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G x E interaction and stability analysis in sunflower (*Helianthus annuus* L.)

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Abstract

The present study was carried out to identify sunflower hybrids suitable for water and salt stress areas which will be highly essential for increasing area of cultivation under sunflower. This study included sixty hybrids along with their parents *viz.,* four Cytoplasmic Male Sterile (CMS) lines and fifteen restores. The 60 hybrids and their 19 parents were evaluated in three different environments *viz.*, Normal condition, Rainfed condition and Salt stress condition. From this study it was concluded that the hybrids are more adaptive than parents for yield and yield components. Among the 60 hybrids studied, 821A x 6D-1, 821A x CO 4 and 852 A x RHA 298 were found to be stable with high mean, regression coefficient (bi) around unity and deviation from regression coefficient (S^2_{di}) around zero for the three characters *viz.*, diameter of stem, head diameter and seed yield per plant. These hybrids were concluded as stable hybrids.

Key words: Cytoplasmic male sterile lines, Eberhart and Russell, Stability and Sunflower

Introductions

Sunflower, a new world plant is now becoming an increasingly important source of edible vegetable oil throughout the world. Though sunflower hybrids are high yielder, the influence of G x E interaction is more on their performance. A specific difference in environment may have a great effect on some genotypes than others. The location effect, seasonal fluctuation and their interaction highly had its influence in the performance of genotypes with its yield potential. The development of well buffered hybrids / genotypes is the major objective of sunflower breeders. Knowledge on the interaction and stability [1] is essential in breeding varieties/ hybrids for general adaptation particularly for a crop like sunflower which has the ability to adjust and grow successfully in different agro-climatic situations. Development of a sunflower hybrid with stable yield under water or salt stress will be highly useful to farming community to get consistent yield. In this understanding, 60 sunflower hybrids were evaluated under normal, rainfed and salt stress environments.

Materials and methods

This experiment was carried out with a purpose of developing sunflower hybrids suitable for normal as well as abiotic stress environments. Sixty hybrids had been developed using four cytoplasmic genie male sterile lines *viz.,* 351 A, 821 A, 852A and 234A and fifteen tester *viz.,* RHA 265, RHA 274, RHA 278, RHA 273, RHA 857, RHA 297, RHA 298, RHA 299, RHA 586, 6D-1, RRI, RHA 859, RHA 856, CO 4 and Morden which also acted as restores for all the CMS lines during *kharif* 2002-03. The seeds from 60 F_1 cross combinations along with their 19 parents were raised in three different environments *viz.,* Agricultural College & Research Institute, Madurai (Alfisol-Irrigated), Regional Research Station, Aruppukkortai (Vertisol - Rainfed) and Anbil Dharmalingam Agrl. College & Research Institute, Trichy (Calcareous sodic soil-Irrigated) in Tamil Nadu. Six important characters *viz.,* plant height, stem diameter, head diameter, hull percent, Oil content and Seed yield/ plant were recorded on five randomly selected plants in each replication for all the genotypes in all environments. The mean data on five plants in each replication for each genotype were utilized for statistical analysis. Eberhart and Russell [2] method was followed to estimate the three parameters of stability namely mean, regression coefficient (b_i) and mean squared deviation (S^2_{di}) for each genotype.

Results and discussion

The estimates of environmental index were computed for different characters. The environmental index for plant height rainfed condition (10.62) registered high environmental index when compared to other environments *viz.*, normal (7.84) and salt stress (–18.46). The range of environmental index for stem diameter was observed from –0.07 (salt stress condition) to 0.08 (rainfed condition). For the trait head diameter, the highest and lowest indices were recorded by E_1 (0.45) and salt stress condition (–0.80). For hull percent normal condition registered high index (3.61) followed by rainfed condition (–0.78) and salt stress condition (–2.84). For the traits oil content and seed yield/plant normal condition registered high indices of 1.45 and 7.99 respectively followed by rainfed condition (–0.32 and -0.03) and salt stress condition (–1.13 and –7.82). Among these environments normal condition recorded high and positive environment indices for all the characters except stem diameter, followed by rainfed condition and then salt stress condition. The conclusion from this study was that the normal irrigated condition provided favourable situation for high phenotypic expression. Between the two abiotic stresses, the interaction of genotypes over environment is less in rainfed condition and more in salt stress condition thereby enabling the sunflower genotypes to adapt more in former condition than the latter.

The analysis of variance for different traits in individual and pooled analysis indicated that they differed among themselves for all the characters. In Eberhart and Russell [2] model, the mean squares of genotypes and environments revealed significant differences between genotypes and environments. Mean squares due to genotype x environment interaction showed differential behaviour of genotypes under different environments. Earlier workers [3-5] also observed considerable G x E interaction in sunflower. Both linear and non linear components of G x E interaction were significant for all the characters indicating the importance of both regression coefficient (bi) and deviation from regression (S^2_{di}) in determining the stability. Breese [1], Samuel *et al.*, [6] and Chaudhary and Paroda [7] advocated that linear regression (b_i) could simply be recorded as measure of response of particular genotype where the deviation from regression (S^2_{di}) as a measure of stability. Based on estimates they classified that if the regression coefficient (b_i) is around zero the genotype is average in stability and if the b_i is significantly more than unity ($b_i > 1$) the stability is below average. It will perform well only in favourable environments and poor in unfavourable environments. The genotypes with low b_i ($b_i < 1$) will be above average in stability and will perform well in poor environments like drought or salt stress conditions. Thus a variety is said to be perfectly stable if it had high or desirable mean, deviation from regression coefficient (S^2_{di}) not significantly deviate from zero and bi not significantly deviate from unity.

Table 1. Stability analysis through Eberhart and Russell (1966) model

Stable genotypes	Mean	b_i	S^2d_i
Plant height (cm)			
351A	151.75**	1.06	-7.91
234A x RHA 298	156.67**	1.05	9.87
234A x RHA 299	149.92**	1.14	-2.88
234A x RHA 859	146.46**	1.08	-4.24
234A x CO4	159.47**	1.05	-2.45
Stem diameter (cm)			
821A x 6D-1	1.78	1.64	0.0
852A x RHA 299	1.86	0.79	0.0
852A x RHA 298	1.98	0.92	0.0
234A x RHA 297	1.73	1.21	0.0
234A x Morden	2.1	1.61	0.0
Head diameter (cm)			
821A x 6D-1	15.83	0.92	0.06
852A x C04	15.77	1.25	0.09
852A x RHA 298	15.67	-1.17	0.05
234A x 6D-1	15.28	1.47	0.04
234A x CO 4	14.79	0.07	0.03
Hull percent			
234A x RHA857	27.22	0.52	0.21
234A x RHA 297	24.78	1.49	-0.2
Oil content %			
CO 4	34.8	1.8	0.03
852 A x 6D-1	27.41	0.53	0.37
852 A x CO4	27.58	0.73	0.06
Seed yield/plant (g)			
234 A	25.67	1.11	-1.74
6D-1	27	0.89	6.31
Morden	29.57	0.78	-1.87
351 Ax RHA 859	41.6	0.58	2.15
821 Ax RHA 273	46.32	1.78	-1.9
821 Ax RHA 274	37.26	1.85	0.48
821Ax6D-1	58.41**	0.76	-0.49
821 Ax CO 4	48.27**	1.5	-1.91
852A x RHA 298	53.27**	1.57	-1.57
852A x RHA 299	41.24	1.79	2.4

The mean performance of the parents in plant height measured from 102.21cm (Morden) to 151.75 cm (351 A) and hybrids from 107.27 cm (821 A x RHA 856) to 159.47 cm (234 A x CO 4). For stem diameter the range varied from 1.21 (586) to 1.79 (Co 4) for parents and 1.22 (351 A x RHA278) to 2.41 cm (821 A x CO 4) for hybrids; for head diameter parents recorded from 5.58cm (RHA 856) to 14.09 cm (Morden) and hybrids recorded from 10.01 cm (234 A x RHA 265) to 20.23 cm (351 A x 6D-1). The per se performance for hull percent ranged from 14.84 (RHA 856) to 25.27 (CO 4) for parents and 15.42% (234 A x RHA 265) to 36.41 (821 A x RRI) for hybrids; for oil content varied from 23.07% (351 A x RRI) to 37.78% (234 A x RHA 265) for hybrids and 19.15% (6 D-1) to 37.671% (RHA 297) for parents and for seed yield/ plant per se performance varied from 18.11 (821 A x Morden) to 64.08g (351 A x 6 D-1) for hybrids and from 19.23 (RRI) to 31.83 (CO4) for parents.

The following genotypes found to be stable since recorded high mean with regression coefficient (bi) values around unity and deviation from regression coefficient (S^2_{di}) non-significant to zero. For plant height, the genotypes 351 A, RHA 265, RHA 298, CO 4, 351 A x RHA 297, 821 A x RHA 299 and 852 A x RRI, 234 A x RHA 297, 234 A x RHA 298, 234 A x RHA 299, 234 A x 6D-1, 234 A x RHA 859, 234 A x RHA 856 and 234 A x CO 4; for stem diameter, the hybrids 234 A, 351 A x RRI, 852 A x RHA 299, 234 A x 6D-1, 234 A x CO 4, 234 A x RHA 297, 234 A x Morden and 821 A x 6D-1; for head diameter, the hybrids 852 A x RHA 856 and 234 A x 6D-1; for hull percent, two hybrids 234 A x RHA 857 and 234 x RHA 297; for oil content the hybrid 234 A x RHA 274; for seed yield/plant the parents 234 A, Morden, 6D-1 and RHA 297 and the hybrids 351 A x RHA 859, 821 A x RHA 274, 821 A x RHA 273, 821 x 6 D-1, 821 A x CO 4, 852 A x RHA 298 and 234 A x RHA 299 were found to possess stability over different environments.

Other than these hybrids some genotypes which recorded high mean, bi more than unity and non-significant S^2_{di} were found to suitable for favourable environments. For plant height the parent RHA 297; for stem diameter Morden, head diameter RHA 273; for oil content (%) 852 A, 351 A x RHA 265, 821 A x RHA 265, 852 A x RHA 299 and 234 A x RHA 278; for seed yield/ plant 234 A x RHA 586, 234 A x 6D-1, 234 A x CO 4 and 234 A x Morden were found to be suitable for favourable environment. Some genotypes which recorded high mean, b_i less than unity and non-

Table 2. Genotypes suitable for favourable/unfavourable environment identified through Eberhart and Russell (1966) model

Genotypes suitable for favourable environment	Mean	b_i	S^2d_i
Plant height (cm)			
RHA297	132.69	2.84**	-7.34
Stem diameter (cm)			
Morden	1.75	2.57	0.00
Head diameter (cm)			
RHA273	7.17	2.44	0.03
Hull percent			
852A x RHA 857	21.54	3.55	–0.20
Oil content (%)			
852 A	31.26	2.1	–0.34
351 A x RHA 265	30.93	3.73	0.43
821 A x RHA 265	34.62	2.64	0.04
852 A x RHA 299	31.75	2.76	0.46
234 A x RHA 298	34.24	3.35	–0.03
Seed yield/plant (g)			
234 A x RHA 5 86	48.83*	3.01**	–1.79
234A x 6D-1	38.93	2.73*	–1.88
234A x CO 4	37.8	2.03	0.79
234A x Morden	38.09	3.44**	0.68
Plant height (cm)			
852 A127.54	0.38	8.48	
Stem diameter (cm)			
821 Ax RHA 857	1.96	–1.97	0.00
Head diameter			
351 Ax RHA 857	13.72	–1.63	0.06
351 Ax RHA 273	14.69	–0.51	0.09
821 Ax RHA 856	14.3	–5.43	0.06
852 A x RHA 299	16.32*	–3.68	–0.07
852 A x 6D-1	14.54	–2.75	0.13
Hull percent			
351 Ax RHA 857	25.56	–0.31	–0.13
234A x RHA 297	24.78	–1.49	–0.21
Oil content (%)			
RHA 265	31.72	–0.37	0.58
RHA 297	37.67**	–0.83	–0.22
RHA 298	33.89	–1.35	–0.08
234 A x RHA 265	37.78**	–0.24	–0.37
Seed yield/plant (g)			
821 Ax RHA 298	35.87	–1.17	–1.17

significant S^2_{di} were found to suitable for unfavourable environments. For plant height 852 A; for diameter of stem 821 A x RHA 857; for diameter of head 351 A x RHA 857, 351 A x RHA 273, 821A x RHA 856, 852 A x RHA 299, 852 A x 6D-1, 852 A x RHA 856, 234 x CO 4; for hull percent 351 A x RHA 857 and 234 A x RHA 297; for oil content RHA 265, RHA 297, RHA 298 and 234 A x RHA 265 and for seed yield/plant 821 A x RHA 298 were found to be promising in unfavourable conditions.

Among parents, the combining ability study revealed that 821 A, 6D-1, CO 4 and Morden in normal condition, CO 4 and Morden in rainfed condition, 821 A, RHA299, 6D-1 and CO 4 in salt stress condition and CO 4 in across environments as best parents for producing superior segregants with favourable genes for yield and different yield contributing characters. While considering environments together the line 821A and 6D-1 performed well both in normal and salt stress conditions and Morden performed well in normal and rainfed conditions.

According to Nuthan [8] and Madrap and Makne [9] the hybrids are more adaptive than parents for yield and yield components. Here also among the 60 hybrids studied, 234 A x 6D-1 and 234 A x CO 4, (for plant height, stem diameter and head diameter) and 821A x 6D-1, 821A x CO 4 and 852 A x RHA 298 (for stem diameter, head diameter and seed yield/plant) were found to be stable with high mean, regression coefficient (bi) around unity and non significant deviation from regression coefficient (S^2_{di}) around zero. These hybrids were concluded as stable hybrids.

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