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Variation and Cluster Analysis for Segregating Populations of Egyptian Cotton (*Gossypium barbadense* L.) for Yield and Fiber Quality Traits under Different Environmental Conditions

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ABSTRACT

The sufficient magnitudes of genetic variation and multivariate analysis of Egyptian cotton segregating populations for yield and quality traits under variable environmental conditions are required for effective selection of promising varieties that may be resilient to climatic changes. The current study will accomplish the obtained view of the first part of these investigations concerning the extent of stability accompanied of yield potentiality of these populations. The environmental conditions either early or late sown, irrigated each two weeks or four ones are highly significant sources of variation for all studied traits except seed index (of late sowing), boll weight (under all environments). Fiber quality traits seemed to be less sensitive to the differences that occurred due to sowing dates and/or irrigation intervals. The studied cotton genotypes had pronounced variations for all traits. The studied germplasm varied differently among different environments for all traits except boll weight. Segregating populations (C) exhibited lower magnitudes of variations than corresponding parents (P). The significance of variances due P *vs* C was more frequent under late sowing or water saving conditions than recommended planting dates or irrigation intervals. The obtained variation parameters and relative expected gains varied from environment to another and due to studied attributes. Cluster analysis proved to be beneficial for cotton selection program by sorting the singleton promising segregating populations rather than grouping similar ones. Thus, four F_2 ungrouped populations: G90xAustralian (P1xP6), G90xG94(P1xP2), G94xG90CB(P2xP5) and G95xG90CB (P3xP5) exhibited superior performance under different investigated conditions and could be considered for generating promising cotton selections.

Keywords: Variation- Cluster analysis- Selection- Egyptian cotton- Climate changes.

INTRODUCTION

Egyptian cotton (*Gossypium barbadense* L) is one of the most important cash crops in Egypt, and its production is a significant component and driver of economic growth. Cotton in Egypt is grown under a wide range of environmental and climatic conditions extended from Northern to Upper Egypt with different varieties that may be their lint quality favor to the climatic zones (El-Seidy *et al.*, 2017).

Climate change in the form of raising and fluctuating temperatures with heightened competition for scarce natural resources potentially threatens the sustainability of agricultural production. Cotton appeared to be sensitive to variation of environmental and agroclimatic conditions (Cetin and Basbag, 2010). Stressful environmental conditions along with insufficient water irrigation influence the phenology and yielding performance of the Egyptian cotton (Dewdar, 2019 and Eid *et al.*, 2022). Water stress significantly declined days to onset flower, plant height, and fiber quality traits (El-Dahan, 2018 and Bakhsh *et al.*, 2019).

The increasing of air temperatures over 35°C during the growth significantly affect cotton's development and productivity (Abro *et al.*, 2015). Thus, this sensitivity of cotton plants to air temperatures should be considered while determining the optimum planting date. The optimum planting date of cotton should achieve sufficient time for optimum germination, boll formation, and boll development. Accordingly, Mahdy *et al.* (2018) pointed out that, the Egyptian cotton varieties are always bred as a full-season crop grown from mid-March to mid-September and such varieties can't tolerate the environmental stress of late planting.

The high temperature during the reproductive phase of cotton plants causes a substantial reduction in cotton yield (Hamed, 2011 and Mahdy *et al.*, 2017). According to Elayan *et al.*, (2015) and Shaker *et al.*, (2020), delaying cotton planting to the end of April had no effect on fiber quality attributes, and they concluded that delaying cotton planting to mid-May resulted in shorter growing periods and lower yields. In contrast, Abdalla (2014) reported that delaying the sowing of cotton until May 15 increased seed cotton yield and earliness index.

However, unpredictable climatic fluctuations greatly affect the productivity and resilience of cotton varieties and consequently should considered for releasing new varieties (Elayan *et al.*, 2014; Baker and Eldessouky, 2019 and Darwish *et al.*, 2022).

The effectiveness of breeding program depends upon the presence of sufficient genetic variability to permit effective selection. The success of early generation testing relies on the ability of breeder to distinguish selected families and the persistence of superior selections in subsequent generations (Jones and Smith, 2006 and Haq *et al.*, 2017).

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The use of molecular marker analysis is preferably employed in the characterization and clustering genotypes into distinct groups independent of the environmental effects and hence considered a more efficient approach (Murtaza *et al.,* 2005). However, Simasiku *et al.,* (2021) pointed out that when molecular markers are unavailable or inaccessible, multivariate analysis is the best alternative for phenotypic characterization of breeding collections.

Multivariate statistical analyses could predict the desirable genotypes from groups or clusters that may be exploited to improve the yield potential and fiber quality of the cotton crop, which would help breeders in designing an efficient breeding program. Shaker (2017) stated that cluster analysis could efficiently describe the characteristics of a group of genotypes and could be classified them into distinct categories. Genotypes from different clusters can be used for hybridization and isolate proper recombination in the segregating generations. El-Kady *et al*., (2021) classified 32 cotton bi-parental progenies based on seed cotton yield and drought tolerance indices to group into three tolerant, semi-tolerant and sensitive genotypic clusters. Yehia (2020) evaluated 24 Egyptian cotton genotypes under irrigated and stressed conditions for discrimination this germplasm into distinct drought-tolerant categories, which may be utilized for producing variable promising recombination.

The genetic potential of some cotton genotypes that may be expected to produce promising combinations under middle Egypt agriculture were crossed in diallel manner (Taha *et al*, 2018). The performance of these cross-combinations along to their parents and their interactions with soil moisture and sowing dates as well as their potential adaptation and stability across such conditions were elucidated (Darwish *et al.,* 2022). They found that each of both G90CB and Australian parents appeared to be superior for seed and lint yield production in addition to stable in performance over the investigated environments. Eight out of the studied fifteen cross combinations may be recommended as encouraging resources for selecting promising SCY and LY as well as desirable for stability. Three cross combinations of G.90 with G.94, G.95 and Karashanky recorded significantly cotton yields with somewhat stability in performance despite none of these parents exhibited similar superiority. The rest five promising cross combinations were those among each of G90CB & Australian and each of G.94 and G.95 in addition to this of G.90CB with Australian, recorded reliable cotton production simultaneously resilient performance. They concluded that these eight combinations may be considered encouraging resources for selecting promising higher SCY and LY accompanied to desirable stability.

Exploring the magnitudes of genetic variation and multivariate cluster phenotyping of the present populations for yield and quality traits as well as stress tolerance criteria are important tasks for precising proper actions towards selecting promising cotton varieties that may be resilient to climate change.

MATERIALS AND METHODS

As mentioned in the first part of these studies (Darwish *et al*., 2022), fifteen F_2/F_3 segregating populations along to their parental genotypes/varieties were evaluated under eight field trials during 2019 and 2020 seasons at the Faculty of Agriculture, Minia University, El-Minya Governorate, Egypt. These populations were stemmed from diallel mating system (Taha *et al*., 2018).

In each season, four field trials were carried out using two sowing dates as early and late during April and May, respectively. In each sowing date, two separate trials were carried out, as normal (each two weeks) and stress (each four weeks) irrigation intervals. The RCBD experimental design with three replications was adopted in all field trials with single-ridge plot, each four-meter long and 65 cm wide (2.6 m^2). The seeds were dry planted at one side of the ridge in hills distanced 25 cm; seedlings were thinned to two plants /hill after six weeks from planting.

The used parents included: Giza 90 (G.90) featured the long-staple and high yielding ability; Giza 94 (G. 94) featured earliness and strong lint; Giza 95 (G. 95) heat tolerance cultivar; Karashanky (Kar.) Russian exotic genotype promising in Egypt for early maturity; Giza 90×CB58 (G90CB), a promising line for long staple and high lint percentage as well as [(G83×G80) ×G89] × Australian (Aust.) a promising strain for high yielding and heat tolerance.

Soil Physical Analysis

The mechanical analyses of experimental soil were conducted in the soil lab of the Soil Sciences Dept. Fac., Agric., Minia University. The data in Table (1) revealed that the soil texture of the experimental site is clay loam. The percentages of clay, silt, and sand were 54.7, 35.3, and 9.9, respectively with pH 7.9. The timetable irrigation and depleted soil moisture percentages during both summer seasons are also presented in this table.

Table 1. Total number of irrigations and soil moisture features percentages during 2019 and 2020 summer seasons.

Season	F_2 (2019)				F_3 (2020)			
Trial	EN	ES	LN	LS	EN	ES	LN	LS
F.C%	40.9	39.9	39.9	40.4	39.5	37.1	38.5	36.4
WP%	14.6	14.2	14.3	14.4	14.1	13.5	13.7	13.0
AW%	26.4	25.6	25.7	25.9	25.4	24.3	24.7	23.4
Sowing dates	7 April 2019		7 May 2019		7 April 2020		7 May 2020	
No. irrigations	10	6	9	5	10	6	9	5

where: F.C %: Field capacity, WP%: Wilting point, AW%: available water%, early sowing of normal (EN) and of stress (ES) irrigation intervals, late sowing of normal (LN) and of stress irrigation (LS).

Data collection

A random sample comprised of 10 guarded plants from each plot was harvested and the studied traits were recorded for each plant and the averages of seed cotton yield (SCY), and lint yield (LY) per plant in grams were calculated. The lint percentage (L%) is the ratio of lint (LY) to seed cotton (SCY). Lint index (LI) was the mean weight of lint obtained from 100 seeds in grams. Seed index **(**SI**)** was the weight of 100 seeds in grams. The boll weight (BW) was the average weight of 5 bolls picked at random from each plant.

The resilience index (RI) was modified of the STI suggested by Fernandez (1992) as:

$$= (\mathbf{YiN})(\mathbf{YiS})/(\mathbf{YN})^{\wedge}\mathbf{2}$$

Where: Y_iN and Y_iS are the yield of genotype i under early sowing and late one, respectively but YN is the mean of all genotypes under recommended sowing date (early).

The genotype of a larger value of RI may be considered possesses higher resilience and yield potential under improper environmental conditions mainly late sowing date.

However, drought tolerance index (DTI) was calculated as the sum product of the relatives of seed cotton yield/plant under stress to corresponding normal conditions of experimental plot, replicate, genotype, and trial or environment. This procedure was adopted to ensure unbiased estimates of these indices according to Darwish *et al.* (2015).

A random sample of cotton lint from each genotype at each experiment of F_2 generation was used for determining the fiber quality by the High-Volume Instrument (H.V.I.), at the laboratories of the Cotton Arbitration and Testing General Organization (CATGO), Alexandria, Egypt. The fiber upper half mean length mm (UHML); uniformity index (UI) (%); Fiber strength, g/tex (Str.) and Micronaire reading, (Mic) were the determined technological fiber parameters.

Biometrical analysis

Data were subjected to statistical analysis according to Gomez and Gomez (1984) as follows:

- Randomized complete block design (RCBD) of the data of each trial summed eight analyses to explore the differences among segregating populations and/or parents under each investigated condition.
- Combined analysis of variance due to segregating populations and/or parents across 4 environments of each season.
- Combined analysis of variance due to 21 cotton genotypes across each four experiments conducted as early or those planted late (irrigated normally and stressed), normal or stressed watering (planted earlier and late) of both seasons.

The genotypic and phenotypic parameters were estimated using the partitioning of the expected mean square of RCBD of combined analysis across investigated environments after testing the homogeneity of error terms. The form of expected mean squares of evaluation cotton genotypes (G) combined across tested environments (E) is presented as follows:

S.V.	df	MS	E.M. S
Env.	e-1		
Reps. (Env)	e(r-1)		
Genotypes (G)	g-1	MS_g	$\delta^2_e + r\delta^2_{g.e} + r.\ e\ \delta^2_g$
G × E	(e-1) (g-1)	$MS_{g.e}$	$\delta^2 e + r\ \delta^2_{g.e}$
Error	(r-1) (g-1)	MS_e	δ^2 e

Where: e, r and g are the number of environments, replications and genotypes, respectively.

δ^2 e = MS_e/ r. E = Error mean square.

$\delta^2 g = (MS_g - MS_{g.e})/r.\ e$ = Genotypic mean square.

$\delta^2_{G.E} = (MS_{g.e} - MS_e)/r$ = GE interaction variance.

$\delta^2 ph = \delta^2 e + \delta^2_{g.e} + \delta^2 g$ = Phenotypic variance.

Broad sense heritability (h^2), genotypic (GCV%) and phenotypic (PCV%) coefficients of variations and expected gain of advance (GA) of selecting the best 10% of families was calculated as follows:

$$\text{Phenotypic coefficient of variations (PCV\%)} = \left(\sqrt{\delta^2 P} \,/\, X^{-}\right) \times 100$$

$$\text{Genotypic coefficient of variations (GCV\%)} = \left(\sqrt{\delta^2 G} \,/\, X^{-}\right) \times 100$$

$$\text{Broad sense heritability } (h^2\%) = \frac{\delta^2 G}{\delta^2 P} \times 100$$

$$\text{Expected gain of advance (GA)} = K \times h^2 \times \sqrt{\delta^2 g}$$

Where:

K is the constant of Z distribution due to the selection intensity (10%) and =1.755

The relative gain of advance (RGA) was calculated as percentage to corresponding mean performance for expressing the remaining variability among the investigated cotton genotypes.

To classify the tested segregating cotton populations plus parents in each conducted trial (EN, ES, LN, and LS) of the F_2 into subgroups defined specifically and without intersection, the cluster analyses were adopted. The unweighted pair group method with arithmetic mean (UPGMA) and the measure of dissimilarity was the squared Euclidean distance cluster analysis as suggested by Sokal and Michener (1958) was performed. Such analysis and dendrogram were carried out using SPSS software version 21.

RESULTS AND DISCUSSION

The magnitudes of variation and significance of combined analyses:

Seed cotton yield and components:

The mean squares of combined analysis of variance across each four trials (either E or L and N or S) and eight environments corresponded to the significance for seed cotton yield and components are presented in Table (2).

The five combinations of the studied trials (environments) are highly significant sources of variation for all studied traits except for seed index (SI) in the late sowing environments (L) and for boll weight (BW) in all investigated environmental combinations. This indicates that the environmental conditions generated from seasons, sowing dates and watering regimes, significantly affected the studied cotton traits.

Cotton genotypes included parents and segregating populations varied highly significant for all traits. Therefore, the studied cotton genotypes had pronounced variations for all analyzed traits.

The performance of cotton genotypes varied differently from one environment to another as proved by significance G x E interaction for all traits except boll weight of all the studied eight environments.

The partitioning of genotypes into parents (P), crosses (C) and P *vs.* Celucidating the significance and magnitudes of both types of genotypes for the investigated traits (Table 3).

Parents varied highly significant in all environmental combinations for SCY, LY and L%. However, the significance of variances due to parental cotton genotypes for SI, LI and BW are lacking under the five environmental combinations except for LI under water stressed trials (S) and SI under all trials.

On the other hands, crosses recorded highly significant mean squares only for SCY and LY in all kinds of analyzed combinations. Generally, the magnitudes of crosses' variances are lower than those calculated by parents.

The single degree of freedom comparison (SDF), i.e., P *vs* C which may be an indication of allover deviation of cross combinations and parents, is significant under early sowing trials, only for L%. However, under late sowings it's significant for SCY, LY and L%. The P *vs* C under normal irrigated trials was significant only for SCY, but it recorded significance for additional three traits (LY, L% and LI) under irrigation stressed trials. Under all the investigated trials, the SDF were significant only for SCY, L% and LI.

Table 2. Significance of mean squares of combined analyses of the fifteen F_2/F_3 segregating populations plus their parents across each four experiments carried out as early (E) or late (L) sowings, normal (N) or stressed (S) watering regimes as well as the eight trials (All) during the 2019 and 2020 seasons.

S. V	d.f	Env.	SCY	LY	L%	SI	LI	BW
Environments	3	E	11112.30**	2188.76**	180.86**	15.05**	28.96**	0.06 ns
		L	1362.37**	330.92**	73.34**	0.82 ns	30.65**	0.14 ns
		N	8924.61**	1580.39**	34.90**	14.52**	11.35**	0.05 ns
		S	7756.95**	1665.81**	207.06**	3.78**	21.60**	1.85 ns
	7	All	7525.11**	1428.42**	110.17**	8.11**	14.27**	0.09 ns
Genotypes	20	E	29.81**	6.93**	5.16**	0.55**	0.62**	0.04**
		L	66.26**	13.32**	3.60**	1.15**	0.85**	0.06**
		N	33.07**	6.32**	2.92**	0.66**	0.48**	0.04**
		S	62.23**	12.07**	11.83**	0.96**	1.31**	0.03**
		All	49.85**	12.00**	7.46**	1.47**	1.30**	0.05**
G × E	60	E	14.45**	5.66**	8.72**	0.33**	0.84**	0.04**
		L	59.20**	7.63**	4.63**	0.42**	0.44**	0.05**
		N	23.34**	4.60**	3.45**	0.44**	0.48**	0.06**
		S	50.57**	9.31**	7.90**	0.33**	0.76**	0.04**
	140	All	38.17**	6.87**	5.91**	0.35**	0.57**	0.01 ns

Ns, *and ** indicate insignificance mean squares, significance at 5% and significance 1%, respectively.

Table 3. Significance of mean squares due to both partitions sources of twenty-one genotypes in combined analyses across each type of four experiments conducted in early (E) or late (L) sowings, each included two watering regimes as normal (N) or stressed (S) as well as the eight experiments (All) during the 2019 and 2020 seasons.

S. V	d.f	Env.	SCY	LY	L%	SI	LI	BW
Parents (P)	5	E	45.10**	13.35**	14.61**	1.05 ns	1.13 ns	0.06 ns
		L	49.28**	18.56**	8.59**	1.54 ns	1.37 ns	0.02 ns
		N	30.60**	6.38**	5.74**	0.97 ns	0.52 ns	0.04 ns
		S	94.79**	30.76**	26.98**	1.67 ns	2.65*	0.03 ns
		All	64.40**	25.78**	21.38**	2.51*	2.39 ns	0.04 ns
Crosses (C)	14	E	26.46**	5.01**	1.71 ns	0.41 ns	0.42 ns	0.03 ns
		L	62.56**	11.49**	0.90 ns	1.02 ns	0.46 ns	0.07 ns
		N	35.10**	6.74**	1.85 ns	0.57 ns	0.50 ns	0.04 ns
		S	29.48**	5.74**	2.10 ns	0.76 ns	0.37 ns	0.04 ns
		All	40.37**	7.75**	1.47 ns	1.15 ns	0.71 ns	0.06 ns
P *vs* C	1	E	0.32 ns	1.63 ns	6.32*	0.02 ns	0.91 ns	0.04 ns
		L	203.01**	12.65**	16.50**	1.09 ns	3.64 ns	0.04 ns
		N	16.86**	0.19 ns	3.73 ns	0.47 ns	0.003 ns	0.001 ns
		S	357.99**	7.35**	72.39**	0.23 ns	7.86**	0.0003 ns
		All	109.73**	2.60 ns	21.62**	0.68 ns	4.09*	0.00004 ns

Ns, *and ** indicate insignificance mean squares, significance at 5% and significance 1%, respectively.

Fiber quality attributes:

Mean square due to combined analyses across each environment carried out in 2019 season (EN, ES, LN, and LS) and four environments for cotton yields and fiber quality traits are presented in Table (4). Results showed that all the investigated genotypes of F_2 generation varied highly significantly in each trial and across four environments.

Table 4. Significance of variances due to cotton genotypes and components, parents and F_2 in each early (E) and late (L) sowings either normally (N) or stressed (S) irrigation trial and combined over trials (Envs) for seed (SCY) and lint (LY) cotton yields as well as fiber quality traits during 2019 season.

Sources of variation	df	Criteria	SCY	LY	UHML	UI	Str.	Mic.
Environment (Envs)	3	Over 4 Envs	266.91**	9.20**	10.47 ns	10.50 ns	5.19 ns	0.18 ns
Genotypes (G)	20	EN	21.15*	6.09**	3.00**	3.51**	5.73**	0.09*
		ES	40.95**	16.35**	5.69**	3.36*	13.18*	0.11**
		LN	39.92**	7.74**	4.51**	4.53**	5.70**	0.17**
		LS	134.20**	18.18**	5.27**	3.46*	13.91**	0.22**
		Over 4 Envs	60.72**	17.13**	14.10**	8.17**	19.20**	0.32**
Parents (P)	5	EN	9.31 ns	4.54*	4.72**	3.98**	6.81**	0.14**
		ES	94.35**	42.88**	9.29**	4.80**	18.65**	0.18**
		LN	43.99**	15.00**	9.71**	8.91**	4.89*	0.56**
		LS	123.31**	20.13**	5.92**	2.06 ns	10.84**	0.34**
Crosses (C)	14	EN	26.83**	7.07**	2.55*	3.55*	5.69**	0.07 ns
		ES	24.44*	7.51*	4.81*	3.05*	10.85 ns	0.08 ns
		LN	40.39**	5.48 ns	2.91**	3.27*	6.21**	0.04 ns
		LS	112.42**	17.88**	4.82*	3.76*	12.02**	0.13*
P. *vs*. C	1	EN	0.80 ns	0.13 ns	0.70 ns	0.64 ns	0.91 ns	0.02 ns
		ES	5.18 ns	7.45 ns	0.001 ns	0.45 ns	18.33 ns	0.28**
		LN	13.01 ns	3.06 ns	0.78 ns	0.20 ns	2.64 ns	0.01 ns
		LS	493.51**	12.51 ns	8.20*	6.20**	55.74**	0.82**
G × Envs	60	Combined	58.50**	10.41**	1.45 *	2.23**	6.44**	0.09 **

Ns, *and ** indicate insignificance mean squares, significance at 5% and significance 1%, respectively.

The environments as a source of variation are highly significant for cotton seed yields, whereas they didn't reach to the level of significance for studied quality fiber traits. This may be indicated that studied fiber traits were less sensitive to the differences that occurred due to sowing dates and/or irrigation watering regimes. These findings are in harmony with Dewdar (2019), who reported that increasing the irrigation intervals from two to four weeks after the first irrigation had no effect on most fiber properties. The author referred this to that most fiber quality traits are highly heritable

The performance of cotton genotypes varied differently from one environment to another as proved by significant the variance of G x Envs interaction for cotton yields and all studied fiber traits.

The partitioning of genotypes into both components, i.e., parents and crosses in addition to considering the residual single degree as Parents *vs.* crosses for cotton yields and fiber quality traits (Table 4). Parents recorded highly significant mean squares for all traits across all environments except for SCY under early sowing with normal irrigation (EN) and UI under late sowing of water-stressed (LS) condition.

Crosses recorded highly significant mean squares for SCY, UHML and UI under all four trials of F_2 generation. However, variances due to crosses for LY lacked significance under late sowing with normal irrigation (LN) and for Str under early sowing with water-stressed (ES), and for Mic. under all environments except (LS). Generally, the magnitudes of parent's variances are higher than those calculated by crosses.

On the other hands, the P *vs*. C were significant under late sowing with water stressed trial (LS) for all traits except LY, whereas all tabulated traits lacked significance under the rest three trials (EN, ES and LN) except Mic under the early sowing of irrigation stressed trial.

Parameters of variations within the given environmental conditions

Seed cotton yield and components:

The mean performance along to genotypic & phenotypic parameters of variations, broad sense heritability (h^2) and the relative expected genetic advance (RGA) to corresponding means from selecting the top 10 % of the investigated genotypes over each sowing date (E & L), each either irrigated normally or stressed (N& S) and over the conducted eight trials) are tabulated in Table (5).

Sowing during the onset of May designated as late (L) produced significantly higher yields of seed and lint cotton than early sowing during April combined across both watering regimes trials in both seasons. Despite both cotton yields and lint % were lower under early sowings than under late ones, the seed and lint indices were higher under early plantings than late ones despite lacking significant differences. Seed cotton yield, lint yield, seed index, and boll weight recorded higher under well irrigated regime, than stressed watering regime and over all environments.

Table 5. Variation parameters of evaluating the F_2/F_3 fifteen populations of Egyptian cotton plus their six parental genotypes across each of the four combinations of trials carried out as early (E) or late (L) sowings, normal (N)or stressed (S) irrigations and the eight experiments during 2019 and 2020 seasons.

Traits	Env.	Mean	Range		GCV%	PCV%	$h^2_{b.s}$%	GA	RGA
			Min	Max					
Seed cotton yield (SCY)	E	49.4	45.8	51.6	2.29	4.52	25.66	1.01	2.04
	L	60.4	56.8	65.2	1.27	7.00	3.30	0.25	0.41
	N	57.2	53.3	59.6	1.58	4.72	11.12	0.53	0.92
	S	52.6	46.6	56.0	1.87	7.50	6.25	0.43	0.82
	All	54.9	51.5	57.2	1.27	6.08	4.38	0.26	0.47
Lint yield (LY)	E	19.8	18.2	21.2	1.64	6.55	6.27	0.14	0.72
	L	24.2	22.3	26.3	2.85	6.59	18.65	0.52	2.16
	N	22.7	21.2	23.9	1.67	5.20	10.26	0.21	0.94
	S	21.3	18.8	22.6	2.25	7.90	8.15	0.24	1.13
	All	22.0	20.7	23.1	2.10	6.50	10.45	0.26	1.20
Lint percentage (L%)	E	39.8	38.4	41.9	0.0	3.58	0.0	0.0	0.0
	L	40.1	39.5	41.9	0.0	2.68	0.0	0.0	0.0
	N	39.7	38.7	40.7	0.0	2.31	0.0	0.0	0.0
	S	40.3	38.9	43.5	1.42	3.80	13.96	0.38	0.93
	All	40.0	39.0	41.9	0.64	3.08	4.25	0.09	0.23
Lint index (LI)	E	6.2	5.8	6.7	0.0	7.54	0.0	0.0	0.0
	L	6.1	5.7	6.7	3.06	6.15	24.77	0.16	2.68
	N	6.1	5.8	6.4	1.33	5.43	6.03	0.03	0.58
	S	6.2	5.7	7.1	3.46	8.06	18.47	0.16	2.62
	All	6.1	5.8	6.6	2.85	6.75	17.81	0.13	2.12
Seed index (SI)	E	9.3	8.9	9.8	1.47	3.52	17.45	0.10	1.08
	L	9.0	8.5	9.8	2.75	4.56	36.32	0.26	2.91
	N	9.2	8.9	9.8	1.48	4.02	13.48	0.09	0.95
	S	9.1	8.6	9.7	2.54	4.09	38.45	0.25	2.77
	All	9.1	8.8	9.8	2.36	3.99	34.94	0.22	2.45
Boll weight (BW)	E	2.8	2.6	2.8	0.0	3.47	0.0	0.0	0.0
	L	2.8	2.6	2.9	0.88	4.24	0.04	0.01	0.32
	N	2.8	2.7	2.9	0.0	4.05	0.0	0.0	0.0
	S	2.7	2.7	2.8	0.0	3.69	0.0	0.0	0.0
	All	2.8	2.7	2.8	0.56	3.77	2.22	0.004	0.15

The ranges of SCY were wider under trials of late (8.4) sowing than those of early ones (5.8), likewise stressed watering recorded wider (9.5) than corresponding normally irrigated experiments (6.3). Ranges as indication of variability for other traits were comparatively wider under late sowings than those of early ones for all studied traits except L%. Likewise, stressed watering exhibited wider ranges than normally irrigated experiments for all studied traits except for BW.

The phenotypic coefficients of variation (PCV%) were higher in magnitudes for all cotton yield attributes, than the genotypic coefficients of variation (GCV%). The extents of PCV% under late or stressed watering regimes are higher than those corresponding of early sowed or normally irrigated ones, respectively.

For SCY, early sowing date (E) and normal irrigated (N) trials showed low levels of GCV% and PCV% coupled with high values of heritability. Similar trends could be observed in late sowing date (L) and stress watering regimes (S) trials, as well as eight environments (All) for LI and SI. This indicates that the selection practices using current populations may be effective for upgrading these traits for these environments.

The expected genetic advance for SCY is higher in early sowing (E) than late one. Likewise normal (N) irrigation recorded more genetic advance for SCY than stressed watering and seemed to be affected by the estimates of broad sense heritability. Contradicting, the GA of LY is higher under late sowing (0.52) and stress (0.24) than corresponding early trial (0.14) and normal irrigation (0.21). Both SCY and LY exhibited similar estimates of GA (0.26) under all environments despite they possessed variable heritability (4.38 and 10.45%, respectively) and RGA. Such situation may be due to variation in estimates of genotypic and phenotypic of variation among both cotton yields. The genetic variation and consequently the expected gain (GA) of selection are lacked for L% under E, L and N environments. Higher estimates of expected gains for lint (LI) and seed (SI) indices could be observed under late sowing and stressed watering than those of corresponding's early and normal irrigation. The genetic variation and advance for BW are only detected under late sowing with two folds of RGA (= 0.32) in L as recorded as by all environments (=0.15).

Fiber characters

Genetic parameters and expected gains of selecting the top 10 % of the investigated genotypes under early (E) or late (L) sowing dates, normal (N) or stressed (S) irrigation regimes as well as combined across the 2019 season for fiber quality traits are presented in Table (6).

Table 6. Variability parameters of the fifteen F_2 segregating cotton populations and their parental genotypes for quality traits across the four trials during 2019 season.

Traits	Env.	Mean	Range		GCV%	PCV%	$h^2_{b.s}$%	GA	RGA
			Min	Max					
SCY	EN	62.8	55.5	67.0	6.91	7.32	88.96	6.79	10.81
	ES	58.7	46.9	63.0	10.48	10.90	92.39	10.00	17.04
	LN	63.3	57.0	71.9	9.50	9.99	90.59	9.59	15.15
	LS	61.5	48.9	74.8	18.29	18.85	94.17	18.63	30.32
	Combined	61.6	56.5	64.6	8.98	11.12	65.21	6.35	10.31
LY	EN	25.0	22.2	27.2	9.43	9.88	91.14	3.78	15.13
	ES	24.8	20.7	30.3	15.79	16.31	93.66	6.45	26.03
	LN	25.7	23.2	28.9	10.27	10.85	89.58	4.15	16.19
	LS	25.4	20.1	30.5	16.15	16.82	92.28	6.65	26.24
	Combined	25.2	23.1	27.3	13.07	14.64	79.70	4.62	18.33
UHML	EN	31.9	30.3	34.3	5.14	5.43	89.50	2.58	8.09
	ES	31.7	29.8	35.2	7.15	7.53	90.18	3.59	11.35
	LN	31.6	30.2	34.9	6.52	6.71	94.22	3.42	10.81
	LS	31.0	28.8	33.4	7.05	7.42	90.46	3.48	11.23
	Combined	31.5	30.4	34.2	3.23	3.52	85.55	1.55	4.90
UI	EN	86.3	84.5	88.2	2.06	2.17	89.50	2.79	3.24
	ES	86.3	84.8	88.9	1.98	2.12	87.44	2.64	3.05
	LN	85.9	83.8	89.0	2.36	2.48	91.03	3.25	3.79
	LS	85.5	83.7	87.7	2.02	2.18	86.15	2.62	3.06
	Combined	86.0	84.8	87.9	0.82	1.12	53.62	0.66	0.77
Str.	EN	42.3	40.6	45.6	5.38	5.65	90.63	3.63	8.58
	ES	41.8	37.8	46.2	8.11	8.68	87.33	5.21	12.47
	LN	42.3	38.3	44.5	5.37	5.64	90.42	3.61	8.54
	LS	42.5	38.3	47.2	8.49	8.79	93.27	5.91	13.93
	Combined	42.2	39.8	44.6	2.44	3.76	42.23	0.77	1.81
Mic.	EN	5.0	4.5	5.2	5.49	5.96	85.00	0.41	8.22
	ES	4.9	4.4	5.3	6.45	6.82	89.52	0.50	10.16
	LN	5.0	4.3	5.5	7.90	8.18	93.25	0.65	12.97
	LS	4.9	4.3	5.5	9.08	9.47	91.88	0.72	14.69
	Combined	5.0	4.4	5.3	2.76	3.96	48.64	0.12	2.37

Fiber upper half mean length (UHML) and uniformity index (UI) were higher in early sowing of normal or stress watering regimes than those the trials of late sowing. Stressed watering regimes of both sowings produced higher micronaire reading (Mic) than normal watering regimes and over all environments.

Fiber attributes displayed narrow ranges of variability and the low difference between GCV and PCV indicated that these traits were least affected by the environmental conditions of soil moisture and climatic features, thus selection for fiber attributes based on phenotype would be valuable. These findings agree with that of Abd El-Moghny *et al*., (2021) and Gibely (2021a) who found a low difference between GCV and PCV for fiber traits in F_2 generation for two Egyptian cotton crosses and indicated that these traits were least affected by the environment, thus selection for fiber attributes based on phenotype would be effective.

Heritability may be considered as moderate to higher percentages for fiber traits in this study. This indicated that the genetic factors controlling the expression of these traits had greater effects than environmental factors. Thus, these traits could be improved via selection in early generation. The genetic advance as a percentage of the mean (RGA) was lower than 10 % for most of the studied fiber traits.

Generally, results pointed out that, the studied fiber traits under stress watering regimes which were sown earlier, or late, recorded higher heritability coupled with low genetic advance as a percentage of the mean (RGA), indicating the presence of additive gene action and less environmental effect. Thus, these results suggest that there is a possibility of improvement of these traits using selection procedures. Similar findings were obtained by Gibely (2021b) reported high heritability coupled with high genetic advance for micronaire reading indicating that additive gene action controlled the inheritance of this trait.

Cluster analysis of F_2 populations and parents during 2019 season:

The dendrograms and mean performance of cluster analysis under early sowed of normal (EN) and stressed (ES) irrigations as well as late planted of normal (LN) and stressed (LS) are presented in Table (7) and Figs (1-2). The unweighted pair group method with arithmetic means (UPGMA) of cluster analysis method was performed. Cluster analysis used seed cotton yield (SCY), lint yield (LY), lint percentage (L %), seed index (SI), LI (lint index), BW (boll wt), UHML (fiber upper half mean length mm), UI% (uniformity index), Str (fiber strength, g/tex) and Micronaire reading, (Mic) as well as resilience index (RI) and drought tolerance index (DTI).

Table 7. Mean performance of clustered Egyptian cotton F_2 populations and parents as well as ungrouped ones (Un. #) for yield components and fiber quality traits under early and late sowed either normal or stressed irrigation during 2019 season.

Env.	Genotype	SCY	LY	L%	LI	SI	BW	UHML	UI	Str	Mic	RI	DTI
EN F2 (2019)	U.1(P4xP6)	55.5	22.2	40.1	6.2	9.3	2.8	31.1	86.3	43.3	5.0	-	-
	G.A (9)	61.7	24.3	39.4	6.4	9.9	2.8	31.9	86.3	41.8	5.0	-	-
	G.B (2)	61.4	24.3	39.7	6.7	10.2	2.8	31.9	86.7	45.0	5.2	-	-
	U.2(P2)	63.2	23.7	37.5	6.2	10.3	2.4	34.3	88.2	45.2	4.5	-	-
	G.C (2)	64.8	25.0	38.6	5.9	9.4	2.7	30.4	85.5	41.3	4.9	-	-
	U.3(P1xP6)	67.0	27.1	40.4	6.3	9.2	2.7	30.7	84.4	41.5	5.2	-	-
	G.D (4)	65.6	26.9	40.9	7.0	10.1	2.9	32.5	86.6	42.4	5.1	-	-
	U.4(P3xP5)	63.2	27.1	42.9	7.7	10.2	2.8	31.8	86.0	40.6	5.1	-	-
	Mean	62.9	25.0	39.7	6.5	9.9	2.8	31.9	86.3	42.3	5.0	-	-
ES F2 (2019)	U.1(P2)	46.9	20.7	44.3	8.6	10.8	2.5	35.2	88.9	44.1	4.4	0.75	0.48
	U.2(P6)	60.8	30.3	49.9	9.1	9.1	2.9	30.8	86.0	39.0	4.8	0.96	0.83
	U.3(P1)	60.4	21.1	35.0	5.1	9.6	2.6	30.4	85.3	37.8	4.9	1.00	0.75
	U.4(P1xP2)	62.7	24.0	38.5	6.3	10.1	2.9	33.4	87.8	44.7	4.8	1.05	0.78
	G.A(11)	60.4	26.0	43.0	7.1	9.3	2.7	31.5	86.2	41.5	4.9	0.97	0.79
	G.B(6)	56.2	23.1	41.0	6.5	9.4	2.7	31.5	86.1	42.7	5.1	0.87	0.76
	Mean	58.7	24.8	42.3	7.0	9.4	2.7	31.7	86.3	41.8	4.9	0.94	0.77
LNF2 (2019)	U.1(P1)	68.3	25.0	36.6	5.2	8.9	2.8	30.7	85.4	41.4	4.8	-	-
	U.2(P5)	68.6	28.9	42.1	6.5	8.9	2.9	30.6	85.9	40.4	5.5	-	-
	U.3(P2xP6)	67.9	27.9	41.1	6.8	9.7	3.1	34.0	88.3	43.8	5.0	-	-
	U.4(P2xP5)	71.9	28.6	39.8	6.3	9.5	2.8	32.5	87.0	44.5	4.9	-	-
	U.5(P2)	59.1	23.1	39.2	6.9	10.7	2.7	34.9	89.0	42.1	4.3	-	-
	U.6 (P6)	64.3	27.7	43.1	7.0	9.3	3.0	30.2	83.8	41.1	5.4	-	-
	U.7(P3)	61.5	27.1	44.0	7.1	9.0	2.9	31.9	85.4	43.2	5.1	-	-
	U.8(P3xP5)	62.2	25.5	40.9	6.1	8.8	2.7	31.6	84.8	38.3	4.9	-	-
	U.9(P4xP5)	57.0	23.2	40.7	6.1	8.9	2.8	31.9	86.1	43.6	5.0	-	-
	G.B (6)	64.0	25.7	40.1	6.2	9.2	2.9	31.6	85.7	42.6	5.1	-	-
	G.A (7)	60.6	24.6	40.6	6.0	8.8	2.7	31.0	85.6	42.4	5.0	-	-
	Mean	63.3	25.6	40.6	6.2	9.1	2.8	31.6	85.9	42.3	5.0	-	-
LSF2 (2019)	U.1(P3xP5)	74.8	30.5	40.8	6.2	9.1	2.5	30.7	84.3	38.6	5.0	1.16	1.36
	G.A (6)	67.0	27.1	40.4	5.9	8.7	2.7	30.3	85.1	42.4	4.7	1.05	1.09
	G.B (6)	62.9	25.7	40.8	6.2	8.9	2.7	31.8	86.2	43.6	4.9	0.99	0.97
	G.C (2)	51.2	21.6	42.4	6.3	8.6	2.7	29.3	84.1	39.2	5.1	0.84	0.60
	U.2 (P2xP3)	48.9	20.1	41.1	6.5	9.3	2.7	32.3	86.5	43.0	4.8	0.77	0.57
	G.D (2)	56.6	22.8	40.3	6.2	9.3	2.8	31.7	86.2	44.9	4.9	0.91	0.74
	G.E (2)	57.6	25.9	45.0	6.8	8.2	2.7	29.8	85.0	40.9	5.4	0.96	0.71
	U.3 (P2)	56.6	25.0	44.3	8.0	9.9	2.8	32.6	85.5	44.1	4.6	0.84	0.86
	Mean	61.5	25.4	41.4	6.3	8.9	2.7	30.9	85.4	42.5	4.9	0.97	0.91

At 5% level of probability, under early sowing with normal irrigation (EN) trial, the studied fifteen F_2 populations and parents, were grouped into four clusters and four ungrouped genotypes (Fig.1 & Table 7). The P4xP6 F_2 population was ungrouped earlier at level 25%, which may be due to its least production of SCY (55.5g), LY (22.2g), LI (6.2) and SI (9.3g), though both parents (P4 & P6) belonged to the intermediate group (A) under the same trial (EN). The formed four groups designated as A, B, C and D included 9, 2, 2 and 4 genotypes, respectively. Group A comprises three parents (P3, P4 and P6) plus six of F_2 (P1xP3, P1xP4, P1xP5, P2xP4, P2xP6 and P3 xP4). The second formed group is "B" included P2xP5 and P4xP5. Both groups performed similarly except "B" had somewhat heavier seed with considerable higher Strength and Mic readings of fibers than "A". At 10% level of probability, G.94 (P2) was the second split (from both

A & B groups) which may be due to its lower L% and LI, heavier seed and lighter boll with reliable fiber quality attributes. It's worth to mention that G.94 is considered a long staple cotton variety recommended for Northern Governorates.

The remainder genotypes under EN formed two groups "C" and "D" plus P1xP6 and P3xP5 ungrouped from "C" and "D", respectively. Group D includes three segregating populations (P1xP2, P2xP3 and P3xP6) and P_1 (G.90). Cluster D produced the second highest SCY (65.6 g) and lint yields (26.9 g) after the most superior F_2 population (P1xP6) with reliable L% (40.9%), SI (10.1 g), LI (7.0), BW (2.9 g) and UHML (32.5) and other fiber traits. The ungrouped P1×P6 (G.90 × Aust.), may be considered the most productive population since it recorded the highest SCY and LY, coupled with lower fiber traits. Otherwise, Group (C) comprises one segregating P5×P6 (G.90CB×Aust.) plus P5 (G.90CB) and produced intermediate yields of lint and seed cotton corresponding with shorter UHML (30.43 mm), lower UI (85.52%), and better fineness (Mic.=4.27).The last ungrouped population is P3×P5 was split from group "D" due to lower seed cotton yield (63.2g) and fiber traits, but it recorded higher lint yield (27.1g), L% (42.9%), SI (10.2g), LI (7.7), and BW (2.8g) than "D" group.

Under early sowing of stress irrigation (ES), the investigated cotton genotypes were clustered into two groups and four ungrouped genotypes (Fig. 1). The first ungrouped genotype was G.94 (P2) due to its least SCY (46.9g), LY (20.7 g) and SI (10.8 g) coupled with better fiber quality traits. Such inferior yield performance may be referred to its low resilience to late sowing under middle Egypt region and/or water saving irrigation which reflected to least RI (=0.75) and DTI (=0.48). The next two ungrouped genotypes were P1 & P6 exhibited similar SCY (≈ 60.8), RI & DTI but higher LY, LI, BW, UI and Str of P6 than those of P1. The last ungrouped genotype is the F_2 population between G.90xG.94 (P1×P2) could be considered the superior one under ES condition since its highest LY (24.0g), SI (10.1g), BW (2.9g), the lengthy staple UHML (33.4mm), high uniformity UI (87.8%), Str. (37.8) and RI (1.05).This superior cross was split at 10% level of probability from A and B two groups under ES but under early normal irrigation (EN) it belonged to the high performed group, i.e. "D". Group A of ES includes 11 genotypes that performed intermediately for most tabulated traits. However, the remainder six populations exhibited lower performance than "A" regarding seed and lint cotton yield as well as RI and DTI formed group "B".

Under late sowing of normal irrigation (LN), the parental genotypes and F_2 populations, the final clustering at 5%, formed two groups and nine ungroups. The first formed group at 15% comprised P1, P5, P2xP6 and P2xP5 were split after forward into four ungroups. The ungrouped segregating population P2×P6 (G.94×Aust.) recorded the highest seed cotton and lint yields, lint %, lint index and the heaviest seed and boll weight as well as the higher for all fiber quality traits except Mic. While the ungrouped P2×P5 segregation recorded the highest seed cotton yield (71.9g), lint yield (28.6g), strength (44.5), and Mic. (4.9). The ungrouped P1 (G.90) and P5 (G90CB) exhibited similar high SCY (68.3g) with lower lint attributes and better Mic reading of P1 than P5.

Group B includes 6 segregating populations of crosses between G.90 (P1) with G.94 (P2), G.95 (P3), Kar. (P4) and Australian (P6) as well as G.94 (P2) with G.95 (P3) & Kar. (P4). The mean performance of group "B" was better for all studied traits except Mic. than all other genotypes either clustered in "A" or ungrouped except the first four split ones (P1, P5, and P2xP6 and P2xP5). The ungrouped P6 (Aust.) produced reliable SCY (64.3g), LY (27.7g), L% (43.07%), LI (7.0), SI (9.3g), boll wt (3.0g), while recorded lower UI and finance of fibers.

It is worth to observe that the cross populations of G.94 (P2) with either P5 (G90CB) or Australian (P6) resulted in better performance under LN (normal irrigation trial under late sown) than their parents per se.

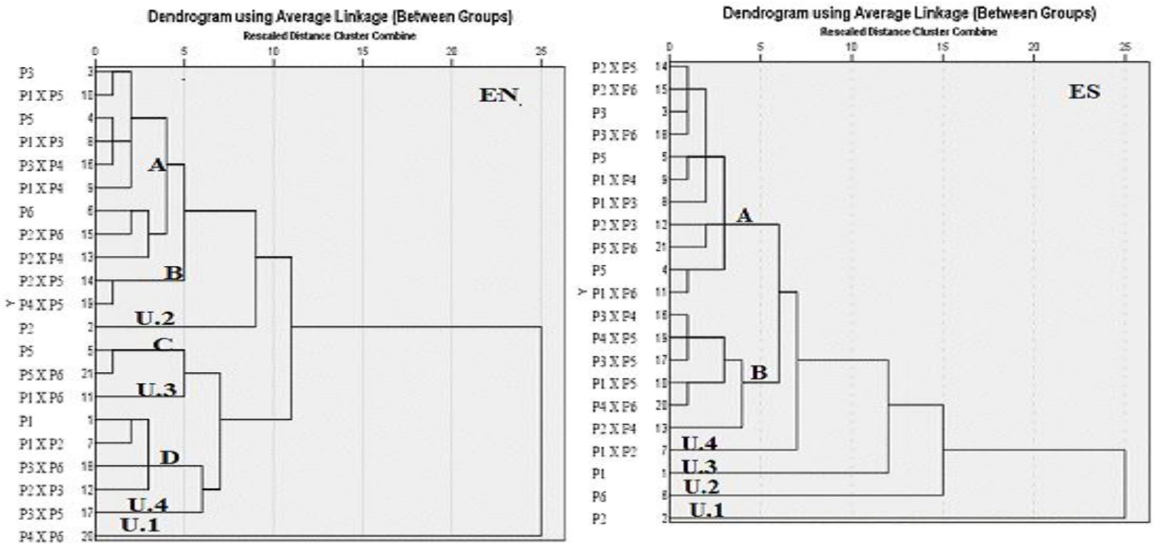

Fig .1. Dendrogram of average linkage clustering of the 15 segregating populations along with their 6 parents in F_2 for yield, yield components and fiber quality traits in early sowing of normal (EN) and stress (ES) watering during the 2019 season.

Under the conditions of late sowing with saving watering irrigation (LS), the cluster analysis formed at 20% level of probability, a desirable cluster for SCY, lint and fiber quality as well as resilience and drought indices comprise of twelve cotton populations along to P3 (G.95), Fig.2. However, at 5% this group was divided into two subgroups as "A" and "B" and one ungroup population, i.e., P3×P5 (G.95×G.90CB). Such sole population, i.e P3xP5 seems to be the most superior one under LS trial followed by group A and then group B in descending order. Population P3×P5 recorded the highest seed cotton and lint yields as well the highest indices of tolerating late sowing (RI) and water saving conditions (DTI). This superior cross combination may be considered a promising population for selecting desirable cotton genotypes that may be performed under wide range environments (EN & LN). Darwish *et al.* (2022) concluded that this segregating population was among the eight superior combinations may be considered encouraging resources for selecting promising higher SCY and LY accompanied by desirable stability.

The remainder five parents (P1, P2, P4, P5 and P6) and the rest three segregations either ungrouped P2xP3 or two formed cluster D (P1xP6 & P2xP4) showed lower performances (with different degrees) for all tabulated traits than groups A and B.

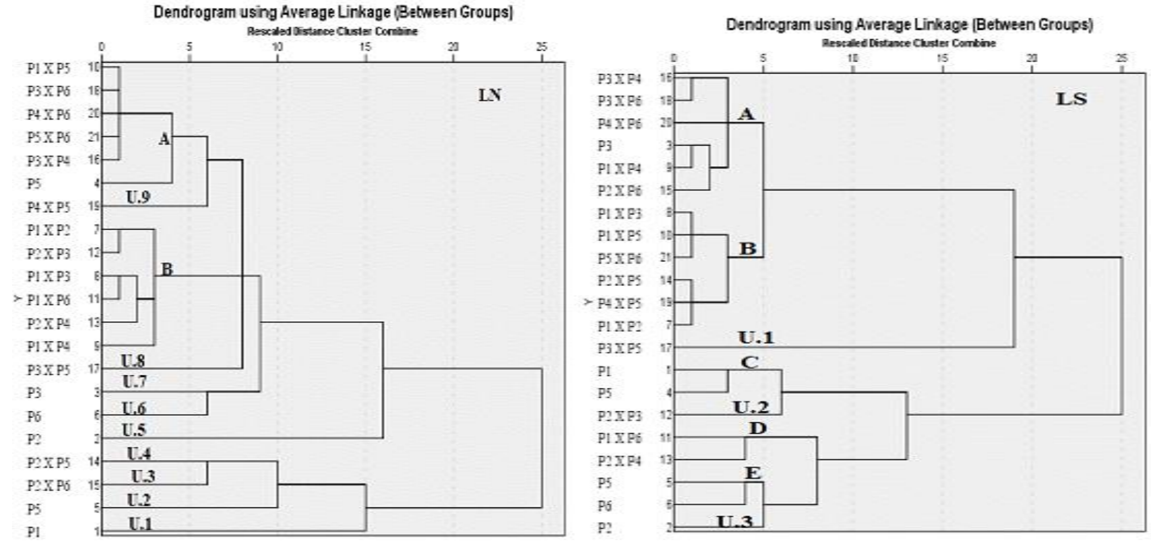

Fig. 2. Dendrogram of average linkage clustering of the 15 segregating populations along with their 6 parents in F_2 for yield, yield components and fiber quality traits in late sowing of normal (LN) and stress (LS) watering during the 2019 season.

It worth to note that there is no acceptable level for fiber quality traits with those possess high cotton seed yield particularly under late sowings. This could be due to temperature fluctuations before anthesis and during fiber development. The negative correlation between seed cotton yield with fiber fineness, fiber strength, and fiber length was reported by Amer *et al*., (2020).

All F_2 studied characters were used by the UPGMA method of cluster analysis method as presented in Table (8) concerning the principal component analysis (PCA). It is obvious that detected PC's varied among the investigated trials (environments). The dominated temperatures and RH as climatic features generated from both sowing dates across both seasons as well as adopted two distinct watering irrigation may be considered the main effects of environmental fluctuations on GEI. However, all the recorded traits and indices were included in cluster analysis to avoid biasness of obtained grouping. All detected PC recorded eigenvalues more than 2.97 with about 60% of cumulative variation.

Cluster analysis frequently used in grouping the studied genotypes into distinct groups presumably genetically divergent but genotypes within each formed group are greatly homogeneous or performed similarly for most of investigated parameters. However, some of analyzed genotypes are singletons or ungrouped due to its superiority or inferiority in performance of formed clusters.

Table 8. Components matrix for the studied traits of 21 cotton genotypes in the F_2 generation across sowing dates and watering regimes during 2019 season.

Traits	Component							
	PC 1				PC2			
	EN	ES	LN	LS	EN	ES	LN	LS
SCY	-0.08	-0.28	-0.01	0.97	-0.03	0.93	0.21	0.02
LY	0.02	-0.18	-0.13	0.98	-0.16	0.60	0.34	-0.06
L%	0.14	0.04	-0.20	-0.27	-0.25	-0.03	0.25	-0.24
SI	0.66	0.38	0.33	-0.19	-0.31	-0.10	-0.14	0.17
LI	0.89	0.86	0.70	0.02	-0.19	-0.16	-0.52	0.56
BW	-0.03	-0.18	0.07	-0.26	-0.12	0.48	-0.22	0.56
UHML	0.84	0.83	0.91	0.08	0.44	-0.17	-0.20	0.87
UI	0.81	0.83	0.87	0.05	0.35	-0.08	-0.03	0.92
Str	0.62	0.21	0.17	-0.04	0.26	-0.15	-0.19	0.76
Mic	-0.31	-0.82	-0.75	-0.27	0.04	-0.03	0.17	-0.47
RI	---	0.02	---	0.84	---	0.93	---	0.15
DTI	---	-0.72	---	0.85	---	0.53	---	-0.14
Eigenvalues	4.05	5.90	4.48	4.52	3.24	3.15	2.97	4.39
Factor var. %	31.15	39.33	34.49	30.16	24.91	21.03	22.84	29.24
Cumulative variation %	31.15	39.33	34.49	30.16	56.06	60.36	57.33	59.40

The cluster analyses of F_2 populations along to their parents in the four investigated trials (environments) summarized the formed groups and ungrouped cotton genotypes under each environment, Table 7. G90xAustralian (P1xP6), G90xG94 (P1xP2), G94xG90CB (P2xP5) and G95xG90CB (P3xP5) are considered four superiors ungrouped F_2 segregating populations under EN, ES, LN and LS conditions, respectively. It's worth to observe that none of corresponding parental genotypes reached to be considered as superior one, but belonged to intermediate cluster/s or inferior singleton like P2 (in ES, LN and LS). The advantages of cluster analysis for sorting the most promising segregating populations may be of great benefit for enrolling a few numbers in selection program.

The hybridization of genotypes from different clusters can be used for isolating proper lines in the segregating generations. This procedure could be employed in the national breeding program for the improvement of Egyptian cotton (Shaker, 2017). Simasiku *et al.*, (2021) concluded that the selection of parents to utilize in generating combinations or in creating availability of offspring for further breeding should come from two distinct clusters.

The parental genotype G.94 (P2) is a long-staple cotton cultivar grown in the Delta region was designated as ungrouped across all F_2 trials which may be due to reliable fiber quality attributes with intermediate or inferior yields of lint and seed cotton. It could be observe that G.94 (P2) when crossed by parental long staple varieties grown in Upper Egypt P1, P_3, and P6 resulted improve cotton fiber characteristics particularly the length of staple fiber. Thus, the selection within these segregating populations under a wide range of conditions in the middle Egypt region may result in new lines that possess improved yield and fiber quality.

The high performed group D and the ungrouped population P1xP6 under EN recorded the highest yields of lint and seed cotton. However, the ungrouped population P1xP2 in ES seemed to be unique due to combining high yield and proper fiber quality with highest resilience index (RI=1.05). Two ungrouped segregating populations P2×P5 and P2×P6 performed better than their parents or other crosses under LN. However, under LS, the ungrouped population P3×P5 recorded the highest seed cotton and lint yields with acceptable levels for fiber quality traits and the highest indices tolerating late sowing (RI) and water-saving conditions (DTI). Such promising combinations may be useful for building high performing gene pool that could be utilized for further selection under different conditions.

Selection for the high performed crosses combinations either under sowing dates (and watering regimes) or especially for the common crosses between the high-performed groups may be effective and produce a promising strain performed well with respect to drought tolerance and/or planting late.

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التباين والتحليل العنقودي لعشائر انعزالية من القطن المصري لصفات المحصول وجودة الألياف تحت ظروف بيئية مختلفة

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الملخص

يعتبر توفر التباين الوراثي وتنفيذ التحليل العنقودي للعشائر الانعزالية من القطن المصري لصفات المحصول وجودة الألياف في ظروف بيئية متباينة، متطلب أساسي للانتخاب الفعال لأصناف مبشرة يمكن أن تتكيف مع تأثيرات التغيرات المناخية. ويعد ذلك استكمالاً للجزء الأول من هذه الدراسات فيما يخص تحليلات تقديرات الثبات مع القدرة الانتاجية العالية. والنتائج التي سيتم التوصل اليها ستكون ذات فائدة في وضع الإستراتيجيات الواجب اتباعها للانتخاب ذو الفاعلية لأصناف القطن المرغوبة. كانت الظروف البيئية الناتجة عن مواعيد الزراعة سواء المبكرة والمتأخرة أو الموصي به او الاجهادي، مصادر عالية المعنوية على أداء كل الصفات المدروسة فيما عدا معامل البذرة في الزراعة المتأخرة ومتوسط وزن اللوزة في كل البيئات المختبرة. وكانت صفات جودة الالياف اقل حساسية للاختلافات البيئية الناتجة عن مواعيد الزراعة وفترات الري. كانت التباينات الراجعة للتراكيب الوراثية عالية المعنوية لكل صفات الدراسة. ولقد اختلف أداء التراكيب الوراثية باختلاف البيئات وذلك لجميع الصفات عدا صفة متوسط وزن اللوزة. أظهرت النتائج ان مقادير التباينات الراجعة للعشائر الانعزالية كانت اقل من تلك الراجعة للآباء. وكانت انحرافات تباينات الآباء عن الهجن أكثر حدوثا في ظروف الزراعة المتأخرة أو الري الاجهادي مقارنة بالزراعة المبكرة أو الري العادي. اختلفت مقاييس التباين المستخدمة والتحسين النسبي المتوقع بالانتخاب بشكل كبير من بيئة إلى أخرى وبين الصفات المختلفة. أظهرت النتائج أن التحليل العنقودي فعال في فرز وغربلة العشائر الانعزالية الواعدة التي يمكن الاستفادة بها في برنامج الانتخاب للقطن. ظهر من التحليل العنقودي أربعة عشائر انعزالية من الجيل الثاني غير منتمية مبشرة واحدة في كل بيئة من إجمالي خمسة عشر عشيرة يمكن أن تكون مصادر لمنتخبات واعدة يمكن أن تتكيف مع التغيرات المناخية.

الكلمات الدالة: التباين، التحليل العنقودى، الانتخاب، القطن المصرى، التغيرات المناخية.