Variety x Density	NS	NS	NS	NS
CV (%)	5.5	8.4	26.4	10.6

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

Table 7 Tokwane 2019/20 season

Treatments	Yield (kg/Ha)	AB-M(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	1433	5.5b	8	73.83
2. CRIMS3	1702	5.6b	10	74.25
3. MAY344	1626	4.7a	10	69.75
4. MAY505	1405	4.5a	11	68.50
P-Value	0.631	<.001	0.554	0.220
LSD	640.5	0.20	3.5	7.122
Plant Density				
1. 33 333	1665b	5.0	8a	66.75a
2. 44 444	1416a	5.1	10b	69.08a
3. 55 555	1568ab	5.1	10b	74.25b
4. 74 000	1517ab	5.1	12c	76.25b
Grand mean	1541	5.1	10	71.58
P-Value	0.048	0.514	<.001	<.001
LSD	173.3	0.19	1.5	3.721
Variety x Density	NS	NS	NS	NS
CV (%)	13.3	4.4	18.0	6.2

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

Table 8 Dande 2018/19 season

Treatments	Yield (kg/Ha)	AB-M(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	1108a	5.30a	9	77.58a
2. CRIMS3	588b	5.21ab	9	69.42bc
3. MAY344	1061a	5.05ab	7	65.17c
4. MAY505	998a	4.69b	7	76.25a
P-Value	0.002	<.001	0.236	<.001
LSD	274.2	0.634	6.7	5.053
Plant Density				
1. 33 333	938	5.41	7	72.92
2. 44 444	948	5.20	8	74.25
3. 55 555	966	5.10	8	71.08
4. 74 000	902	4.54	9	69.67
Grand mean	939	5.06	8	72.10
P-Value	0.969	0.11	0.063	0.211
LSD	274.2	0.634	2.5	5.053
Variety x Density	NS	NS	NS	NS
CV (%)	30.5	15	11.8	8.4

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

Table 9 Tokwane 2018/19 season

Treatments	Yield (kg/Ha)	ABM(g)	ABN	PH (cm)
Varieties				
1. CRIMS1	403.2c	4.178ab	7	59.83
2. CRIMS3	725.0a	4.733a	8	60.58
3. MAY344	622.7ab	4.183ab	8	60.33
4. MAY505	459.4bc	3.693b	7	60.67
P-Value	0.002	0.024	0.982	0.449
LSD	170.4	0.646	6.7	3.861
Plant Density				
1. 33 333	451b	3.65b	6	61.83
2. 44 444	490b	4.17ab	8	59.33
3. 55 555	563cb	4.45a	8	60.83
4. 74 000	707a	4.52a	7	59.42
Grand mean	553	4.20	7	60.35
P-Value	0.024	0.041	0.408	0.499
LSD	170.4	0.646	2.9	3.861
Variety x Density	NS	NS	NS	NS
CV (%)	30	18.5	29.0	7.7

Means followed by the same letter are not significantly different at P = 0.05 and means were separated by the Fishers' LSD: **ABM-average boll mass, ABN-average boll number**

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