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Original Research Article

Performance Evaluation of Cotton (*Gossypium hirsutum* L.) Varieties for Yield and Related Traits in North-Western Ethiopia

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Abstract: Cotton is one of the most important cash crops in Ethiopia and plays a significant role in the agricultural and textile industrial development of the country's economy. However, the progress in cotton production and productivity in rain-fed environments has been impeded by the absence of improved varieties and inadequate management practices. Presently, there are no recommended cotton varieties specifically tailored for rain-fed environments in northwestern Ethiopia, an area that is largely conducive to cotton cultivation. Interestingly, some investors have chosen to cultivate genotypes that have been recommended for irrigation purposes, particularly within the central Rift Valley of Ethiopia. In the current investigation, an assessment was conducted on various cotton varieties in order to determine their quantitative traits during the primary cultivation period of 2017 and 2018 at Pawe Agricultural Research Centre. The objective of the experiment was to assess seven cotton genotypes using a randomized complete block design, with the aim of identifying genotypes that are highly adaptable and possess high-yielding characteristics. The statistical analysis of variance demonstrated a significant distinction among the traits that were examined. Within this study, the most productive genotypes were identified as Werer-05 and Candia, with yields of 1722.19 kg/ha and 1617.41 kg/ha, respectively. The observed variations in the characteristics of the various cotton varieties indicate the presence of diversity, which holds significant implications for future cotton breeding.

Keywords: Cotton varieties, Quantitative trait.

1. INTRODUCTION

Cotton (*Gossypium spp. Malvaceae family*) is known as the king of fiber crops and one of the most important commercial and industrial crops in the world (Noreen *et al.*, 2020). Cotton is cultivated in Ethiopia under both irrigated and rain-fed conditions, on both large and small scales (EIA, 2012). It holds significant importance in the textile industry and contributes significantly to the national economy, generating numerous direct and indirect employment opportunities for the continuously expanding population in both the agricultural and industrial domains of cotton production and processing (Addis & Wang, 2021). However, the utilization of arable and potential land for cotton production remains limited, resulting in an insufficient cotton output for the nation (ETIDI, 2020). Cultivation of these crops is undertaken by both small-scale farmers and private enterprises, as indicated in the ETIDI report (2021). In accordance with the National Cotton Development Strategy (NCDS), there is a projected rise in the yield of seed cotton from 15 q/ha to 20 q/ha in rain-fed regions, while an increase from 25 q/ha to 35 q/ha is anticipated in irrigated cotton production systems. Smallholder agriculture, which represents more than 85% of total employment, revenues from foreign exchange, and more than 55% of the gross domestic product (GDP) of the nation, serves as the predominant sector in Ethiopia. Currently, the Ethiopian government is engaged in the establishment of industrial parks that provide the necessary services and infrastructure for businesses with the aim of expediting economic transformation and attracting both local and foreign capital (NCDS 2017). There are biotic and abiotic factors for cotton production and productivity: Limited germplasm resources, lack of cultivars with traits that are both high yielder and excellent quality, Shortage of varieties for rain-fed cotton growing areas; lack of varieties resistant to biotic (diseases and pests) and abiotic (salinity, drought, and temperature) stress; lack of cotton varieties suitable for mechanical harvesting; lack of plant biotechnology research to support conventional

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cotton breeding Kedir *et al*., (2019). Ethiopia initiated the experimentation of Bt cotton following the reception of authorization for confined field trials from the regulatory body in the nation. The objective was to address the limitations posed by bollworms in cotton cultivation. Consequently, two genetically modified cotton hybrids were suggested for widespread commercial production Gudeta & Egziabher, (2019).

In the study area, the production of cotton is not supported by a suitable variety, whereas the Metekel zone is recognized as one of the most productive areas for cotton cultivation in the Benshangul Gumuz region of Ethiopia. This area has a high potential for low-land crops with high rainfall and humidity. So the present study is to have a well-adapted and high-yielding cotton variety for Metekel and similar agroecologies of the northwestern part of Ethiopia. This particular region exhibits favorable conditions for the growth of low-land crops due to its abundant rainfall and high levels of humidity. Therefore, the objective of the present study is to develop a cotton variety that is well-adapted and high-yielding specifically for the Metekel zone and other similar agro-ecologies found in the northwestern part of Ethiopia

2. Cotton Production and its Status in Ethiopia

In Ethiopia, a total of three million hectares of land are deemed appropriate for the cultivation of cotton. Out of this total, 1.9 million hectares, accounting for 66%, are located in regions known for their high potential in cotton production. The remaining one million hectares, representing 34%, are situated in areas with medium potential for cotton cultivation. Cotton cultivation is widespread throughout various regions of Ethiopia, namely Amhara accounting for 22%, SNNPR with 20%, Oromia encompassing 13%, Gambella representing 10%, Benshangul at 10%, Tigray at 9%, Somali at 8%, and Afar constituting 7% of the total cotton production (Balcha *et al*., 2022; EIAR, 2017). The potential for cotton cultivation in Ethiopia has been identified in river basins such as Omo-Gibe, Wabi-Shebele, Awash, Baro-Akobo, Blue Nile, and Tekeze (Balcha *et al.*, 2022; EIAR, 2017). With variations in land area, environmental adaptability, and proximity to the textile and ginning industries, each regional state within the country possesses a significant capacity for the cultivation of cotton they are therefore grown by both smallholder farmers and private commercial farms (ETIDI, 2021). Currently, the Ethiopian government has established industrial parks that provide the necessary amenities and infrastructure for businesses with the aim of expediting economic transformation and attracting both domestic and foreign investments (NCDS 2017).

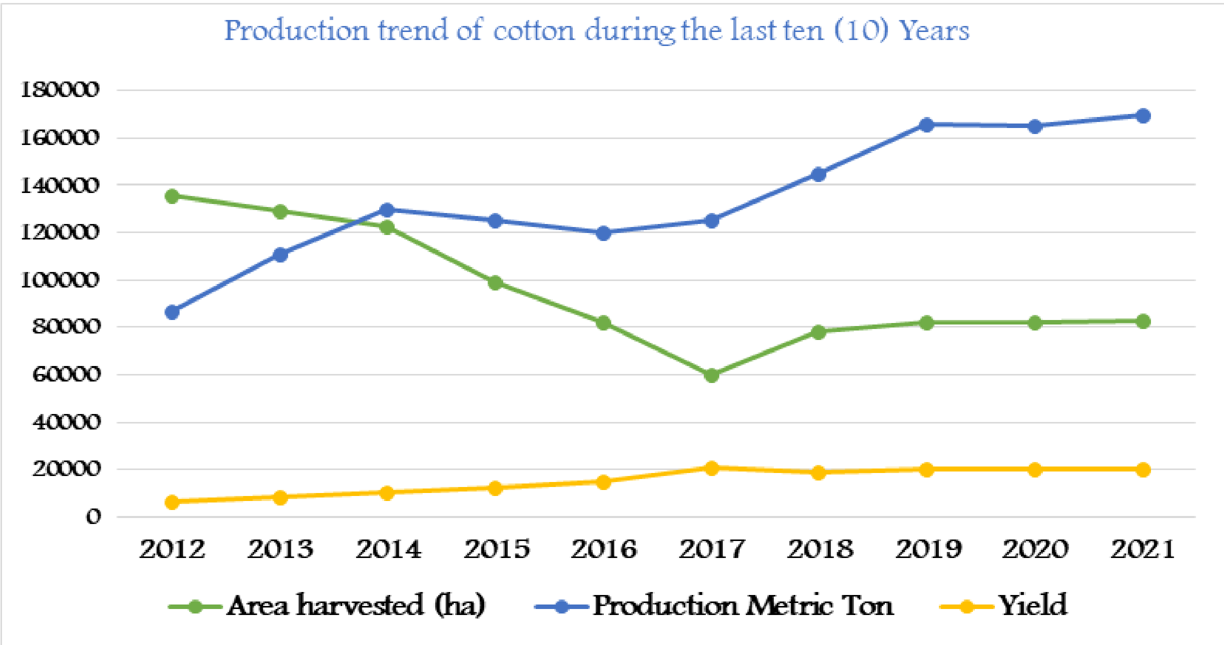

Fig 1: Production trend of cotton during the last ten (10) Years
Source FAOSTAT (2023).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted at Pawe Agricultural Research Center (PARC) in the Benshangul Gumuz Regional State in the northwestern region of Ethiopia during the primary cropping season, which involved rain-fed conditions, for two consecutive years, specifically in 2017 and 2018. Pawe is situated in the western part of Ethiopia within the Benishangul-Gumuz region, approximately 550 km away from Addis Ababa. Its precise geographical coordinates are 11º 18‟49.6” N latitude and 036º 24‟29.1‟ E longitude. Seven varieties that had been previously released were assessed for their adaptability and traits related to yield at the Pawe Agricultural Research Center (PARC). To categorize the different genotypes, a randomized complete block design (RCBD) consisting of three replications was employed. Each plot encompassed five 5m lengths, with a row spacing of 90 cm and a within-row spacing of 20 cm.

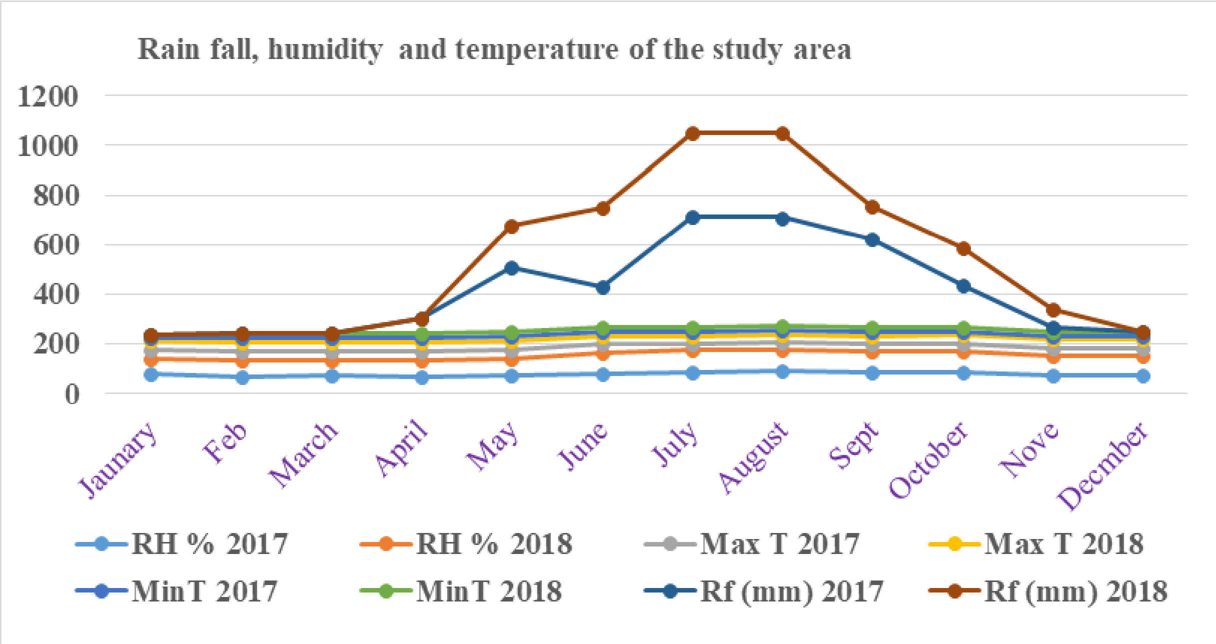

Fig 2: Rainfall, humidity, and temperature of the study area

3.2. Experimental Materials and Design

Seven recently released cultivars were assessed for their suitability and characteristics related to yield at the Pawe Agricultural Research Center (PARC). The genotypes were grouped using a randomized complete block design (RCBD) with three replications. Each plot consisted of five segments, each measuring 5 meters in length, with a spacing of 90 cm between rows and 20 cm within rows, respectively.

Table 1: Cotton varieties tested in the experiment

NO	Genotype name	Year of release	Seed yield kg/ha	Recommended for
1	Werer-05	2015	2860	Irrigated
2	Weyto	2015	3853	Irrigated
3	Delta pine 90	1985	3860	Irrigated
4	Candia	2014	4060	Irrigated
5	Sisikuk-02	2015	3742	Irrigated
6	STG14	2014	3880	Irrigated
7	Stam59A	2007	3340	Irrigated

Source: MORAD, (2021).

3.3. Data collection and statistical analysis

Phonological and agro-morphological data such as; days to 50% flowering, days to 65% boll opening, plant height, number of branches per plant, boll number per plant, boll weight, and seed cotton yield. The data collected were statistically analyzed according to Steel and Torrie (1984) by using SAS software for analysis of variance (ANOVA). Means for each trait were further separated and compared by using (LSD) test at a 5% level of probability.

4. RESULT AND DISCUSSION

The analysis of variance was found highly significant for all the characters indicating the considerable level of genetic variability among the genotypes observed for the characters under study Table 3. There were highly significant (P<0.01) differences among genotypes for days to 50% flowering, days to 65% boll opening, plant height, number of branches per plant, and number of bolls per plant, for seed cotton yield. In cotton production, boll number per plant, and cotton yield are the most important parameters as explained by Méndez Natera *et al.*, (2012). Similar findings were also reported by Kedir *et al.*, 2019, and

Premalatha *et al.*, (2020). Days to initial squiring range from 57-61 days while days to initial flowering range from 73-75 days. Similar findings were also reported by Ali Imtiaz *et al.*, (2017). As days to 50% flowering ranged from 90 to 96 the indication was that these genotypes are in the same maturity class. While days to 65% boll opening ranged from 145 to 154 days. This finding was in accordance with the findings of Fentahun *et al.*, 2019. Sisikuk-02 was the early boll opener at 145 days whereas stam59A and Candia are the latest at 154 days after emergence (Table 3). So, delay in flowering is a sign of late maturity which may be acceptable in non-moisture stress areas. Plant height ranged from 1.19 cm to 1.54 cm with a mean value of 1.33 indicating that there was variability between the tested varieties. Similar findings were also reported by Damtew, *et al.*, (2022). Seed cotton yield (SY) ranged from 1722.19 to 1196.4kg/ha with a mean value of 1449.12kg/ha. The top yielders, as shown in Table 3, are Werer-05 and Candia, respectively.

Table 2: Analysis of variance for studied traits of cotton varieties

No	Traits	Mean squares				Error mean square
		Year	Rep (Year)	Year*Trt	Trt	
1	Days to initial squaring	342.86^{**}	15.05	11.58^{ns}	10.66^{ns}	5.80
2	Days to initial flowering	46.10^{*}	7.24	12.87^{ns}	4.65^{ns}	5.57
3	Days to flowering	1070.10^{**}	4.10	24.54^{ns}	24.60^{ns}	5.93
4	Initial ball opening	10529.17^{**}	28.17	44.44^{ns}	95.21^{ns}	20.53
5	Days to 65% ball opening	14522.88^{**}	36.31	2.05^{**}	190.30^{ns}	12.37
6	Number of branches per plant	5.19^{*}	0.49	2.11^{*}	4.68^{**}	0.40
7	Plant height	1.10^{**}	0.04	0.00^{ns}	0.25^{**}	0.02
8	Number of balls per plant	2.61^{ns}	0.45	4.39^{*}	4.57^{*}	0.80
9	Cotton seed Yield kg/ha	16117989.94^{**}	20877.85	380466.49^{**}	215411.80^{**}	7402.78

The studied traits days to initial squiring, days to 50% flowering, initial ball opening days to 65% ball opening, plant height, number of balls per plant, and cotton Yield showed a highly significant difference; days to initial flowering and number of branch per plant showed a significant difference for year effect but the number of balls per plant showed non- significant for year effect (Table 2). This showed that, except the number of balls per plant most of the traits were highly influenced by the year effect. On the other hand, the treatment and treatment x year interaction was highly significant for Cotton seed yield and days to 65% ball opening showed. A similar finding was also reported by Damtew et al., (2022), Jalilian, et al., (2023).

Table 3: Performances of cotton varieties tested

Genotypes	DIS	DIF	DF	IBO	DBO	NBPP	PHT(cm)	NBOPP	Yield kg/ha
Werer-05	57.33	75.33	93.17	153.17	170.17^{a-c}	8.56^{bc}	1.29^{bc}	13.87^{ab}	1722.19^{a}
Weyto	61	74.5	92.17	149.67	166.83^{c}	8^{c}	1.19^{cd}	12.25^{c}	1431.91^{c}
Delta pine 90	59.5	73.5	91.17	152.83	169.67^{bc}	8.44^{bc}	1.21^{b-d}	13.52^{b}	1482.84^{c}
Candia	57.67	75.67	94.5	154.83	174.33^{a}	8.45^{bc}	1.66^{a}	12.26^{c}	1617.41^{b}
Sisikuk-02	59.17	73.5	90.33	145	158^{d}	9.16^{b}	1.08^{d}	13.8^{ab}	1460.99^{c}
STG14	60.33	74.5	96.33	157	174^{a}	10.64^{a}	1.35^{b}	14.62^{a}	1196.48^{d}
Stam59A	58.67	73.67	92.67	154.67	172.17^{ab}	8.33^{c}	1.54^{a}	13.17^{bc}	1232.04^{d}
Mean	**59.1**	**74.38**	**92.90**	**152.45**	**169.31**	**8.80**	**1.33**	**13.35**	**1449.12**
CV%	**4.07**	**3.17**	**2.62**	**2.97**	**2.08**	**7.21**	**9.58**	**6.7**	**5.94**
P- value	**NS**	**NS**	**NS**	**NS**	**	**	**	**	**

*, ** Indicate significance at the 0.05 and 0.01 levels, respectively; Ns=non-significant;

DIS= days to initial squiring, DIF=days to initial flowering, DF=days to 50% flowering IBO=initial ball opining, DBO = days to 65% ball opining, NBPP=number of branch per plant, PHT=plant height, NBOPP=number of ball per plant, Ykg/ha=cotton Yield kg/ha

5. CONCLUSION AND RECOMMENDATIONS

Ethiopia has a diverse agro-ecology suitable for cotton production in both irrigated and rain-fed conditions. Cotton production and productivity could not be achieved solely under irrigation environments; it needs to be expanded to rain-fed environments. This could be achieved through the development of varieties for rain-fed conditions. In this study, testing of cotton genotypes in this area has revealed that promising cotton genotypes are climatically suitable and adaptable. The analysis of variance in this study revealed substantial variations in all Phonological and agronomic characteristics for the experimental cultivars examined. This indicated the existence of Heterogeneity among the studied genotypes and provided a possibility to enhance seed cotton production and other desirable characteristics through adaptation testing and selection. Based on cotton seed yield performance Werer-05 and Candia varieties scored the highest cotton seed yield. However, they didn't express their full genetic potential due to the fact that they are released for irrigated environments. Generally testing of more genotype is recommended to have high genetic variation since this area has high potential for cotton cultivation.

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