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STABILITY OF COTTON CULTIVARS FOR EARLY CROP MATURITY ACROSS VARIABLE PLANT SPACING AND SOWING TIMES

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Abstract

Earliness of crop maturity being a complex trait in cotton is significantly altered by a number of agronomic practices including inter plant spacing and sowing time thus making identification of true early maturing cultivars a difficult task under field conditions. In this study, cotton cultivars were subjected to twelve environments provided through three plant spacings, two sowing dates over two years to assess phenotypic stability for earliness index. The stability parameters were calculated following Eberhart & Russell. Stability analysis revealed presence of genetic differences among cultivars for earliness index. Significant cultivar X environment (linear) indicated differential response of cultivars to various environments for earliness index. Cotton cultivars 15/2S and Krishna showing near unity (<1.0) regression coefficient (b) were regarded as above average stable which can mature early under all environments. CIM-448, despite showing higher mean value, had b value significantly distant from unity, hence regarded as unstable for earliness over variable growing conditions. CIM-448, under May sowing and CIM-1100 under June sowing, can be utilized as substitutes in the absence of true early maturing cultivars. Cultivars Krishna and 15/2S were found to be stable for earliness of crop maturity over a range of environments and can safely be utilized as early maturing parents in any cotton crop maturity improvement programme.

Introduction

Earliness of maturity in cotton provides escape mechanism from late season pest pressure especially boll-worm as the plants are exposed to pest attack for a shorter period and therefore fewer sprays reducing pesticide use. The genetic characters and their interaction with the environments affect crop maturity in cotton, by altering timing and duration of various growth stages. Impact of plant spacing on earliness and yield and dependence of_various phenological stages (days to squaring, flowering, boll opening, boll maturation period) on temperature are well documented (Atwell, 1996; Malik & Shahawy 1999; Reddy *et al*., 1999; Hussain *et al*., 2000; Shaheen *et al*., 2001; Jost & Cothren, 2001).

Large genotype-environment interactions reduce progress from selection (Comstock & Moll 1963). The possible way to reduce the effect of genotype-environment interaction would be to select stable genotypes that interact least with the environment where it is grown. Thus screening genotypes for stability of performance under varying environmental conditions has become an essential part of any breeding programme.

Stability analysis (Eberhart & Russell, 1966) has been successfully used to determine stable cotton genotypes for seed cotton yield (Mert *et al*., 1994, Palomo & Godoy 1996), lint yield and crop maturity (McPherson *et al*., 1996), seed cotton yield under leaf curl virus disease environment (Rahman *et al*., 2001), seedling vigour traits across moisture stress conditions (Saadia *et al*., 1996) and different sodium chloride regimes (Perveen *et al*., 1997).

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To start a breeding programme aimed at crop maturity improvement, real/ true determinate breeding cotton parents are required that are almost absent in Indo-Pakistan sub-continent (Ahmad & Malik, 1996; Kairon & Singh, 1996). Due to paucity of true determinate parents, cotton cultivars belonging to various maturity groups were subjected to different environments provided through variable plant spacing and sowing dates (Mather & Jinks, 1982) to select cotton cultivars stable for earliness of crop maturity over a range of environment for its efficient utilization in breeding programme, aimed at crop maturity improvement.

Material and Methods

The experiment was conducted in the research area of Cotton Research Institute, Faisalabad during 2001 and 2002. Six cotton cultivars representing local gene pool viz., Krishma, 15/2S, CIM-448, S-14, FH-87 and CIM-1100, of variable crop maturity were planted at three plant spacing i.e., 45, 30 and 15cm over 2 sowing dates i.e., first week of May, (normal sowing) and first week of June, (late sowing).

The lay out was a randomized complete block design comprising three replications with a split plot arrangement of treatments. Sowing time was kept in main plots and plant spacing and cultivars were randomized in subplots in factorial arrangement. The plots consisted of 3 rows, 75 cm wide by 6 m long. The plots were hand thinned at the 4th or 5th true leaf stage to ensure the number of plants per plot according to plant spacing treatment.

General agronomic practices recommended for early and late sown cotton crop were adopted. Adequate irrigation was applied by flooding when necessary especially during reproductive stage to avoid drought induced earliness. Irrigation interval varied in years and sowing dates from 7 to 20 days depending upon the plant requirement, temperature, and rainfall. The last irrigation was applied 145 days after sowing (DAS). Fertilizer was applied @ 150-50-0 (NPK) kg/ha, with 1/3 nitrogen and all phosphorus at sowing time. The remaining nitrogen was applied in two equal splits at flowering and boll formation. No potash was applied as pre sowing soil analysis revealed sufficient amount of potash in the soil (<140ppm during both years). Plant protection measures were adopted as and when necessary. During both the years, the plants were sprayed with suitable pesticides for proper insect control and 3-4 hoeings were carried out for proper weed control.

At maturity ten equally competitive plants were earmarked at random for recording the data. All the plots were picked twice. First picking was done 130 days after sowing and second/final pick was made 200 days after sowing. Earliness index was calculated as % of total seed cotton picked in the first pick.

Statistical and stability analyses

Each plant spacing-sowing date-year combination was considered as one environment after comparing variances of 12 environments through Bartlett's test (Gomez & Gomez, 1984). Data were recorded for seed cotton yield 130 and 200 days after sowing to calculate earliness index. Linear regression (b), Deviation from regression (S2di) and mean performance (mi) were calculated following Eberhart & Russell (1966) to assess phenotypic stability of cultivars over environments (sowing date-plant spacing-year) for earliness index.

Results

Analysis of variance for earliness index (EI) of six cotton cultivars evaluated across 12 environments revealed significant differences among cultivars, environment and cultivar X environment interaction (Table 1). As cultivar X environment interaction was significant the data were subjected to stability analysis which revealed highly significant differences among the cultivars depicting presence of large genetic differences among cultivars for EI (Table 2). Cultivar X environment (linear) interaction was also significant, indicating the differences among cultivars for their differential response to various environments.

Table 1. Analysis of variance for earliness index (%) of six cotton cultivars evaluated across twelve environments created through three plant spacing and two planting times over two years (2001 and 2002).

Source of variation	df	Sum of squares	Mean square	F-value
Replication	2	20.034	10.017	0.111
Environment	11	112824.581	10256.78	113.6548
Genotype	5	19540.149	3908.03	43.3047
Env. X Genotype	55	20229.513	367.809	4.0757
Error	142	12814.791	90.245	
Total	215	165429.068		
	CV%	**18.25**		

Table 2. Stability analysis of variance for earliness index (%) of six cotton cultivars evaluated across twelve environments created through three plant spacing and two planting times over two years (2001 and 2002).

Source of variation	df	Mean squares	F-ratio
Environment (E)	11	3418.935	37.885
Variety (V)	5	1302.677	14.435
V x E	55	122.6041	1.359
Env. (linear)	1	37608.273	416.735
V x E (linear)	5	445.7628	4.939
Pooled deviation	60	75.2408	0.834
15/2S	10	67.9946	0.753
Krishna	10	83.2114	0.922
CIM-448	10	39.9192	0.442
S-14	10	161.1973	1.786
FH-87	10	39.1682	0.434
CIM-1100	10	59.9543	0.664
Pooled error	**142**	**90.245**	

Stability parameters showed that cotton cultivar 15/2S exhibited maximum mean value for earliness index and was significantly different from all other cultivars studied followed by CIM-448 and Krishna, both showing non-significant differences among themselves (Table 3). FH-87 was next in lane, trailed by CIM-1100 and S-14 at the bottom (both showing non-significant differences). S-14, 15/2S, Krishna and FH-87 showed non-significant regression coefficient near to unity whereas, CIM-448 and CIM-1100 exhibited regression coefficient significantly deviating from unity. The values of mean deviation from regression (S^2d) for all cultivars were non-significant.

Table 3. Estimates of stability parameters for six cotton cultivars evaluated for earliness index across twelve environments created through three plant spacing and two planting times over two years (2001 and 2002).

Genotype	Mean	Mean deviation	b-value	SE of b
Krishna	58.24 b	83.2114 ns	0.9161 ns +/-	0.1152
S-14	39.56 d	161.1973 ns	0.9440 ns +/-	0.1604
CIM-448	58.30 b	39.9192 ns	0.6309 ** +/-	0.0798
CIM-1100	42.61 d	59.9543 ns	1.4302 ** +/-	0.0978
FH-87	47.49 c	39.1682 ns	1.1419 ns +/-	0.079
15/2S	66.18 a	67.9946 ns	0.9368 ns +/-	0.1042
Average=	52.06			
L.S.D. (0.05%)	**4.42**			

Estimates of environmental index and genotypic means revealed negative environmental index values for May sowing and positive for June sowing irrespective of plant spacing (Table 4). It depicted that May sowing was "unfavourable" environment, whereas, June sowing proved "favourable" for the enhancement of early crop maturity in cotton. Highest mean value for EI was shown at 6, followed by 5 and 11, however, the differences were statistically non-significant. The other environment to produce EI values of more than 50% were 10, 12 and 4. Rest of the environments showed EI value of less than 50%. Cotton cultivars 15/2S, FH-87 and CIM-1100 gained maximum earliness under 5, whereas, CIM-448 and Krishna produced highest EI values under environment 6. S-14 excelled under environment 11 for earliness of crop maturity.

Earliness index and regression coefficients were plotted together (Fig. 1) as ordinates in a two-dimensional scatter diagram which depicted that cultivars 15/2S and Krishna had high mean and regression coefficient $\simeq$ 1.0, thus showing general adaptability to all environments for earliness of crop maturity. Cv. S-14 also had regression coefficient $\simeq$ 1.0 but lowest mean value for earliness index. Cv. CIM-448 with regression coefficient less than 1.0 and the mean greater than overall average show specific adaptability to unfavourable environments. FH-87 and CIM-1100 showed specific adaptability to favourable environments with regression coefficient higher than 1.0. The slopes of individual cultivars are depicted in Fig. 2a, b, c, d, e, and f. Regression lines of 15/2S, Krishna and S-14 had almost similar slopes (due to b $\simeq$ 1.0) but had different intercepts (due to maturity differences over environments). CIM-448, CIM-1100 and FH-87 had different slopes and different intercepts (Fig. 2).

According to Eberhart & Russell (1966), the ideal genotypes would be the one with high mean, regression coefficient equal to unity (b=1) and low deviation mean squares (Sd1=0). The statistics "b" measures the linear response of individual cultivar to an environmental index, whereas S_2di refers to deviations from this response. They further pointed out that the varieties exhibiting high regression coefficients (b>1) could be considered as below average stable varieties. Such varieties will perform well only in favourable environments while their performance will be poor in unfavourable environments. The varieties with low regression coefficients (bi>1) are above average stable and are adapted especially to poor environments.

Based on the above set criteria, the cultivars 15/2S and Krishna, showing general adaptability to all environments due to their high mean value and regression coefficient ($\simeq$ 1.0), appeared to be stable for earliness of crop maturity. It showed that both the cultivars possessed relatively high degree of earliness as compared to other cultivars and this earliness seemed to be function of genotypes due to their consistent performance for earliness of crop maturity exhibited at all combinations of year, plant spacing and planting time.

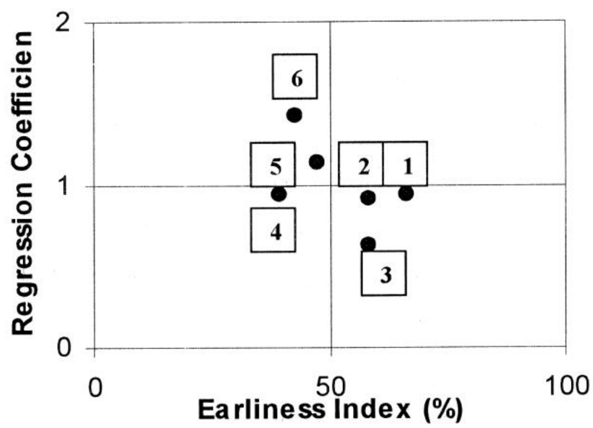

Fig. 1. Scatter diagram of six cotton cultivars for earliness index (%) and regression coefficient over twelve environments created through three plant spacing and two planting times over two years (2001 & 200)
1= 15/2S 2= Krishna 3= CIM-448 4= S-14 5= FH-87 6= CIM-1100

Discussion

Cotton cultivars 15/2S and Krishna, due to their high mean value and regression coefficient above unity showed general adaptability to all environments, hence, appeared to be stable for earliness of crop maturity. There is sufficient evidence that the mean performance and the ability to perform consistently over variable environments are two independent characters, which can be genetically manipulated (Bucio-Alanis *et al.,* 1969; Bains, 1976). Dowker (1971) suggested that in a practical breeding programme, it is desirable to capitalize on the G X E interaction present in order to find those environments in which the genotypic effects of interaction may be maximized. The present study revealed that June sowing with close plant spacing (15cm) can be used to enhance earliness. Cultivar CIM-448 showed higher EI under unfavourable environment and therefore, can be utilized for May sowing. Similarly, CIM-1100 showing high degree of earliness under favourable environments, can be recommended for June sowing to get enhanced earliness. Palomo *et al*., (1998) and Carvalho *et al*., (1999) also made recommendations for favourable and unfavourable environments on the basis of stability parameters in cotton.

Significant variety X treatment or variety X location interactions suggest that appropriate breeding programme should allow for the development of a number of varieties each particularly adapted to one of the special environments. Such a course of action is usually feasible because there seems to be no limit to the variability available enabling plants to adapt to specific conditions of temperature, photoperiod, soil fertility and method of harvesting. In certain cases the environmental factors may be one with adverse effects which could be remedied if suitable agronomic or other steps were taken e.g., correction of salinity. However, it may often be easier to cure the genotype rather than the environment (Epstein, 1963, Allard & Bradshaw, 1964). However, the varieties developed with specific adaptation to predictable special environments should also be adapted to withstand unpredictable transient environmental variations. Such varieties will be able to adjust their life processes in ways such as to maintain productivity at a level despite unpredictable fluctuations of the environment (Allard & Bradshaw 1964).

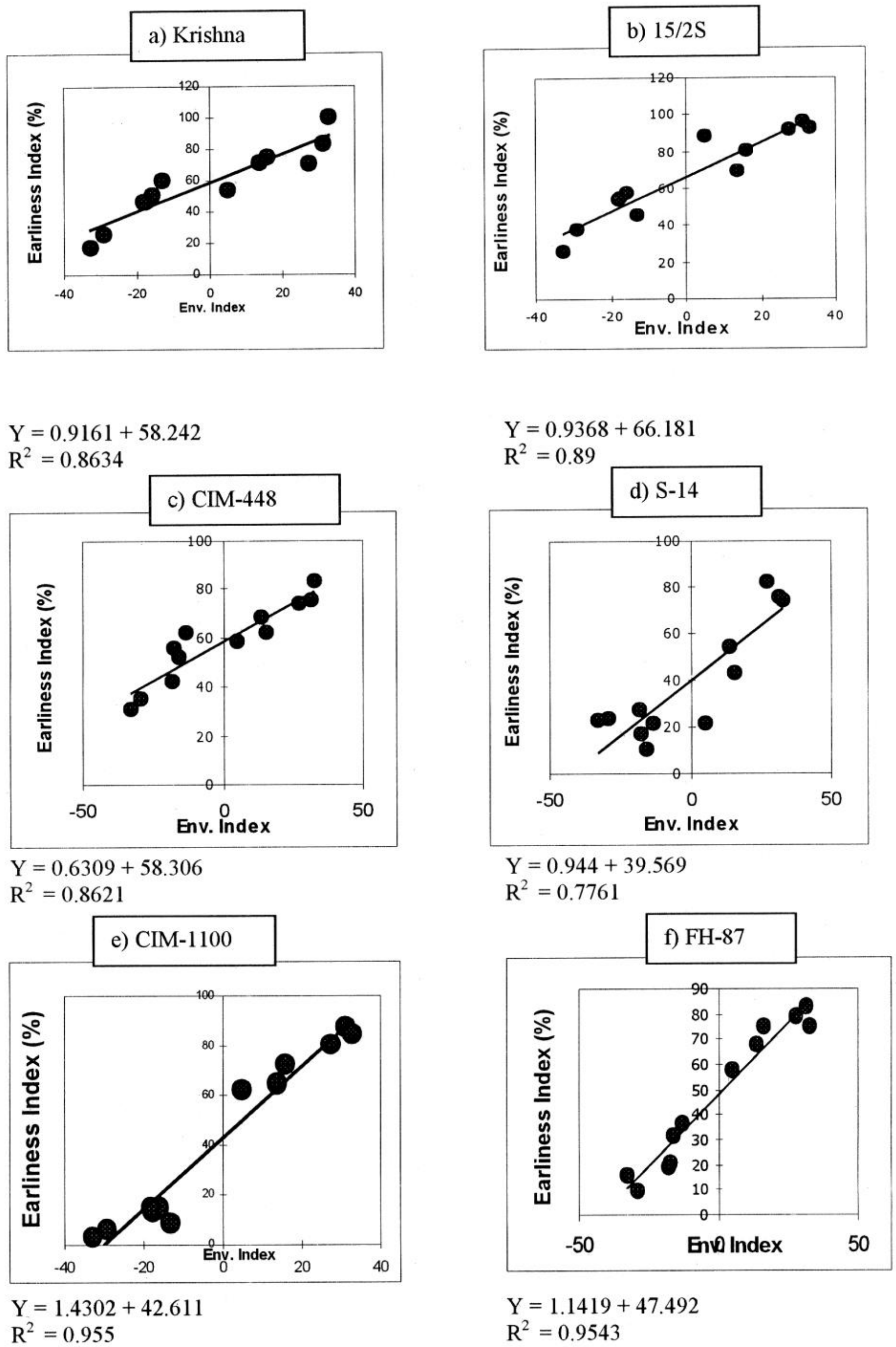

Fig. 2. Slope of six cotton cultivars for earliness index (%) over twelve environments created through three plant spacing and two planting times over two years (2001 & 2002).

Talukdar & Bains (1982) while studying both segregating and non-segregating generations of wheat, indicated the genetic nature of stability. McPherson *et al*., (1996) identified stable cotton cultivar for earliness of crop maturity through stability parameters. The efficiency of stability analysis to identify genotypes stable for various traits in cotton and other crops have also been demonstrated by Rahman *et al*., (2001). Hence, earliness with linear stability, shown by 15/2S and Krishna, can be transferred to the genotypes, which are unstable for earliness but otherwise possessing high mean performance. It could therefore suggest that both the cultivars could effectively be utilized as early maturing parents in any breeding programme aimed to improve earliness of crop maturity in cotton.

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