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Adaptability performance of cotton hybrids under dry conditions of Zimbabwe

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Abstract

Cotton (*Gossypium hirsutum* L.) is one of the most prominent and important industrial crops in Zimbabwe. Cotton production is largely practiced by smallholder farmers in Zimbabwe with an average of one hectare for every farmer. Production is mainly done in averagely drier parts of the country with considerably high temperatures and rainfall amounts averaging 500mm per annum (AMA Cotton Country Report, 2022). The adverse effects of climate change have raised concerns regarding the cotton sector's performance in the near future. However, to ascertain the significance and potential of hybrids in Zimbabwe, confirmatory tests were conducted to proffer knowledge that is critical for informed decision-making regarding the commercialization of cotton hybrids in Zimbabwe. Therefore, a two-year (2022 and 2023) multi-locational adaptability experiment to determine the performance of cotton hybrids was conducted. The experiment was carried out at seven locations following a Randomised Complete Block Design (RCBD) replicated three times. Included were seven OPVs and four hybrids. Significant differences in seed cotton yield mean performance were only realized at Svisvi P=0.002 and Kuwirirana P=0.007. An across-site and season analysis did not reveal any significant differences in yield. CRIMS1, Jaguar, and C569 recorded more bolls per plant, whilst all OPVs recorded significantly high ginning percentages over hybrids, and a similar trend was recorded on boll weight. The results hence indicate the need to support the production of locally adaptable Open Pollinated Varieties which is a response to import substitution since the hybrids are imported products.

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Introduction

Cotton (*Gossypium hirsutum*) is an important crop because of its global and valuable contribution to many economies worldwide. The crop is dominant in Zimbabwe as the second most important cash crop after tobacco. Cotton production in Zimbabwe is predominantly constituted and driven by small-scale farmers and is chiefly rainfed. Since immemorial times, the cotton sector in Zimbabwe has been dominated by open-pollinated variables (OPVs) due to their adaptability and superior performance under dryland conditions. The cotton sector in Zimbabwe recorded an average annual production of 198357.3 metric tons and an average yield of 669kgha-1 over 23 years (Fig. 1) (AMA 2022 Report) whilst the industrial crop's global production in 2020 was 121.3 million bales (USDA, 2021).

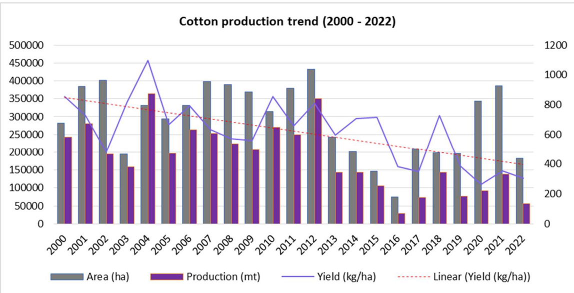

Fig. 1. Production figures (Mt) from 2000 to 2022

The Zimbabwean cotton sector has an expected role to play and contribute to the attainment of Vision 2030 through strategies for improved production and productivity. According to the COTTCO report, cotton provides livelihoods to 2 million households country-wide, also offers employment to over 3000 people and the country earns between US$30 –US$60 million foreign currency from lint exports annually. The decline in cotton production since 2012 from 350703Mt (Fig. 1) has negatively affected the performance of the cotton value chain. The deterioration in cotton production over the years was linked to many factors and among them, high cotton production costs, droughts, inadequate and late supply of inputs, low producer prices, viability issues, and climate change characterized by low rainfall leading to many farmers neglecting the crop (COTTCO, 2023). This is indicated by a five-year rainfall analysis (Fig. 2). The government of Zimbabwe intervened in 2015 through the introduction of the Presidential Input Scheme to revive the cotton sector (COTTCO, 2023). The declining trend has however been a great concern in the sector and led to some players in the sector introducing cotton hybrids in 2017 from Maharashtra Hybrid Company (MAHYCO) of India, expecting a positive change in the production and productivity trend.

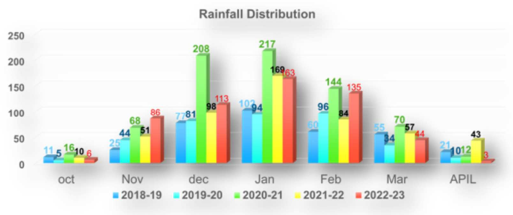

Fig. 2. Five year rainfall analysis from 2019 – 2023

Cotton hybrids were regarded as highly productive and profitable by some players who posed notions that they produced 120 bolls per plant with the potential to yield 11 tonnes of seed cotton per hectare against 30 bolls per plant for Zimbabwean Open Pollinated Varieties (OPVs), (The Herald, Zimbabwe, 11 June 2019). The performance details were based on the hybrids' performance in India and not in Zimbabwe. This means there was the need to perform confirmatory tests to proffer knowledge that is critical for informed decision-making regarding the commercialization of cotton hybrids in Zimbabwe, putting into consideration that cotton hybrids have not been traditionally grown in Zimbabwe. Therefore, the Cotton Research Institute conducted a two-year (2022 and 2023) multi-locational adaptability experiment to determine the performance of cotton hybrids under different agroecological conditions in Zimbabwe. The experiments were carried out under dryland conditions, a real prototype, and predominantly cotton-growing conditions in Zimbabwe.

Materials and methods

The experiment was conducted at different locations (Table 1, Fig. 3) over two seasons; 2021/22 and 2022/23 seasons

Table 1. Experimental locations and their details

Location	Latitude	Longitude	Altitude (m)	Av. annual rainfall (mm)	Max temp°C
Chitekete	17°25' South	28° 56' East	914	450-500	45
CRI	18°19' South	29° 53' East	1156	750-1000	38
Kuwirirana	17°54' South	29°1' East	1483	500-600	38
Matikwa	20°48' South	32°14' East	300	450-500	40
Dande	16° 16' South	31°34' East	436	450-500	42
Tokwane	20° 51' South	31° 3' East	1105	350-650	37
Wozhele	19°31' South	30°14' East	1345	650-700	37

Source: AGRITEX planning branch: Zimbabwe natural regions and farming areas boundaries

Table 2. Cotton genotypes used in the multi-locational trials

Treatment	Description
CRIMS 3	Government of Zimbabwe Open Pollinated Variety (OPV) - Check variety
CRIMS 4	Government of Zimbabwe OPV - Check variety
CRIMS 1	Government of Zimbabwe OPV - Check variety
CRIMS 2	Government of Zimbabwe OPV - Check variety
LS9219	Government of Zimbabwe OPV - Check variety
MAHYCO C567	Indian Test Hybrid
MAHYCO C569	Indian Test Hybrid
MAHYCO 571	Indian Test Hybrid
QM301	Quton OPV - Check variety
SZ 9314	Government of Zimbabwe OPV - Check variety
Jaguar	Indian Test Hybrid

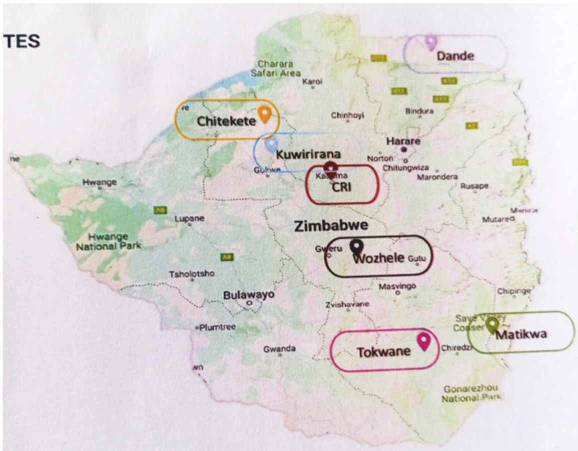

Fig. 3. Experimental locations

Experimental treatments

Experimental genotypes used in the experiment included Mahyco commercial hybrids and Zimbabwean released commercial OPVs (Table 2).

Experimental design and data analysis

Randomised Complete Block Design (RCBD) with three replications was used. Genstat 18th Edition statistical package was used to generate an Analysis of Variance and Means per site and across sites for all the measurements recorded. Statistical means (within and across trial sites) were calculated for the recorded parameters' data. Analyses of Variance (ANOVA) were generated to account for variations brought about by genotype (entry), environment (location), and interaction between genotype and environment, as appropriate, across sites and seasons.

Plot size

a. Gross plot : 4 rows × 1m × 5m=20m^2

b. Net Plot : 2rows × 1m × 4m=8m^2

c. In-row spacing : 0.3cm

d. Inter-row spacing: 1m

Measurements

Seed cotton yield (kg)

Also known as the total seed cotton yield was recorded per net plot. This was a collection of all harvested fully split bolls which included bolls samples, pick one, two, three and so on.

Gin Out-Turn (GOT %)

Also known as ginning percentage is sub-sample (approximated 1 kg) from each plot ginned (lint and seed). Ginning percentage, calculated as (100 × lint weight)/(weight of lint +seed + trash), and is used to convert seed cotton yield to lint yield (Watts *et al.*, 2014).

Boll weight (g)

Average weight of seed cotton from a single undamaged boll calculated from a 50 or 100 boll sample taken from each plot prior to second pick (large values desirable). This is calculated as the total weight of a sample divided by sample size.

Number of bolls per plant

Number of bolls per plant was recorded as a total count of all harvestable bolls from 5 randomly selected plants in the net plot. The total number of bolls from the sample area and is divided by number of plants in the sample area.

Results

Seed cotton yield

Significant differences were only at Svisvi and Kuwirirana, thus P=0.002 and P=0.007 respectively (Table 3). Svisvi recorded a grand mean performance of 862.6kg/ha whilst Kuwirirana recorded 1518.4kg/ha. Mahyco C567 recorded the highest mean at Svisvi (1455.5kg/ha), though similar to CRIMS 2 (1310kg/ha) whilst LS9219 and SZ-9314 recorded the lowest mean performance of 495kg/ha and 556.9kg/ha respectively. At Kuwirirana, Mahyco C569, CRIMS 1, and Jaguar recorded the highest means of 1719.2kg/ha, 1748.8kg/ha, and 1717.5kg/ha respectively (Table 3). Though no significant differences were recorded for Chitekete and Dande recorded the highest grand means of 2878.9kg/ha and 2283.8kg/ha respectively (Table 3). An across-site analysis (2021/22 season) revealed significant differences (P=0.040) (Table 7), with a grand mean record of 1483.65kg/ha. Mahyco C567 recorded the highest yield mean of 1651.23kg/ha, which was also statistically similar to Mahyco C569 (1588.23kg/ha), CRIMS 2 (1531.42kg/ha), Jaguar (1518.76kg/ha), CRIMS 1 (1515.60kg/ha) and CRIMS 3 (1476.47kg/ha). A combined analysis (2022 & 2023) did not record significant differences (Table 8).

Table 3. Performance of Mahyco hybrids for total seed cotton yield (kg/ha)

Treatment name	Seed cotton yield (kg/ha)							
	Chitekete	CRI	Chitekete	CRI	Chitekete	CRI	Chitekete	CRI
CRIMS 3	3080.3	446.7	21.00	5.50^{bc}	21.00	5.50^{bc}	21.00	5.50^{bc}
CRIMS 4	2614.1	282.4	17.75	4.00^{ab}	17.75	4.00^{ab}	17.75	4.00^{ab}
CRIMS 1	3228.8	337.3	16.00	4.00^{ab}	16.00	4.00^{ab}	16.00	4.00^{ab}
CRIMS 2	2775.3	543.9	18.75	4.75^{ab}	18.75	4.75^{ab}	18.75	4.75^{ab}
Jaguar	3222.2	688.8	22.75	7.00^{c}	22.75	7.00^{c}	22.75	7.00^{c}
LS9219	2990.3	307.0	17.00	3.25^{a}	17.00	3.25^{a}	17.00	3.25^{a}
C567	2825.3	359.5	21.00	4.75^{ab}	21.00	4.75^{ab}	21.00	4.75^{ab}
C569	2616.9	516.2	20.25	7.50^{c}	20.25	7.50^{c}	20.25	7.50^{c}
QM301	2519.7	217.7	18.75	3.25^{a}	18.75	3.25^{a}	18.75	3.25^{a}
SZ 9314	2916.2	268.1	18.75	4.75^{ab}	18.75	4.75^{ab}	18.75	4.75^{ab}
Grand Mean	2878.9	403.4	19.20	4.88	19.20	4.88	19.20	4.88
P. Value	0.549	0.500	0.429	0.005	0.429	0.005	0.429	0.005
LSD 5%	779.55	8.701	5.818	2.214	5.818	2.214	5.818	2.214
SED	379.93	4.233	2.835	1.079	2.835	1.079	2.835	1.079
CV%	18.7	31.1	20.9	31.3	20.9	31.3	20.9	31.3

Table 4. Performance of Mahyco hybrids for boll number per plant

Treatment name	Boll number per plant							
	Chitekete	CRI	Dande	Matikwa	Tokwane	Wozhele	Svisvi	Kuwirirana
CRIMS 3	21.00	5.50^{bc}	985.0	649.0	309.1	684.4	275^{ab}	603.3^{abc}
CRIMS 4	17.75	4.00^{ab}	837.5	665.8	369.1	652.8	352.9^{abc}	597.3^{abc}
CRIMS 1	16.00	4.00^{ab}	865.0	860.3	310.0	542.1	289.4^{ab}	767.7^{d}
CRIMS 2	18.75	4.75^{ab}	956.3	653.6	308.1	673.9	530.8^{cd}	676.4^{cd}
Jaguar	22.75	7.00^{c}	577.3	479.5	197.5	611.6	254.7^{ab}	546.9^{ab}
LS9219	17.00	3.25^{a}	886.1	659.2	301.1	612.5	198.1^{a}	606.3^{abc}
C567	21.00	4.75^{ab}	984.8	686.5	307.4	702.1	539.3^{d}	632.8^{abc}
C569	20.25	7.50^{c}	926.2	707.1	302.2	580.6	338.3^{ab}	673.6^{bcd}
QM301	18.75	3.25^{a}	868.8	672.8	369.1	746.0	398.8^{bcd}	524.9^{a}
SZ 9314	18.75	4.75^{ab}	839.7	596.6	299.6	720.0	229.6^{ab}	542.9^{a}
Grand mean	19.20	4.88	872.7	663.0	307.3	652.6	340.7	617.2
P. Value	0.429	0.005	0.104	0.438	0.206	0.876	0.005	0.017
LSD 5%	5.818	2.214	251.01	268.55	112.00	272.04	183.29	127.44
SED	2.835	1.079	122.33	130.88	54.59	132.58	89.33	62.11
CV%	20.9	31.3	19.8	27.9	25.1	28.7	37.1	14.2

Number of bolls per plant

Significant differences were recorded at CRI, Dande, Kuwirirana, and Wozhele (Table 4). Dande recorded the highest number of bolls per plant (32.3) followed by Chitekete which recorded 19.20 bolls. CRI recorded the least number of bolls (4.88 bolls). At Dande, CRIMS 1 and Mahyco C569 recorded the highest number of bolls (50 and 46 bolls respectively) whilst QM301 recorded the least number of bolls (15.5 bolls). Based on results obtained across sites during the 2021/22 season, a grand mean of 16.56 bolls was recorded upon a realized statistically different genotypic mean performance (P<0.001). Jaguar recorded many bolls per plant (20.38 bolls), followed by Mahyco C569 and CRIMS 1 which recorded 18.56 and 18.44 bolls respectively. QM301 recorded the least number of bolls (12.75 bolls).

Table 5. Performance of Mahyco hybrids for Gin out turn (%)

Treatment name	Gin out turn (%)							
	Svisvi	Chitekete	CRI	Dande	Matikwa	Tokwane	Wozhele	Kuwirirana
CRIMS 3	41.2^{cde}	44.5^{de}	44.4	40.1^{de}	43.6^{ef}	41.7^{d}	44.1^{cd}	43.8^{efg}
CRIMS 4	42.5^{de}	45.0^{ef}	46.4	40.8^{de}	43.2^{def}	41.2^{cd}	43.8^{cd}	42.5^{de}
CRIMS 1	41.7^{cde}	45.3^{ef}	31.0	40.4^{de}	43.7^{ef}	40.6^{bcd}	43.7^{cd}	44.0^{fg}
CRIMS 2	40.3^{cd}	44.6^{de}	45.5	41.0^{e}	42.4^{de}	42.1^{d}	45.8^{d}	43.2^{def}
Jaguar	32.0^{a}	33.8^{a}	35.6	29.5^{a}	31.8^{a}	29.9^{a}	36.6^{a}	31.9^{a}
LS9219	40.0^{c}	42.1^{cd}	41.7	38.2^{c}	41.2^{cd}	38.2^{bc}	40.8^{abc}	41.0^{c}
C567	37.1^{b}	41.1^{c}	40.9	36.0^{b}	39.6^{c}	37.8^{b}	42.5^{bcd}	38.7^{b}
C569	36.9^{b}	37.6^{b}	39.3	35.5^{b}	36.5^{b}	37.7^{b}	38.3^{ab}	37.6^{b}
QM301	43.0^{e}	47.3^{f}	37.2	40.5^{de}	46.1^{g}	42.5^{d}	44.9^{cd}	44.7^{g}
SZ 9314	41.4^{cde}	43.8^{de}	42.1	39.8^{d}	45.2^{fg}	43.3^{d}	44.2^{cd}	42.5^{de}
Grand Mean	39.7	42.5	40.4	38.2	41.3	39.5	42.5	41.0
P. Value	<0.001	<.001	0.181	<.001	<.001	<.001	0.005	<.001
LSD 5%	2.28	2.55	11.13	1.04	2.30	3.01	4.58	1.33
SED	1.11	1.24	5.41	0.51	1.12	1.47	2.23	0.65
CV%	4.0	4.1	18.9	1.9	3.8	5.3	7.4	2.2

Table 6. Performance of Mahyco hybrids for Boll weight (g)

Treatment name	Boll weight (g)							
	Chitekete	CRI	Dande	Kuwirirana	Tokwane	Wozhele	Svisvi	Matikwa
CRIMS 3	6.2^{de}	6.0	5.9^{bc}	6.1^{bc}	5.1^{b}	5.7^{bc}	6.0^{bc}	5.3^{bc}
CRIMS 4	5.7^{bcd}	4.8	5.9^{bc}	6.6^{d}	5.8^{bc}	5.6^{bc}	6.1^{bc}	5.7^{c}
CRIMS 1	6.4^{e}	5.3	5.7^{bc}	6.4^{cd}	5.7^{bc}	5.6^{bc}	6.1^{bc}	5.6^{c}
CRIMS 2	5.7^{bc}	5.7	5.6^{b}	5.9^{b}	6.0^{c}	5.4^{abc}	6.1^{bc}	5.3^{bc}
Jaguar	4.1^{a}	4.8	4.2^{a}	4.5^{a}	4.3^{a}	4.5^{a}	4.8^{a}	3.6^{a}
LS9219	6.3^{e}	5.1	6.0^{bc}	6.4^{cd}	5.2^{b}	5.7^{bc}	5.7^{b}	5.7^{c}
C567	5.3^{bc}	5.2	5.6^{b}	5.8^{b}	5.2^{b}	6.2^{c}	6.2^{bc}	4.9^{b}
C569	5.3^{b}	5.7	5.8^{bc}	5.9^{b}	5.4^{bc}	5.1^{ab}	5.7^{bc}	5.3^{bc}
QM301	5.8^{cd}	4.8	6.1^{c}	6.4^{cd}	5.7^{bc}	6.0^{c}	6.6^{c}	5.6^{c}
SZ 9314	6.2^{de}	5.7	5.8^{bc}	6.5^{d}	5.5^{bc}	5.8^{bc}	6.3^{bc}	5.3^{bc}
Grand Mean	5.7	5.3	5.7	6.0	5.4	5.6	6.0^{bc}	5.2
P. Value	<.001	0.844	<.001	<.001	0.005	0.040	0.027	<.001
LSD 5%	0.52	1.82	0.46	0.32	0.75	0.89	0.90	0.57
SED	0.25	0.88	0.23	0.16	0.37	0.43	0.44	0.28
CV%	6.2	23.5	5.7	3.7	9.6	11.0	10.5	7.5

Gin out turn

The ginning percentage revealed significant differences for all locations except CRI (Table 5). Chitekete and Wozhele recorded the highest grand mean performance of 42.5% whilst Dande recorded the least performance of 38.2%. High means were recorded at Svisvi for QM301 (43%), CRIMS 4 (42.5%), CRIMS 1 (41.7%) and SZ-9314 (41.4%). Jaguar recorded the lowest mean performance of 32%, as well as Mahyco C567 and Mahyco C569 (37.1% and 36.9% respectively). At Chitekete, QM301 recorded the highest ginning percentage of 47.3%, whilst SZ-9314, CRIMS 1, CRIMS 2, CRIMS 3 and CRIMS 4 recorded ginning percentages between 43.8% and 45.3% whilst Jaguar and Mahyco C569 recorded the least percentage of 33.8% and 37.6% respectively.

Dande showed the same trend whereby Jaguar recorded the lowest percentage of 29.5%, whilst Mahyco C567 and C569 recorded 35 and 36% against the performance of between 38.2% and 41%.

An across-site analysis (2021/22 season) revealed significant differences (P<0.001) (Table 7), CRIMS 4 and CRIMS 2 recorded the highest percentage of 43.18% and 43.11% respectively though similar to CRIMS1, SZ9314, QM301, and CRIMS 3. Mahyco hybrids recorded the least with Jaguar recording 32.66%, C569 recording 37.44% and C567 recording 39.20%.

Table 7. Key performance data on total seed cotton yield and related components of Mahyco hybrids evaluated at eight sites during the 2022/23 season

Entry	Seed cotton yield (kg/ha)	Average boll number per plant	Average boll weight (g)	Gin out turn %
	Av.	Av.	Av.	Av
CRIMS 1	1515.60^{abc}	18.44^{de}	5.86^{cd}	42.58^{e}
CRIMS 2	1531.42^{abc}	16.56 ^{cd}	5.58^{bcd}	43.11^{e}
CRIMS 3	1476.47^{abc}	16.25^{c}	5.87^{cd}	42.93^{e}
CRIMS 4	1388.74^{a}	15.41^{bc}	5.84^{bcd}	43.18^{e}
Jaguar	1518.76^{abc}	20.38^{e}	4.44^{a}	32.66^{a}
LS9219	1436.93^{ab}	13.97^{ab}	5.77^{bcd}	40.41^{d}
MAHYCO C567	1651.23^{c}	16.12^{c}	5.54^{bc}	39.20^{c}
MAHYCO C569	1588.23^{bc}	18.56^{de}	5.51^{b}	37.44^{b}
QM301	1377.95^{a}	12.75^{a}	5.76^{bcd}	43.44^{e}
SZ 9314	1351.21^{a}	17.16^{cd}	5.90^{d}	42.79^{e}
Grand Mean	1483.65	16.56	5.61	40.77
CV (%)	26.0	25.0	11.5	5.5
LSD (5%)	189.632	2.037	0.318	1.113
Genotype (G)	0.040	<.001	<.001	<.001
Environment (E)	<.001	<.001	<.001	<.001
GXE	0.365	<.001	0.139	0.022

Table 8. Key performance data on total seed cotton yield and related components of Mahyco hybrids at five sites over two seasons (2021/22 and 2022/23 seasons)

Entry	Seed cotton yield (kg/ha) Av.	Plant height (cm) Av.	Gin out turn % Av.	Boll weight (g) Av.
CRIMS 1	1980.44	107.19^{b}	43.04^{ef}	6.01^{d}
CRIMS 2	1950.81	107.46^{bc}	43.51^{ef}	5.82^{bcd}
CRIMS 3	2024.93	113.49^{c}	43.26^{ef}	6.00^{d}
CRIMS 4	1854.68	109.39^{bc}	43.37^{ef}	5.78^{bcd}
Jaguar	1880.40	125.39^{d}	32.38^{a}	4.39^{a}
LS9219	1823.40	113.02^{bc}	40.47^{d}	6.04^{d}
MAHYCO C567	2046.01	112.19^{bc}	39.01^{c}	5.52^{b}
MAHYCO C569	1936.35	100.27^{a}	37.56^{b}	5.68^{bc}
MAHYCO C571	1932.79	109.67^{bc}	41.34^{d}	5.76^{bcd}
QM301	1708.89	107.22^{b}	43.75^{f}	5.85^{cd}
SZ 9314	1912.26	113.09^{bc}	42.66^{e}	6.08^{d}
Grand Mean	1914.38	110.09	41.35	5.78
CV (%)	29.4	11.0	4.2	10.4
LSD (5%)	359.205	7.750	1.115	0.385
Genotype (G)	0.482	<.001	<.001	<.001
Environment (E)	<.001	<.001	<.001	<.001
GXE	0.740	0.568	0.082	0.770

A season and site combined analysis revealed significant differences (P<0.001) and recorded a grand mean of 41.35%. High ginning percentages were recorded for QM301, CRIMS 1, CRIMS 2, CRIMS 3, CRIMS 4, and SZ9314 which recorded 43.75%, 43.04%, 43.51%, 43.26%, 43.36%, and 42.66% respectively. Jaguar, C567, and C569 recorded the lowest performance; 32.38%, 39.01%, and 37.56% respectively (Table 8). The results are in disagreement with a study which was conducted to improve upland cotton production through a comparative evaluation of hybrid generation and the results indicated that lint yield for hybrids was 24.8% higher in F1 and 11.6% in F2 than that of the control Ruiza816. The performance of SJ48 × Z98 was excellent in Alar which showed 36.5% higher LY in F1 and 10.9% in F2 than control Zhongmiansuo 49. The superiority in terms of ginning percentage for OPVs over hybrids could be attributed to genetics.

Boll weight

The effect of genotypic mean performance on boll weight was significantly different at all sites except for CRI only. Kuwirirana and Svisvi recorded the highest means both of 6.0g, whilst smaller bolls weighed 5.2g at Matikwa (Table 6). At Chitekete (p<0.001), CRIMS 1 recorded the largest bolls which weighed 6.4g, similar to LS9219 (6.3g), CRIMS3 and SZ-9314 (both 6.2g) whilst Jaguar recorded the smallest bolls (4.1g). This was the same trend for Dande, where Jaguar recorded the smallest bolls (4.2g), against QM301, LS9219, SZ9314, CRIMS 1, CRIMS 2, CRIMS 3, and CRIMS 4 which recorded more than 5.6g. Generally, the same trend followed other sites like Kuwirirana, Tokwane, Wozhele, Svisvi, and Matikwa. Analysis of variance across sites (2021/22 season) revealed significant differences (P<0.001) for boll weight (Table 7). A grand mean of 5.61g was recorded, whilst SZ9314 recorded the largest bolls (5.9g) but similarly to CRIMS 1, CRIMS 2, CRIMS 3, CRIMS 4, LS9219 and QM301. Jaguar recorded the smallest bolls (4.44g). A two-season combined analysis revealed statistical differences (P<0.001) and a grand mean of 5.78g (Table 8). Sz9314, LS9219, CRIMS 1, and CRIMS 3 recorded boll sizes above 6g, though similar to CRIMS 2, CRIMS 4 and QM301. Jaguar recorded the smallest boll size of 4.39g.

Discussion

Few studies have been performed to evaluate the differential performance between cotton hybrids and Open Pollinated cotton varieties under dry conditions however several studies were conducted but focusing mainly on irrigated conditions. The research findings from a study that was done by Gurmessa *et al.*, 2022 indicated that three introduced hybrid cotton varieties gave higher seed cotton yields than the two local check varieties at all locations.

Accordingly, the cotton hybrids showed seed cotton yield advantage of 35.59% (YD-211), 35.54% (YD-206), and 29.43% (YD-223) over the best-performed local check variety (Deltapine 90). However, the study by Gurmessa *et al.*, 2022 was conducted under irrigated conditions, unlike this current study which was conducted under dryland conditions which is a prototype of the cotton production landscape in Zimbabwe.

A study by Chen *et al.*, 2022, on the comparative performance of hybrid generations reviewed the potential application of F1 hybrids in upland cotton. The results showed that variance analysis had significant differences for agronomic, yield, and fiber quality in both generations and environments. Interestingly, hybrid L28×Z98 performed outstandingly in Anyang. Its lint yield was 24.8% higher in F1 and 11.6% in F2 than that of the control Ruiza816. The performance of SJ48 × Z98 was excellent in Alar which showed 36.5% higher LY in F1 and 10.9% in F2 than control Zhongmiansuo 49. These findings are however contrary to what was obtained from the study which was carried out in Zimbabwe under dry conditions. This is a general thumb of confirmation that cotton hybrids are more resource utilizers when compared to OPVs, hence given the climate change effects, OPVs have shown resilience and adaptability.

Another study by Amanu *et al.*, 2021, was again performed under irrigated conditions in Ethiopia to evaluate the performance of introduced hybrid cotton under irrigated conditions and the results showed that some medium staple length hybrid kinds of cotton namely, VBCH 1533, VBCH 1537and Hero VBCH 1511 tested at Werer Agricultural Research Center (WARC), Amibara (sheleko), Melkasedi, Gawane, Sille, and Woyto surpassed for seed cotton yield of yielding 51.22, 50.05 and 49.97 q/ha, respectively. The lowest seed cotton yield was scored at Amibara for the check variety DP-90 (7.55 q/ha). Almost all test candidate genotypes surpassed the check varieties for seed cotton yield at each location. These results are conflicting with those from the study in Zimbabwe which was carried out under dry conditions. Gudeta *et al.*, 2023 carried out an experiment involving Bt Hybrids where the author realized that Hybrids JKCH 1947 and JKCH 1050 were the top high yielders under high and mild bollworm infestations, with mean seed cotton yield of 3.10t.ha-1 each and lint yield of 1.20 and 1.19t.ha-1 respectively, whereas the standard check Deltapine-90 (OPV) recorded a mean seed cotton and lint yield of 2.3t.ha-1 and 0.8t.ha-1, respectively.

Shavkiev *et al.*, 2021 discovered in an experiment under irrigated and non-irrigated conditions, that deficit irrigation conditions negatively affected the yield-contributing traits and eventually the seed cotton yield. The parental cultivars Ishonch and Navbakhor- and their F1 diallel hybrids were found to be more stable and performed better than the other genotypes under both water regimes. On average, the genotypic and phenotypic variances for various traits were greater under water deficit conditions than under the optimal irrigation regime.

Shahzad *et al.*, 2020 carried out a study to explore how hybridization produces superior yield in upland cotton is critical for efficient breeding programs. The results were in contrasting trend with the current study and showed that a high hybrid produced a mean of 14% more seed cotton yield than its better parent. The comparative performance of hybrid generations reveals the potential application of F2 hybrids in upland cotton (Chen, 2022).

Bourgou *et al.*, 2023 in a study conducted the results showed that hybrids were superior to their OPV parents on yield and other fiber properties. Zhang, 2021 experimented and the results were contrary to the current study as eleven crosses recorded a magnitude of heterosis for seed cotton yield/plant of above 40 percent. The highest economic heterosis for seed cotton yield was observed by the cross H 1489 x C 210 (64.02%), which also exhibited the highest per se performance for important characters; bolls/plant and boll weight. It was followed by H 1472 × C 211 (63.74%), H 1522 × C 211 (57.62%), H 1488 × C 211 (52.60%) and H 1522 × C 201(47.87%). The cross H 1472 × C 211 (63.74%), H 1489 × C 210 (9.30%), and H 1098i × C 201 (19.72%) registered the highest significant heterosis for boll weight, bolls/plant, and ginning out turn respectively. These obtained results from various studies under irrigated provide a true reflection of the gaps in testing both hybrids and OPVs under dryland conditions. The study results have provided a conclusion that cotton hybrids and OPVs perform similarly for yield under dry conditions whilst pertaining parameters predominantly controlled by genetics like GOT%, OPVs bred in Zimbabwe showed superiority over hybrids.

Conclusion

The study revealed no significant variation between hybrids and Open Pollinated Varieties (OPV) in seed cotton yield after an across season analysis. For attributes like Gin-out-turn and Boll weight, significant variations after across site analysis were observed, and Open Pollinated Varieties showed superiority over the hybrids. Generally on Boll weight, OPVs recorded high means which were above 5.8g compared to some hybrids which recorded less than 5g, whilst on on Gin-out-turn all OPVs recorded at least 40% whilst some hybrids recorded as low as 33%. The results indicated more weight in favour of OPVs than the hybrids. Based on the current study results, the author recommends that more experiments should be done for hybrids under dry conditions upon realization that climate change effects have continuously negatively affected cotton production and productivity. There is also need to develop more drought stress tolerant cotton hybrids since the cotton production landscape in Zimbabwe and other developing countries is dominated by smallholder and resource-constrained farmers. This will lead to improved cotton production and productivity in Zimbabwe.

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