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Evaluation of Two Earliness Cotton Genotypes in Three Ecological Regions

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***Abstract*—**Two earliness cotton genotypes I and II, which had been developed by hybridization and backcross methods between sindise-80 as an early maturing gene parent and two other lines i.e. Red leaf and Bulgare-557 as a second parent, are subjected to different environmental conditions. The early maturing genotypes with coded names of I and II were compared with four native cotton cultivars in randomized complete block design (RCBD) with four replications in three ecological regions of Iran from 2016-2017. Two early maturing genotypes along with four native cultivars viz. Varamin, Oltan, Sahel and Arya were planted in Agricultural Research Station of Varamin, Moghan and Kashmar for evaluation. Earliness data were collected for six treatments during two years in the three regions except missing data for the second year of Kashmar. Therefore, missed data were estimated and imputed. For testing the homogeneity of error variances, each experiment at a given location or year is analyzed separately using Hartley and Bartlett's Chi-square tests and both tests confirmed homogeneity of variance. Combined analysis of variance showed that genotypes I and II were superior in Varamin, Moghan and Kashmar regions. Earliness means and their interaction effects were compared with Duncan's multiple range tests. Finally combined analysis of variance showed that genotypes I and II were superior in Varamin, Moghan and Kashmar regions. Earliness means and their interaction effects are compared with Duncan's multiple range tests.

***Keywords*—**Cotton, combined, analysis, earliness.

I. Introduction

COTTON is an important fiber crop in the world and reputed as queen of the fiber plants. American cotton (*Gossypium hirsutum* L.) is the dominating cotton species grown for its natural fiber. Earliness is one of the most important objectives of cotton breeders. Early maturing varieties not only enhance cropping intensity but also increase income of the growers. Early maturing cultivars cause less fertilizer, irrigation and insecticide applications for farmers and avoids cotton crop from white fly attack, disease buildup, soil moisture depletion, frost damage. Early harvesting also leaves field for the next cultivation [1]

Early maturing is the shortest time to produce a suitable crop. Early maturing also has a relative component that must be recognized when interacting with management practices. For example, in the rainy regions without supplemental irrigation, planting may be delayed to coincide the bloom period with increased rainfall conditions. Delaying in planting also will minimize boll weevil reproduction following their spring emergence from diapauses [2].

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Cotton plant is in-determinant in habit and its boll maturation takes over a period of about 80 days in the early maturing. Plant breeders utilize early open bolls to measure the relative maturity of cotton varieties. Environmental variations make comparisons difficult between years, or specific managements have deferent impacts on the diverse varieties. Morphology of different varieties also can influence maturity, on the other hands morphological traits also impact root/shoot ratios and leaf shape. Divided leaves in the some varieties like Okra allow sunlight to penetrate deeper into the canopy, which improves early boll set. Varieties with lower root/shoot ratios expend less carbohydrate on soil exploration which can enhance early maturing [2].

There are different indices and criteria for earliness evaluation viz. (a) Early flowering days (EFD), (b) Fraction of first seed cotton picking to the total seed cotton yield (FFP), (c) Bartlett's Index (BI) and (d) combined picking and day index (CPD) [3], [4].

For observing the consistency of genotypes and determining the range of their geographical adaptability, repetition of the experiment over locations and years with specific climates and conditions is necessary. In this study, we decided to evaluate the developed genotypes in the three specific regions by combined analysis of variance in fixed model [5].

II. Materials and Methods

In this study, evaluation of two early maturing cotton genotypes is being reported. Initial cross between Sindise-80 as an early maturing parent and Red leaf was attempted 2005. It was followed by selection for superior and early maturing segregants till 2010. During 2011, early maturing genotypes from this cross were hybridized with Sindose-80 and selection for superior and early maturing genotypes were conducted till 2015. The new early maturing genotype identified from this cross named as a genotype I. The same processes have been done between sindos-80 and Bulgare-557 and its early maturing genotype was identified II [6]. The new earliness genotypes identified from these crosses were compared with four native cotton cultivars in RCBD with four replications in the three regions of Varamin, Moghan and Mashhad. The distance between row to row and plant to plant was maintained at 0.8 m and 0.2 m, respectively. Each treatment plot consisted of four rows of 12 m length. Standard agronomical and managements practices were followed to raise the crop. Among the test entries, "early" genotypes I and II were ready for first picking about average of 110 days after germination. The first picking of the remaining varieties was conducted about 169 days after germination and the last

picking of the all varieties was accomplished about 182 days after germination. Followed formula in this study was FFP method for earliness comparison. The collected early maturing data from Varamin, Moghan and Kashmar regions during 2016-2017, except the second year of the Kashmar region which is considered as missed experiment, are subjected to values estimation. On the basis of Yates [7] consideration, missed values of the lost experiment as sixth experiment ($Exp'_{l=6}$) were estimated and imputed using available data. Therefore data set was completed as:

Missed plot estimation = $X'_{lij}=\frac{(t\sum_{i.j}X + r\sum_{li.}X)-\sum_{l...}X}{rt(l-1)}$

$X'_{611}=\frac{6(379+\cdots+302)+(488+\cdots+454)-(1982+\cdots+1886)}{4\times6\times(6-1)}=73$

$X'_{612}=\frac{6(364+\cdots+369)+(488+\cdots+454)-(1982+\cdots+1886)}{4\times6\times(6-1)}=77$

$X'_{621}=\frac{6(379+\cdots+302)+(483+\cdots+459)-(1982+\cdots+1886)}{4\times6\times(6-1)}=70$

$X'_{622}=\frac{6(364+\cdots+369)+(483+\cdots+459)-(1982+\cdots+1886)}{4\times6\times(6-1)}=74$

$\vdots$

$X'_{646}=\frac{6(254+\cdots+282)+(513+\cdots+477)-(1982+\cdots+1886)}{4\times6\times(6-1)}=56$

TABLE I
OBSERVED AND ESTIMATED DATA OF SIX COTTON GENOTYPES AND CULTIVARS FOR EARLINESS (%)

$Exp_{l=1}$		T_1	T_2	T_3	T_4	T_5	T_6	
	R_1	$X_{lij=111}=94$	$X_{112}=89$	77	73	90	65	$X_{11.}=488$
Year = 1	R_2	$X_{121}=96$	91	68	87	79	62	$X_{12.}=483$
Site = 1	R_3	96	92	90	82	77	61	$X_{13.}=498$
	R_4	93	92	90	86	86	$X_{146}=66$	$X_{14.}=513$
		$X_{1.1}=379$	$X_{1.2}=364$	$X_{1.3}=325$	$X_{1.4}=328$	$X_{1.5}=332$	$X_{1.6}=254$	$X_{1..}=1982$
$Exp_{l=2}$		T_1	T_2	T_3	T_4	T_5	T_6	
	R_1	$X_{lij=211}=95$	$X_{212}=91$	76	72	90	66	$X_{21.}=490$
Year = 2	R_2	$X_{221}=95$	91	68	88	79	62	$X_{22.}=482$
Site = 1	R_3	96	92	89	82	76	60	$X_{23.}=495$
	R_4	93	92	89	86	86	$X_{246}=67$	$X_{24.}=513$
		$X_{2.1}=379$	$X_{2.2}=366$	$X_{2.3}=322$	$X_{2.4}=328$	$X_{2.5}=331$	$X_{2.6}=255$	$X_{2..}=1981$
$Exp_{l=3}$		T_1	T_2	T_3	T_4	T_5	T_6	
	R_1	$X_{lij=311}=69$	$X_{312}=68$	48	60	48	33	$X_{31.}=326$
Year = 1	R_2	$X_{321}=39$	59	46	50	37	49	$X_{32.}=280$
Site = 2	R_3	49	57	40	74	65	37	$X_{33.}=322$
	R_4	63	56	48	56	42	$X_{346}=32$	$X_{34.}=297$
		$X_{3.1}=220$	$X_{3.2}=240$	$X_{3.3}=182$	$X_{3.4}=240$	$X_{3.5}=192$	$X_{3.6}=151$	$X_{3..}=1225$
$Exp_{l=4}$		T_1	T_2	T_3	T_4	T_5	T_6	
	R_1	$X_{lij=411}=53$	$X_{412}=48$	55	37	37	46	$X_{41.}=276$
Year = 2	R_2	$X_{421}=39$	51	47	51	19	31	$X_{42.}=238$
Site = 2	R_3	35	39	39	25	23	46	$X_{43.}=207$
	R_4	30	38	43	30	20	$X_{446}=44$	$X_{44.}=205$
		$X_{4.1}=157$	$X_{4.2}=176$	$X_{4.3}=184$	$X_{4.4}=143$	$X_{4.5}=99$	$X_{4.6}=167$	$X_{4..}=926$
$Exp_{l=5}$		T_1	T_2	T_3	T_4	T_5	T_6	
	R_1	$X_{lij=511}=66$	$X_{512}=89$	84	84	58	73	$X_{51.}=454$
Year = 1	R_2	$X_{521}=76$	92	88	89	47	67	$X_{52.}=459$
Site = 3	R_3	79	94	92	85	78	68	$X_{53.}=496$
	R_4	81	94	86	77	65	$X_{546}=74$	$X_{54.}=477$
		$X_{5.1}=302$	$X_{5.2}=369$	$X_{5.3}=350$	$X_{5.4}=335$	$X_{5.5}=248$	$X_{5.6}=282$	$X_{5..}=1886$
$Exp'_{l=6}$		T'_1	T'_2	T'_3	T'_4	T'_5	T'_6	
	R'_1	$X'_{lij=611}=72.98$	$X'_{612}=76.88$	69.28	69.83	61.23	56.58	$X'_{61.}=406.8$
Year = 2 '	R'_2	$X'_{621}=69.95$	73.85	66.25	66.8	58.2	53.55	$X'_{62.}=388.6$
Site = 3 '	R'_3	72.45	76.35	68.75	69.3	60.7	56.05	$X'_{63.}=403.6$
	R'_4	72.02	75.92	68.32	68.87	60.27	$X'_{646}=55.62$	$X'_{64.}=401$
		$X'_{6.1}=287.4$	$X'_{6.2}=303$	$X'_{6.3}=272.6$	$X'_{6.4}=274.8$	$X'_{6.5}=240.4$	$X'_{6.6}=221.8$	$X'_{6..}=1600$
Sites		Site.1: Varamin		Site.2: Moghan		Site.3: Kashmar		
Treatments		T_1 = genotype I	T_2 =Genotype II	T_3 = Varamin	T_4 = Oltan	T_5 = Sahel	T_6 = Arya	

After testing the homogeneity of individual experiment's error variances using Hartley and Barttlett's Chi-square method, data were subjected to the combined analysis of variance following [8] and [9] by fixed model of treatment [10]. Earliness Means was compared with Duncan's multiple range tests.

III. RESULT AND DISCUSSION

Combined analysis of variance [11] is carried out if the errors of each experiment at the locations and years are homogeneous. Therefore, for testing the homogeneity of error variances, each experiment at a given location or year is analyzed separately using Bartlett's Chi-square test and both

tests allowed combined multiple analyses of variance (Table II). Obviously, estimated values make the error sum of square zero in the individual experiment and minimum in the combined multiple analysis of variance.

Hartley's Ratio Test = $\frac{S^2_{max}}{S^2_{min}} = \frac{92.686}{34.788} = 2.66$

Bartlett Test = $\frac{1}{1+\frac{1}{3(k-1)}(\frac{1}{df_i}+\frac{1}{df_i}+\frac{1}{df_i}+\frac{1}{df_i}+\frac{1}{df_i}-\frac{1}{df_p})}\left[df_p \times lnS^2_p - \sum(df_i \times lnS^2_i)\right]$

$S^2_p = \frac{\sum(df_i \times S^2_i)}{df_p}$

$S^2_p = \frac{\sum(df_i \times S^2_i)}{df_p} = \frac{3837.45}{75} = 51.165$

$x^2 = \frac{1}{1+\frac{1}{3(5-1)}(\frac{1}{15}+\frac{1}{15}+\frac{1}{15}+\frac{1}{15}+\frac{1}{15}-\frac{1}{75})}[75 \times 3.935 - 289.845] = 5.147$

TABLE II
HARTLEY AND BARTLETT'S CHI-SQUARE TEST FOR HOMOGENEITY OF ERROR VARIANCES

Sources	DF	Tehran		Moghan		Mashhad		Bartlett's index	Hartley's index
		Year 1	Year 2	Year 1	Year 2	Year 1	Missed		
Replications	3	29.167	27.375	78.486	184.732	60.723	10.562		
Treatments	5	468.267	469.542	314.242	235.367	514.267	227.715	5.147	2.66
$MS_E = S^2_i$	df_i=15	34.788	36.808	92.686	50.189	41.356	0.000		
CV%		7.14	7.35	18.86	18.36	8.18	0.000		

χ^2 for 4 degrees of freedom in 95% probability = 9.49. Harley's Ratio table for (5,15) in the 95% probability is 4.37.

TABLE III
MEAN SQUARES FROM ANOVA FOR EARLINESS (%) IN COTTON CULTIVARS

Sources	DF	MS	F-Values	Prob	CV%
Year	1	2384.694	55.9265	0.0000	
Location	2	18378.813	421.0247	0.0000	
Year ×Location	2	590.965	13.8595	0.0000	
R(YL)	18(- $\frac{rt}{l} = \frac{4\times6}{6}$ =14)	65.079 (83.673)	1.5262	0.0992	9.79
Earliness	5	1360.95	31.9174	0.0000	
Year × Earliness	5	69.111	1.6208	01626	
Location × Earliness	10	235.663	5.5268	0.0000	
Year × Location ×Earliness	10	161.382	3.7848	0.0003	
Error	90 (- rt = 66)	42.64 (58.145)			

Combined analysis of variance shows significant differences among the cultivated cultivars and varieties, location, year × location, year ×treatment and year × location ×treatment and non-significant between location × earliness effects for earliness (Table I). Missed value estimations caused that the values of $\frac{rt}{l} = \frac{4\times6}{6}$ =14 and rt = 66 deducted from R(YL) and Error and F-test should be done after adjustment of the two above mentioned values. Varamin, Moghan and Kashmarsites in the two different years had specific different environments for specific cotton cultivars and these sites are considered as a non-random sample from the population. Therefore their effects considered are fixed effect model (Table III).

Duncan's mean comparison [12] is carried out by three categories of comparisons: two means normal (2-N), one mean normal and other mean including missed value (1-M) and both two means including missed values (2-M). Their least significant ratios for required ranges are computed by related following formulae and briefed in Table IV.

$S_{\bar{x}}$ Estimation for two normal means:

$S_{\bar{x}} = \sqrt{\frac{MS_E}{r(l-1)}} = \sqrt{\frac{58.145}{4(6-1)}} = 1.705$

$S_{\bar{x}}$ Estimation for one missed mean:

$S_{\bar{x}} = \sqrt{\frac{MS_E(\frac{2}{r(l-1)}+\frac{t}{r(r-1)(t-1)(l-1)})}{2}}$

$S_{\bar{x}} = \sqrt{\frac{58.145(\frac{2}{4(6-1)}+\frac{6}{4(4-1)(6-1)(6-1)})}{2}} = 1.868$

$S_{\bar{x}}$ Estimation for two missed means:

$S_{\bar{x}} = \sqrt{\frac{MS_E(\frac{1}{(l-1)}+\frac{1}{(l-1)})}{2}} = \sqrt{\frac{\frac{2MS_E}{(l-1)}}{2}} = \sqrt{\frac{\frac{2\times58.145}{(6-1)}}{2}} = 3.411$

TABLE IV
CRITICAL VALUES AT 1% SIGNIFICANCE LEVEL FOR DUNCAN'S MULTIPLE RANGE TEST IN N= NORMAL AND M= MISSED VALUE CONDITION OF MEANS

DF = 66	2	3	4	5	6	7	8	9	10	11	12	13	14
SSR	3.75	3.91	4.02	4.11	4.16	4.22	4.26	4.3	4.33	4.38	4.4	4.43	4.45
LSR.2-N	6.398	6.668	6.858	7.009	7.095	7.197	7.265	7.333	7.387	7.475	7.555	7.553	7.587
LSR.1-M	7.010	7.306	7.514	7.679	7.773	7.885	7.960	8.034	8.093	8.189	8.277	8.275	8.331
LSR.2-M	12.8	13.340	13.721	14.023	14.193	14.398	14.534	14.671	14.778	14.954	15.114	15.111	15.179

Duncan's mean comparison shows that new earliness genotype II and I allocated the first ranking of the earliness percentage with 75.75% and 71.83% in three regions respectively. In the three studied sites, Varamin had the best

ranking of 82.56% of earliness and for interaction effects of treatment × location genotype I and II with 94.75% and 91.25% respectively and for interaction effects of cultivar and varieties in the three regions and two years genotypes I had the best ranking with 94.75%. More comparisons are available on Table V.

TABLE V
DUNCAN'S MEAN COMPARISON OF EARLINESS (%) IN COTTON CULTIVARS

Source	Mean	Rank	Source	Mean	Rank	Source	Mean	Rank
Year	1= 70.74	A	Location	1= 82.56	A	Y× L= (1×1)	82.58	A
	2= 62.60*	B		3= 72.63*	B	2× 2	82.54	A
				2= 44.81	C	2× 1	78.58	A
						3× 2	66.67*	B
						1× 2	51.04	C
						3× 1	38.58	D
	2= 75.75*	A	L×T(1×1)	94.75	A	Y×L×T = (1×1×1)	94.75	A
Earliness	1= 71.83*	AB	1×2	91.25	A	2×1×1	94.74	A
	4 = 68.71*	ABC	3×2	84*	B	1×3×2	92.25	A
	3= 68.13*	ABC	1×5	82.88	B	2×1×2	91.50	A
	5= 60.08*	BC	1×4	82	B	1×1×2	91	A
	6= 55.5*	C	1×3	80.88	B	1×3×3	87.5	B
			3×3	77.75*	B	1×3×4	83.75	B
			3×4	76.25*	B	1×1×5	83	B
			3×1	73.63*	B	2×1×5	82.75	B
			1×6	63.63	C	1×1×4	82	B
			3×6	63.13*	C	2×1×4	81.9	B
			3×5	61*	C	1×1×3	81.25	B
			2×2	52	D	2×1×3	80.5	C
			2×4	47.88	D	2×3×2	75.75*	C
			2×1	47.13	D	1×3×1	75.5	C
			2×3	45.75	D	2×3×1	71.75*	D
			2×6	39.75	E	1×3×6	70.5	D
			2×5	36.38	E	2×3×4	68.75*	D
						2×3×3	68*	D
						2×1×6	63.75	E
						1×1×6	63.5	E
						1×3×5	62	E
						1×2×2	60	E
						2×3×5	59.9*	E
						1×2×4	59.8	E
						2×3×6	55.75*	F
						1×2×1	55	G
						1×2×5	48	H
						2×2×3	46	H
						1×2×3	45.5	H
						2×2×2	44	H
						2×2×6	41.75	H
						2×2×1	39.25	I
						1×3×1	37.75	I
						2×2×4	35.75	I
						2×2×5	24.75	J

IV. CONCLUSION

The main purpose that trials carried out on the specific sites simultaneously was to find compatible early maturing cotton genotypes for particular regions of Varamin, Moghan and Khashmar. Analysis of variance showed significant differences among treatments for earliness trait and related Duncan's mean comparison showed that newly developed genotypes had the first ranking of early maturing.

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