

Participatory Variety Selection of Improved Cotton (*Gossypium Hirsutum* L.) Varieties in North Western Gondar, Ethiopia

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Abstract

Participatory variety selection (PVS) of cotton was conducted in 2016 and 2017 main cropping season at Metema and Tach-armachiho. The experiment was done with an objective of evaluating the performance of varieties participating with farmers, and thereby to identify the most important farmers' criteria for future improvement work. Eight released varieties were evaluated. The trial was laid out in randomized complete block design with three replications. There was significant difference among varieties for seed cotton yield, lint yield and some of the other traits. The varieties Mian-01 (2829.9 kg/ha), Sisikuk-02 (2584 kg/ha) and Ionia (2422.7 kg/ha) gave superior seed cotton and - lint yield over the standard check Deltapine-90 (1988.9 kg/ha). The farmers showed priority for both qualitative and quantitative traits. In both Metema and Tach-armachiho, farmers identified eight traits as the best criteria of selection. These were early maturity, size of bolls, number of bolls, height, branching habit, softness, stretching ability and disease tolerance. According to those criteria's, farmers' selection result was in accordance with seed cotton yield and lint yield analysis results. Whereby, the high yielder varieties (Mian-01, Sisikuk-02 and Ionia) were selected by farmers for its ability to mature early, larger size of bolls and uniformly. These three varieties showed higher performance for yield, and on top of that, were ranked top based on farmer's selection. Therefore, the varieties are recommended for cultivation in the high potential area of the North Western Gondar and similar agro ecologies. Moreover, our future cotton improvement program should target on developing varieties that fulfill farmers' preferences.

Key words: Cotton, Participatory variety selection, Yield

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Introduction

Cotton is the world most important source of natural textile fiber (Morais et al., 2013). It is unique among agricultural crops as it provides both oil and fiber. It also provides

seed by-products for livestock feed. Cotton production is a source of income and employment for hundreds of millions of people worldwide (Chaudry and

Guitchounts, 2003). Optimum yield and quality fiber for cotton production require a long frost-free period with enough heat (sunshine). Moreover, it prefers warm and humid climate. Suitable soil types for

achieving high yield are a deep well drained sandy loam soil with enough clay, organic matter, and a moderate concentration of nitrogen and phosphorus (Constable, and Bange, 2015). Cotton is an industrial crop produced in both developing and developed countries. It accounts for more than half of all fibers used in clothing and household furnishings (Bedane and Arkebe, 2019). Cotton has played a significant role in the economic and political history of the world. Its role has been comparatively higher since the industrial revolution of the 17th century (Baffes, 2004).

Cotton has been grown commercially in more than 110 countries in the temperate and tropical regions. Specific countries with high production of cotton include China, USA, India, Pakistan, Uzbekistan, Turkey, Australia, Greece, Brazil, and Egypt. Cotton is also an important oil and fiber crop in Ethiopia. The primitive cultivated form *Gossypium hirsutum* L., race *aceri folium* is found in Ethiopia. This perennial cultivated species has been grown

in the back yards of few farmers in the south and southwestern parts of the country (Girma, 1982). *Gossypium hirsutum* L. is the only species of cotton widely cultivated by cotton growers across the country (Tekalign and Fassil, 2011). It is grown widely in Ethiopia under large-scale farms in the irrigated lowlands of middle Awash. Cotton is also cultivated under small scale in the warmer mid and low altitudes Northwestern Ethiopia.

It is widely grown in the lowlands of Northwestern Gondar as a cash crop by investors and small-scale farmers. Among the major cotton producing areas in North Gondar, Metema, Tach-armacho, Merabe-armacho and Quara take the leading share. The major part of the soil in this area has vertic property. The landscape is mostly flat which is suitable for cotton production.

Ethiopia has a great potential in cotton production, but it only uses 111,886 hectares, which is 3 % of the total land available for cotton and produces about 80,000 metric tons annually (Alebel et al., 2014). The total area of cotton cultivated by commercial farms in Meher (Main) Season was 40,366.71 hectares.

The cotton production and productivity are 824,702.44 quintals and 20.43 respectively. In Amhara Region, the total cotton area

cultivated by commercial farms in Meher (Main) Season was 1,777.32 hectares and production and productivity were 11,340.46 quintals and 6.38 respectively (CSA, 2011). The Amhara region land, which is covered by cotton, production and productivity compared to the national one was very low. The productivity of cotton (0.64tons/ha) in Amhara Region is low when compared to the crop genetic potential ranged from 3.5-4 tons per hectare.

Water logging problem, low level of soil fertility, damage by insect pest and lack of improved varieties are the most important production challenges in Ethiopia (Bosena et al., 2011). Thirty-four improved cotton varieties have been released and cultivated by farmers in different regions of the

country under irrigated and rain fed. However, these have not been introduced in the Northwestern Gondar cotton growing areas. Therefore, this participatory variety selection was done with an objective of identifying high yielder and stable improved cotton varieties in the growing area.

Materials and Methods

Description of the experimental sites

The experiment was conducted at Metema and Tach-Armachiho districts during 2016 and 2017 main cropping seasons. The locations represent the major cotton growing areas of North-Western Ethiopia. Climate, soil type, altitude, latitude and longitude of the experimental site are presented in Table 1

Table 1. Description of the Experimental Sites

Location	Altitude (m)	Total RF (mm)	Temperature		Relative humidity	Latitude	Longitude	Soil type
			Max	Min				
Metema	760	1030.2	19.5	35.9	45.1	36 ⁰ 17' E	36 ⁰ 17' E	Vertisol
Tach - armacho	1022	970.88	18.32	34.03	59.34	37 ⁰ 43' E	37 ⁰ 43' E	Vertisol

Source: Ethiopian National Meteorology Agency, Bahir Dar Branch (2017)

Experimental Materials and Design

Eight improved cotton varieties (Candia, Werer50, Weyto07, Sisikuk-02, Mian-01, Stam 59A, Ionia and Deltapine-90) were evaluated. The experimental materials were obtained from Werer Agricultural Research Center. The experiment was laid down in Randomized Complete Block Design (RCBD) with three replications. A mother and baby trial fashion was followed: at Metema two mother and three baby trials and at Tach-armachiho three mother and three baby trials were evaluated. Each plot had five rows of 5m length with a spacing of 45, 20 and 100 cm between rows, plants and plots respectively. The plot area used was 11.25m² (5m X 2.25m). A distance of 1.5m was maintained between replication. Date of planting varied from late June to early July for the two testing sites. A fertilizer rate of 100 kg/ha (both Urea and NPS) was applied at the time of planting and squaring. Seed rate of 15-20kg/ha was applied. Seed and fertilizer were drilled uniformly by hand. Weeding was done three times for each location and thinning was done equally for each treatment. To protect the trials from flea beetle, Apron star with a rate of 300g per one quintal cotton seed dressing and Diazinol 60%

as spray with a rate of 2 l/ha were used to for flea beetle protection.

Data collection

Data on seed cotton and lint yield and agronomic traits were taken from the three central rows Sowing data was recorded. Days to squaring, initial flowering, 50 % flowering, initial boll opening and sixty-five boll opening were separately taken when 1/2, 1/5, 1/2, 1/5 and 2/3 crop stands squared, flowered, boll opened and matured, respectively. Plant height (cm) was taken at maturity from five randomly selected plants of the central rows. Seed cotton yield was taken from both the 1st and 2nd pickings after keeping it in the same cloth bag. Thirty bolls weight per plot were obtained from thirteen randomly bolls taken from the central three rows in each plot. Lint percentage was taken from weight of ginned lint as a percentage of 30-boll weight taken from each plot. Lint yield calculated from the product of total weight of seed cotton yield per plot and lint percentage for that plot. Seed cotton yield and lint yield per plot were converted to kilogram per hectare. Farmers' perception was taken from baby trial. Matrix ranking system was used to assess farmers' opinion and

perceptions on the varieties. To reveal farmers' preferences and their perceptions on the cotton varieties, focus group interviews were held with a group of farmers. Therefore, selected farmers at each village were invited to visit the trial site at maturity stage and asked for their perceptions on the cotton varieties under evaluation based on the specific criteria they set. A scale of 1-5 was used to assess these traits with the definition as follows: 1 = not preferred, 2 = less preferred, 3 = moderately preferred, 4 = highly preferred 5=very highly preferred. Farmers were asked to rank 1, 2, 3, 4 and 5 for each variety. Farmers' responses were counted to get the totals for ranking each trait per the tested variety.

Statistical Analysis

All measured parameters were subjected to analysis of variance (ANOVA) using SAS software version 9.0 (SAS Institute Inc., 2002) to assess the differences among the tested varieties. The homogeneity of error mean squares between the two locations were tested by F-test on variance ratio.

Treatment means were compared using the least significant difference (LSD) test at 5% significant level. The GGE biplot pattern explorer was performed using Gen Stat

Statistical Software to identify stable varieties across location.

Results and Discussion

The separate and combined analysis for yield and yields related traits was presented on Table 2, 3 and 4 at Metema on station in 2016/17 and 2017/18 seasons. The combined analysis showed that there was highly significant ($p < 0.01$) genetic variation for days to initial boll opening, plant height, total boll number per plant, seed cotton yield and lint yield. On the other hand, sixty-five percent boll opening and average boll weight showed significant genetic variation at 5% probability. The genotype by environment (G*E) interaction showed the presence of significant ($p < 0.05$) interaction for days to initial flowering, initial boll opening, plant height, total number of bolls per plant, average boll weight, seed cotton yield and lint yield (Table 2). Tekalign and Fassil (2011) found similar results except for days to initial squaring, initial flowering, flowering and lint percentage. Similar results were also noticed by Ali Imtiaz *et al.* (2017) on their study on Genotype by environment of seed cotton yield in upland cotton; however, in that study, average boll weight showed a non-significant result. The highest average boll weight was recorded in variety Mian-01 (5.5gm) and the

lowest average boll weight was recorded in variety Candia (4.5 gm) and Weyto-07(4.5 gm). The highest boll number per plant was recorded variety Mian-01(11) and the lowest boll number per plant was observed from variety Werer-50(6.5). The variety Stam-59A(103cm) was the longest variety while the variety Sisikuk-02(68.5cm) was the shortest. An average seed cotton yield (2311 kg/ha) and average lint yield (9.89 ton/ha) were recorded. The highest seed cotton yield was recorded from the varieties Mian-

01(2922 kg/ha), Ionia (2520 kg/ha) and Sisikuk-02 (2488kg/ha), respectively. Werer-50, on the other hand, was the lowest yielder (1947 kg/ha). The highest lint yield was recorded from the varieties Mian-01 (1307 kg/ha), Ionia (1069 kg/ha) and Sisikuk-02 (1021 kg/ha) respectively. Deltapine-90, on the other hand, was the lowest lint yielder with the value of 815 kg/ha (Table-2).

Table 2. Mean performance for yield and yields related traits of Cotton varieties tested at Metema during 2016/17 & 2017/18 (Combined) main cropping season

TRT	DISQ	DIF	DF	DIBOP	DSIFBOP	PH(cm)	TBNP	ABW(gm)	YHA(kg)	LYH(kg)	LP(%)
Ionia	43	60	62	106 ^c	130 ^{bc}	83.5 ^{bcd}	9.067 ^b	5.3	2520 ^b	1069 ^b	42.8
Sisikuk-02	43	59	61	100 ^d	121 ^c	68.5 ^e	9.617 ^b	4.95	2488 ^{bc}	1021 ^{bc}	41.1
Stam 59A	45	61	63	112 ^a	147 ^a	103 ^a	6.95 ^{cd}	4.617	2034 ^{de}	864.1 ^{cd}	42.42
Mian-01	45	60	62	109 ^{bc}	138 ^{ab}	85.3 ^{bc}	11.13 ^a	5.533	2922 ^a	1307 ^a	44.77
Candia	43	59	61	108 ^{bc}	144 ^a	73.1 ^{cde}	9.12 ^b	4.567	2257 ^{bcd}	1019 ^{bc}	45.2
Werer-50	46	61	63	111 ^{ab}	151 ^a	91.5 ^{ab}	6.55 ^d	5.05	1947 ^e	815.1 ^d	41.8
Weyto-07	45	60	63	109 ^{abc}	148 ^a	72.5 ^{de}	9.783 ^b	4.55	2195 ^{cde}	945.1 ^{bcd}	43.33
Deltapine-90	42	59	61	107 ^{bc}	141 ^{ab}	73.3 ^{cde}	7.68 ^c	4.967	2122 ^{de}	876.6 ^{cd}	41.32
Mean	43.85	59.7	62	108.16	140.2	81.32	8.73	4.94	2311	989.6	42.84
CV (%)	6.71	4.5	4.38	2.86	8.02	13.01	9.81	10.18	11.25	14.58	12.65
LSD (0.05)	3.5	3.23	3.21	3.51	13.28	12.48	1.01	0.6	306.5	170.21	6.39
TRT	NS	NS	NS	**	*	**	**	*	**	**	NS
TRT*Year	NS	*	NS	*	NS	*	**	*	*	*	NS

DISQ=Days to initial squaring, DIF= Days to initial flowering, DFIF=Days to 50 %flowering, DIBOP=Days to initial boll opening DSIFBOP=Days to sixty-five boll opening, TBPP=Total boll number per plant, ABW=average boll weight YHA= seed cotton yield LYHA=lint yield, LP= lint percentage, NS=non-significant, Sig=significant

At Tach-Armachiho, in 2016/17 and 2017/18 seasons, the combined analysis at three locations showed that there was highly significant ($p < 0.01$) genetic variation for days to initial squaring, days to flowering, total boll number per plant and seed cotton yield. Similarly, days to initial flowering, days to initial boll opening, plant height, average boll weight, lint yield and lint percentages showed significant variation at ($p < 0.05$). Significant genetic by environment ($G \times E$) ($p < 0.05$) was revealed on days to (initial squaring, flowering, boll opening), total boll number per plant, average boll weight, seed cotton yield and lint yield (Table 3). Tekalign and Fassil (2011) noticed similar results except for days to sixty-five percent boll opening and lint percentage. Ali .Imtiaz *et al.* (2017) have also noticed similar results.

Among the tested varieties, Mian-01, Sisikuk-02 and Ionia showed a good

performance. Most of the traits were significant on those three varieties. Particularly, a total boll number per plant, average boll weight, seed cotton yield and lint yield showed high variation in relation to the rest-tested varieties. In addition, the variation among the high yielder varieties was not significant. Under mean comparison of the two districts, the tested varieties performed in a similar manner. However, at Metema district, the varieties performed slightly higher than at Tach-armachiho, especially, seed cotton and lint yield. Those three varieties gave more than the average mean value in seed cotton and lint yield. The productivity of cotton (0.64 tons/ha) in Amhara Region is lower than 1 ton/ha (CSA, 2011). However, the productivity of those three varieties gave more than 2.5 ton/ha. Thus, the cotton producer farmers of the region economically get four times before they get from cotton.

Table 3. Mean performance for yield and yields related traits of Cotton varieties tested at Tach-armachiho during 2016 & 2017-combined main cropping season

TRT	DISQ	DIF	DF	DIBOP	DSIFBOP	PH	TBNP	ABW(gm)	YHA(kg)	LYH(kg)	LP(%)
Ionia	50 ^{bc}	62 ^b	74 ^d	113 ^{cd}	145	91.2 ^{bc}	8.45 ^b	5.6 ^a	2357.9 ^b	981.72 ^b	41.4 ^{bc}
Sisikuk-02	41 ^d	58 ^c	68 ^e	106 ^e	139	78.5 ^c	8.9 ^b	5.1 ^c	2648 ^a	1188.79 ^a	44.8 ^a
Stam 59A	53 ^a	65 ^a	76 ^{bc}	116 ^{ab}	149	124.6 ^a	7.4 ^c	5.2 ^{bc}	1651.6 ^d	696.22 ^e	41.8 ^{bc}
Mian-01	49 ^c	64 ^{ab}	74 ^{cd}	117 ^{ab}	147	97.9 ^b	11.1 ^a	5.7 ^a	2768.4 ^a	1246.84 ^a	44.9 ^a
Candia	52 ^{ab}	62 ^{ab}	76 ^{bcd}	115 ^{abc}	152	86.1 ^{bc}	8.4 ^b	5.4 ^{ab}	2117.7 ^{bc}	961.24 ^{bc}	45.4 ^a

Werer-50	51 ^{abc}	64 ^{ab}	78 ^b	115 ^{abc}	151	116.9 ^a	7.2 ^c	5.4 ^{ab}	2062.8 ^c	826.8 ^{cde}	39.8 ^c
Weyto-07	54 ^a	64 ^{ab}	81 ^a	118 ^a	153	95.5 ^b	8.8 ^b	4.6 ^d	2045.1 ^c	865.6 ^{bcd}	42.3 ^b
Deltapine-90	49 ^{bc}	63 ^{ab}	75 ^{cd}	110 ^d	151	85.5 ^{bc}	8.6 ^b	5.4 ^{ab}	1900.2 ^{cd}	758.6 ^{de}	39.8 ^c
Mean	50.3	63.1	75.4	114.1	148.86	97.02	8.0	5.31	2193.9	940.72	42.51
CV (%)	5.7	5.1	3.4	2.6	5.59	16.8	11.6	6.3	12.37	16.03	5.7
LSD (0.05)	2.7	3.04	2.4	2.84	7.96	15.4	1.9	0.31	256.69	142.56	2.29
TRT	**	*	**	*	NS	*	**	*	**	*	*
TRT*Year	*	NS	**	*	NS	NS	**	*	**	*	NS

DISQ=Days to initial squaring, DIF= Days to initial flowering, DFIF=Days to 50 % flowering, DIBOP=Days to initial boll opening DSIFBOP=Days to sixty five boll opening, TBPP=Total boll number per plant, ABW=average boll weight YHA= seed cotton yield LYHA=lint yield, LP= lint percentage, NS=non-significant, Sig=significant

The overall combined analysis showed that there was highly significant ($p < 0.01$) genetic variation for total boll number per plant, average boll weight, seed cotton yield and lint yield. The overall combined analysis of two years' data showed that significant ($p < 0.05$) variation for days to initial flowering, days to sixty five percent boll opening and lint percentage were presented. Based on the combined ANOVA, the presence of significant interaction among the genotypes and environments was shown for days to initial flowering, days to flowering, days to initial boll opening, plant height, total boll number per plant, seed cotton yield and lint yield. Mudada et al. (2017) noticed similar results in first order interactions (genotype X year and genotype X location) and second order

interaction (genotype X location X year) components were significant but different results were observed in seed cotton yield. Ali Imtiaz, et al. (2017) also noticed similar results Genotype by environment and GGE-biplot analyses for seed cotton yield in upland cotton but different results in days to sixty-five percent boll opening (fiber maturity). Variety Main-01 has the highest performing in average boll weight, boll number per plant, seed cotton yield and lint yield. On the other hand, Stame 59A has the lowest performing variety in boll number per plant, seed cotton yield and lint yield. In cotton production average boll weight, boll number per plant, seed cotton yield and lint yield are the most important parameters. As indicated by Méndez-Natera et al. (2012), total bolls number per

plant and average boll weight were positively and significantly correlated with seed cotton and lint yield. Thus, among the tested varieties, Main-01 has a maximum value of those decisive traits followed by Siskuk-02 and Ionia (Table-4). Under Ethiopian condition, the potential of

developed varieties gave a remarkable seed cotton yield of 3000 – 5000 kg/ha under research condition (Bedane and Arkebe, 2019). In this research finding, variety Main-01 gave 2830 kg/ha seed cotton yield followed by siskuk-02 (2584kg/ha) and Ionia (2423kg/ha).

Table 4. Mean performance for yield and yields related traits of Cotton varieties from the combined analysis over five environments

TRT	DISQ	DIF	DF	DIBOP	DSIFBOP	PH	TBNP	ABW	YHA	LYHA	LP
Ionia	47 ^{bc}	61 ^b	69 ^d	110.6 ^{cd}	139	88.1 ^c	8.8 ^{bc}	5.5 ^{ab}	2422.7 ^b	1017 ^c	41.9
Sisikuk-02	42 ^d	58.7 ^c	65.4 ^e	103.9 ^e	132	74.5 ^e	9.2 ^{bc}	5.01 ^c	2584 ^b	1121 ^b	43.3
Stam 59A	50 ^a	63.6 ^a	70.9 ^{bc}	115.1 ^a	148	116 ^a	7.7 ^{bcd}	4.9 ^c	1804.5 ^e	763.4 ^f	42.1
Mian-01	47 ^{bc}	62.8 ^{ab}	69.6 ^{cd}	114 ^{ab}	144	92.9 ^c	11.1 ^a	5.6 ^a	2829.9 ^a	1271 ^a	44.9
Candia	49 ^{ab}	61 ^{ab}	70.1 ^{cd}	112.4 ^{bc}	149	80.9 ^{de}	8.8 ^{bc}	5.1 ^c	2173.5 ^c	984.5 ^{cd}	45.3
Werer-50	49 ^{ab}	62.6 ^{ab}	72.1 ^{ab}	113.6 ^{ab}	151	106.8 ^b	7.2 ^{cd}	5.3 ^{bc}	2016.5 ^{cd}	822.1 ^{ef}	40.6
Weyto-07	50 ^a	62.6 ^{ab}	73.8 ^a	114.8 ^a	151	86.3 ^{cd}	9.3 ^b	4.6 ^d	2105.1 ^{cd}	897.4 ^{de}	42.7
Deltapine-90	47 ^a	61.3 ^b	69.7 ^{cd}	109.4 ^d	147	80.6 ^{de}	8.1 ^{bcd}	5.3 ^{bc}	1988.9 ^d	805.8 ^f	40.4
Mean	47.6	61.7	70.1	111.75	145	90.75	8.4	5.16	2240.6	960.3	42.6
CV (%)	5.57	4.59	3.6	2.3173	5.9	10.8	11.71	13.53	13.956	13.02	8.9
LSD (0.05)	1.95	1.9	1.85	1.88	6.3	7.13	1.18	15.2	227.7	156.45	6.1
Loc*TRT	*	NS	*	NS	NS	*	*	NS	*	*	NS
Year*TRT	*	NS	*	NS	NS	NS	**	*	**	**	NS
Year*Loc*TRT	NS	*	**	*	NS	*	**	NS	**	**	NS

DISQ=Days to initial squaring, DIF= Days to initial flowering, DFIF=Days to 50 % flowering, DIBOP=Days to initial boll opening DSIFBOP=Days to sixty five boll opening, TBPP=Total boll number per plant, ABW=average boll weight YHA= seed cotton yield LYHA=lint yield, LP= lint percentage, NS=non-significant, Sig=significant

Table 5. Seed cotton yield advantages of highly performed varieties over standard check

	Mian-01	Sisikuk-02	Ionia	Deltapine-90
Seed cotton yield per ha	2829.9	2584	2422.7	2088.9
Seed cotton yield advantage	35.5%	23.7%	15.9%	
Seed cotton yield advantage	9.5%	6.65%		
Seed cotton yield advantage	16.8%			



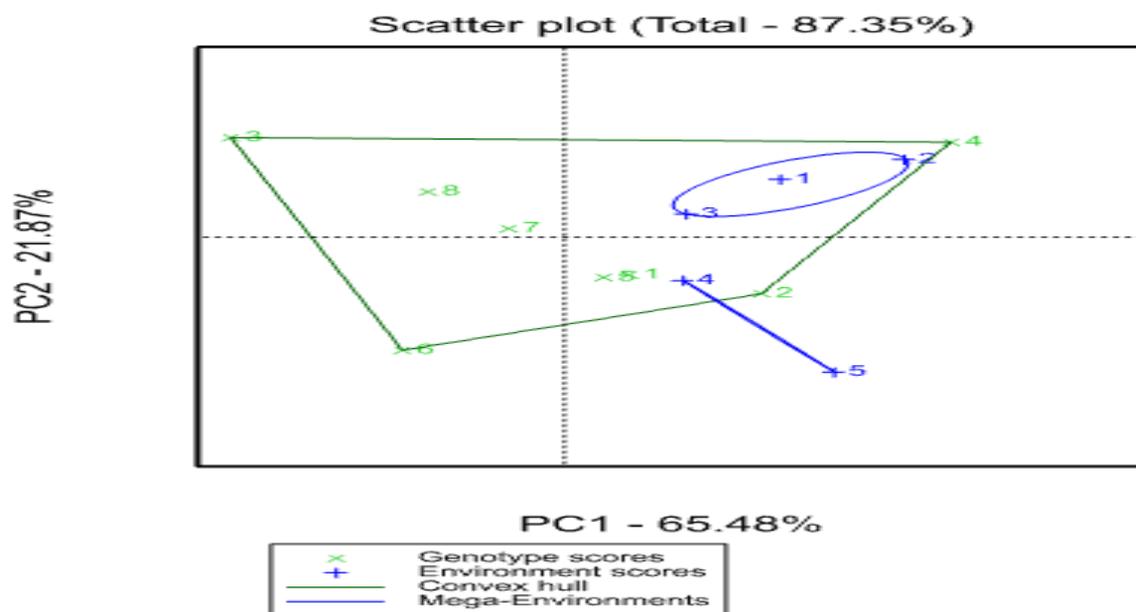
GGE biplot results

Seed and lint yield of cotton genotypes are mostly affected by location and season (JM

La Cape et al., 2010). Cotton is a sensitive crop to weather fluctuations; it shows a higher magnitude of genotype x environment interaction (Campbell and Jones, 2005). The polygon from the GGE biplot (Figure 1) grouped the sites Metema 2016(X1), Metema 2017(X2) and Tach-armachiho 2016(X3) in the environment 1 and Tach-armachiho 2017 station (X4) and Tach-armachiho 2017 on farm (X5) in environment 2. The variety Mian-01 (x4) presented at the vertex achieved the highest means of seed cotton yield in the environments Metema 2016(X1), Metema 2017(X2) and Tach-armachiho 2016(X3). Similarly, Mian-01 had the highest mean seed cotton yield among all of the tested varieties (Table 3). Variety Sisikuk-02(x2) also presented at the vertex achieved the second highest means of seed cotton yield in the environment Tach-armachiho 2017(X4) and Tach-armachiho 2017(X5).

Even though the genotypes give rise to polygon vertices, and do not contain any clustered environments, they have low yield and are considered unsuited to the groups of tested environments (Karimizadeh et al., 2013). The PC analysis was fitted the first two PCs explained 87.35% (PC1 = 65.48% and PC2 = 21.87%) of total variation for cotton multi-environmental trials. The varieties that were farthest from the origin of biplot (Sisikuk-02(x2), Mian-01(x4), Stam -59A (x3) and Werer-50(x6)) used as corners of a polygon when these varieties were

connected with straight lines (Figure 2). Main-01 (x4) and Sisikuk-02, which rise on the polygon vertices on the right side, were the best-performed varieties among the tested varieties. Main-01(x4) had the highest yielding performance in environments Metema 2016(X1), Metema 2017(X2) and Tach-armachiho 2016(X3, and Sisikuk-02(x2), Ionia(x1) and Candia(x5) well performed in the environments Tach-armachiho 2017(X4) and Tach-armachiho 2017(X5). In general, treatment Mian-01(x4), Sisikuk-02(x2) and Ionia(x1) are the best-performed varieties.



Farmers' Evaluation

Farmers of both genders participated in the selection process. Selection was carried out by organizing a field day at physiological maturity. All members of the farmers' group, comprising female and male, had a

strong discussion during selection. The results obtained from farmers' evaluation in the three baby trials are presented in Table 6, 7, 8 and 9. The farmers were keen to compare the criteria and rank them in order of importance. At Metema, 18 male,

6 female farmers and 2 agricultural experts participated. Accordingly, farmers ranked selection criteria in the order: earliness, stretching ability, branch habit, size of bolls, softness and height (Table 6). At Tach-armachiho, 12 male, 6 female and 2 agricultural experts participated. Accordingly, they ranked the selection criteria in the order of earliness, size of bolls, number of bolls per plant, height, softness, branch habit, stretching ability and disease tolerance (leaf blight) (Table 7). Participatory variety selection is more effective than conventional plant breeding.

Participatory variety selection is seen by several scientists as a way to overcome the limitations of conventional breeding by offering farmers the possibility to choose in their own environment, which varieties suit better to their needs and conditions (Ceccarelli, S., 2015). Joshi and Witcobe (2003) reported that it was a more rapid and cost-effective way to identify farmers' preferred varieties.

Adoption rates of varieties would be improved by increasing farmers' participation. Ceccarelli and Grande (2007) also reported that participatory research is important to understand the combinations of traits of interest to farmers,

which are in a wider range than breeders expect.

From the farmers' selection criteria, we have noticed that farmers not only set the criteria based on what they have seen in the trials but also from their perspective on the challenges of cotton production. Therefore, at Metema, farmers preferred Mian-01 (92) followed by Sisikuk-02 (77) and Ionia (68) (Table 8). At Tach-armachiho, they preferred Sisikuk-02(128) followed by Ionia (110) and Main-01(107) (Table 9).

Generally, Mian-01, Sisikuk-02, and Ionia were selected as the top-ranking varieties. The varieties Mian-01, Sisikuk-02, and Ionia were among the better performing varieties and found to be promising from the analysis of the researchers' collected data. In this trial, we were also able to ascertain the importance of participating farmers in the cotton improvement program from the very beginning and exploit their indigenous knowledge. Integrating the researchers' and farmers' indigenous knowledge are more important for selecting better varieties. Moreover, the farmers gave their own perception and indigenous knowledge about cotton varieties development for the next breeding program.

Table 6. Pair wise ranking matrix of selection criteria for cotton varieties at Metema.

Major attributes	Branch habit	Early maturity	Height	Softness	Stretching ability	Size of bolls	Total	Rank
Branch habit (1)							3	3
Early maturity (2)	2						5	1
Height (3)	1	2					0	6
Softness (4)	1	2	4				1	5
Stretching ability (5)	5	2	5	5			4	2
Size of bolls (6)	1	2	6	6	5		2	4

Table 7. Pair wise ranking matrix of selection criteria for cotton varieties at Tach-armachiho

Major attributes	Branch habit	Number of bolls	Early maturity	Height	Softness	Stretching ability	Disease tolerance	Size of bolls	Total	Rank
Branch habit (1)									3	5
Number of bolls (2)	2								5	3
Early maturity (3)	3	3							7	1
Height (4)	4	2	3						4	4
Softness (5)	1	2	3	4					2	6
Stretching ability (6)	1	2	3	4	5				1	7
Disease tolerance (7)	1	2	3	4	5	6			0	8
Size of bolls (8)	8	8	3	8	8	8	8		6	2

Table 8. Average scores for each trait, overall mean value of each selection criterion, and ranking of genotypes at three farmer sites in Metema.

Criteria	Rank	Weight	Treatments							
			Candia	Deltapine-90	mian-01	Sisikuk-02	Weyto-07	Werer-50	Ionia	Stam 59A
Branch habit	3	4	8	8	16	16	20	12	12	8
Early maturity	1	6	18	6	24	30	6	12	24	18
Height	6	1	3	4	4	3	5	4	2	3
Softness	5	2	6	6	8	4	4	8	6	4
Stretching ability	2	5	15	20	25	15	5	15	15	10
Size of bolls	4	3	9	6	15	9	3	6	9	3
		Total	59	50	92	77	43	57	68	46
		Rank	4	6	1	2	8	5	3	7

1= not preferred, 2= less preferred, 3 = moderately preferred, 4 = highly preferred, 5 = very highly preferred

Table 9. Average scores for each trait, overall mean value of each selection criterion and ranking of genotypes at three farmer sites in Tach-armachiho district.

Criteria	Rank	Weight	Treatments							
			Candia	Deltapine-90	mian-01	Sisikuk-02	Weyto-07	Werer-50	Ionia	Stam 59A
Branch habit	5	4	8	16	8	12	16	16	12	16
Number of bolls	3	6	18	30	12	24	24	18	24	12
Early maturity	1	8	32	8	32	40	24	16	24	8
Height	4	5	10	15	20	20	20	10	20	10
Softness	6	3	12	12	12	12	12	12	9	12
Stretching ability	7	2	8	8	8	8	4	6	8	8
Disease tolerance	8	1	4	3	3	4	4	20	3	3
Size of bolls	2	7	21	21	28	28	14	14	28	14
		Total	113	113	123	148	118	112	128	83
		rank	5	5	3	1	4	6	2	7

1 = not preferred, 2 = less preferred, 3 = moderately preferred, 4 = highly preferred 5=very highly Preferred

Conclusions and Recommendations

There are many different cotton varieties available in Ethiopia on the seed market. Research institutes and seed companies continuously release new varieties. Most of them developed for maximum production under high inputs (fertilizers, pesticides and irrigation) conditions. However, the availability of varieties in main cotton growing areas is still limited and the farmers cannot prefer all the released varieties. Continuous evaluation of diverse cotton varieties to provide high yielder varieties accelerate the adoption of improved varieties and at the same time maintain genetic diversity of cotton. Farmers may require multiple traits from one key crop for production of a particular crop. Most of the time, researchers may not consider the traits that are important and preferred by farmers. In such a way, participatory varietal selection has a significant role in technology adaptation and dissemination in short time than conventional approach.

In this study, farmers' selection criteria in the two districts were branching habit, number of bolls, early maturity, plant height, softness, stretching ability, disease tolerance, and size of bolls. Based on the selected criteria, farmers in Metema

preferred the varieties Mian-01, Sisikuk-02 and Ionia. Farmers at Tach-armachiho preferred Sisikuk-02, Ionia and Mian-01. Except rank change, farmers in both districts preferred those three varieties. The analysis of variance of the biological data revealed that varieties gave the highest seed cotton and lint yield. With regards to seed cotton yield, Mian-01, Sisikuk-02 and Ionia have 35.5, 23.7 and 15.9 % yield advantage over the check (Deltapine-90) respectively. Based on GGE biplot results, Mian-01, Sisikuk-02 and Ionia were high yielder and stable varieties in both districts. Based on the analysis of variance, GGE biplot results and farmers' preference, it was realized that the varieties are adaptive and preferable for those areas. Moreover, varieties Mian-01, Sisikuk-02 and Ionia were identified as the most consistent. Thus, those three varieties are recommended for production in Metema, Tach -Armachiho and similar agro ecologies. However, under this study, only eight varieties were tested. Thus, further improvement is vital by testing and developing much more cotton materials.

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