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STABILITY ANALYSIS OF SUNFLOWER HYBRIDS THROUGH NON-PARAMETRIC MODEL

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SUMMARY

An investigation was carried out at the experiment plots of the Department of Genetics and Plant Breeding, Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore, India, to assess the stability of fifteen newly developed sunflower hybrids along with four checks across four seasons using a non parametric stability model for simultaneous selection of high yielding and stable hybrids. Highly significant mean squares due to genotype × environment interaction suggested differential performance of hybrids across the four seasons for all the characters except plant height, stem diameter, head diameter and test weight. Hybrid 9 was found to be highly stable for five characters, viz., plant height, volume weight, oil content, oil yield and earliness. Apart from this hybrid, hybrids 4 and 11 were stable for three characters, viz., head diameter, seed yield and oil yield. Another hybrid, number 5, was also stable for seed and oil yields.

Key words: **non-parametric stability analysis, Shukla's stability variance, G × E interaction, sunflower**

INTRODUCTION

Genotype × environment interaction continuous to be a challenging issue among the plant breeders, geneticists and production agronomists who carry out crop performance trails across diverse environments. Stability of performance should be considered as an important aspect of yield trials. Researchers need a statistic that provides a reliable measure of stability or consistency of performance across a range of environments, particularly, one that reflects the contribution of each genotype to the total G × E interaction. Shukla's (1972) stability variance sta-

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tistic ($\sigma^2{}_i$) is one such measure and is equivalent to ecovalance measure (Wi) of Wricke (1962). However, $\sigma^2{}_i$ by itself, is only of limited usefulness. To be of practical utility in a breeding or cultivar-testing program, $\sigma^2{}_i$ and yield (or any other trait) must be considered simultaneously so as to make selection of genotypes more precise and reliable. Integration of stability of performance with yield through a suitable measure will go a long way in selecting a high yielding and stable genotype. Kang *et al.* (1993) proposed rank sum method for selection of genotypes simultaneously for yield and stability. But the method has an inherent weakness, that it weighs heavily in the direction of yield performance, apart from the arbitrariness in the scoring involved. Therefore, this method is not fit for drawing general conclusions. Keeping these points in view, Bajpai and Prabhakaran (2000) proposed a few improved indices that are free from all the aforesaid drawbacks. The basic element in the construction of these proposed indices is that the levels of achievement of genotypes and their stability are quantified by expressing the individual achievements relative to the mean performance in the set of genotypes evaluated. The proposed indices have an inbuilt integration of both stability and mean performance. Hence, in the present investigation, the method proposed by Bajpai and Prabhakaran (2000) has been used to identify sunflower hybrids that are both stable and high yielding. They have proposed a stability index (I), which takes care of both mean performance and stability.

MATERIAL AND METHODS

The material for the study comprised of 15 newly synthesized hybrids along with four checks viz., KBSH1, MSFH-17, PAC 1091 and Sungene 85, which were evaluated in four seasons viz., rabi 1998, summer 1999, *kharif* 1999 and *rabi* 1999 by following randomized complete block design with three replications in the experiment plots of the Department of Genetics and Plant Breeding, Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore-560 024, India. The observations involved eight quantitative traits viz., days to flowering, plant height, stem diameter, head diameter, test weight, seed yield, oil content and oil yield. The mean values recorded for 10 random plants of each of the hybrids and in each replication were subjected to stability analysis as per Eberhart and Russel (1966) model to detect the presence or absence of G × E interaction. Subsequently, the data was subjected to Bajpai and Prabhakaran (2000) non-parametric stability analysis to identify stable and high yielding sunflower hybrids. As proposed by Bajpai and Prabhakaran (2000) the stability index (I) was computed as follows:

$$I = \frac{\frac{\bar{Y}_i}{\bar{Y}} + \frac{1}{\sigma_i^2}}{\left[\frac{1}{n}\Sigma\left(\frac{1}{\sigma_i^2}\right)\right]}$$

where,

$\bar{Y}_i$ =average performance of the ith genotype,

$\bar{Y}$ =the overall mean,

$\sigma^2{}_i$=Shukla's (1972) stability variance of the i^{th} genotype.

$\sigma^2{}_i$ is the contribution of i^{th} genotype towards total G × E interaction variance.

According to Bajpai and Prabhakaran (2000), genotypes were ranked based on the stability index (I). Ranks were assigned in increasing order to the genotypes whose stability indices varied in decreasing order *i.e.*, the genotype which had highest stability index (I) received first rank and the one with the lowest 'I', received 19th rank in the present study involving 19 hybrids (15 test hybrids + 4 checks) for all the characters except days to 50% flowering for which the ranking was in the reverse order.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) for stability indicated highly significant differences among the hybrids for all the characters except head diameter.

Table 1: Analysis of variance for stability for eight quantitative traits in sunflower across four seasons

Source	df	Days to 50% flowering	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	Test weight (g)	Seed yield (q/ha)	Oil content (%)	Oil yield (q/ha)
Hybrids (G)	18	106.88**	2294.82**	0.16**	1.56	1.08**	63.26*	22.49**	14.98**
Environments (E)	3	283.96**	2579.71**	0.87**	45.03**	5.33**	844.24**	1.23	132.51**
Hybrid × Environment	54	3.44**	118.51	0.04	1.06	0.22	29.87**	1.51**	4.84**
Environment+ (G × E)	57	18.21	248.04	0.08	3.37	0.49	72.74	1.51	11.56
Environment (linear {L})	1	851.75**	7738.18**	2.62**	135.09**	16.01**	2532.71**	3.74	397.56**
Hybrid × Environment (L)	18	7.46**	160.95	0.061*	1.22	0.29	27.97	2.71**	5.23
Pooled deviation	38	1.37**	92.18**	0.03	0.92**	0.17**	29.21**	0.87**	4.41**
Pooled error	144	2.41	1390.61	0.05	2.15	0.32	11.19	1.24	1.94

*Significant at P=0.05 level **Significant at P=0.01 level

Highly significant differences among the environments suggested that the hybrids under study were evaluated under diverse seasons, thus justifying the seasons chosen for stability analysis. Significant mean squares due to genotype × environment interaction suggested differential behavior of the hybrids across the four seasons for all the characters except plant height, stem diameter, head diameter and test weight. This differential behavior of genotypes was entirely unpredictable with respect to plant height, head diameter, test weight, seed yield and oil yield as suggested from significance of mean squares due to pooled deviation but non-significance of mean squares due to genotype × environment (linear). However, the variation in the performance of the hybrids with respect to the remaining characters is partly predictable as indicated from significance of mean squares due to both pooled deviation and genotype × environment (linear) interaction. Similar observations were made by Virupakshappa (1991), Muppidathi *et al.* (1996) and Laishram and Singh (1997). The presence of highly significant genotype × environment interaction for the most important characters such as days to flowering, oil content, seed

Table 2: Ranking of sunflower hybrids based on Mean, Stability variance and Stability index (I part)

Hybrid	Days to flowering						Plant height (cm)						Stem diameter (cm)					
	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index(I)	Rank	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index(I)	Rank	MEAN (x)	Rank	$1/\sigma^2_i$	Rank	Stability index(I)	Rank
Hybrid 1	71.7	14	0.24	15	1.28	13	216.4	5	0.014	8	1.65	6	2.71	3	133.33	1	4.45	1
Hybrid 2	72.1	16	3.91	2	4.47	2	200.2	8	0.002	19	1.11	17	2.57	8	11.63	16	1.33	16
Hybrid 3	73.6	19	0.18	16	1.26	14	235.4	1	0.007	14	1.46	9	2.73	2	90.91	2	3.39	2
Hybrid 4	72.1	16	0.26	13	1.30	11	215.1	6	0.008	13	1.39	12	2.60	7	76.92	3	2.98	3
Hybrid 5	71.1	13	0.58	7	1.57	8	213.6	7	0.008	12	1.41	10	2.67	5	8.06	19	1.28	18
Hybrid 6	72.4	17	0.57	8	1.58	7	223.6	3	0.003	18	1.26	15	2.63	6	14.71	15	1.43	13
Hybrid 7	72.8	18	0.11	17	1.19	17	233.5	2	0.005	16	1.40	11	2.77	1	20.00	9.5	1.62	9
Hybrid 8	69.1	12	0.38	11	1.37	9	218.1	4	0.059	2	3.39	2	2.69	4	16.95	14	1.51	11
Hybrid 9	64.0	8	0.83	6	1.68	6	180.3	12	0.022	5	1.77	5	2.29	15	20.00	9.5	1.43	14
Hybrid 10	62.4	5	0.08	19	1.01	19	172.6	17	0.006	15	1.10	18	2.42	12	52.63	6.5	2.30	6
Hybrid 11	62.6	6	0.10	18	1.03	18	174.4	15	0.031	4	2.10	4	2.36	14	52.63	6.5	2.28	7
Hybrid 12	62.3	4	0.41	9	1.29	12	178.7	13	0.039	3	2.40	3	2.25	16	47.62	8	2.11	8
Hybrid 13	61.6	3	5.99	1	6.12	1	174.0	16	0.018	6	1.57	8	2.24	17	66.67	4	2.58	4
Hybrid 14	66.0	9	3.25	3	3.81	3	198.0	9	0.016	7	1.62	7	2.48	11	22.73	9	1.57	10
Hybrid 15	68.3	11	0.25	14	1.24	16	182.7	11	0.009	11	1.29	14	2.50	9	10.99	17	1.28	17
KBSH1	62.8	7	0.36	12	1.25	15	190.7	10	0.223	1	9.55	1	2.39	13	17.24	13	1.40	15
MSFH17	60.2	2	2.83	4	3.35	4	162.0	18	0.004	17	0.98	19	2.23	18	62.50	5	2.47	5
PAC1091	66.2	10	0.38	11	1.32	10	175.1	14	0.011	9	1.32	13	2.49	10	18.87	12	1.48	12
Sungene85	56.3	1	1.21	5	1.89	5	161.6	19	0.010	10	1.23	16	2.11	19	10.53	18	1.12	19
Grand Mean	66.7		1.15				195.1		0.03				2.48		39.73			

Table 2: Continued (II part)

Hybrid	Head diameter (cm)						Test weight (g)					
	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index (l)	Rank	Mean	Rank	$1/\sigma^2_i$	Rank	Stability index (l)	Rank
Hybrid 1	16.15	7	3.77	4	1.04	6	4.76	17	2.67	15	1.14	18
Hybrid 2	15.87	10	0.29	19	1.00	12	5.70	8	2.54	16	1.30	15
Hybrid 3	16.58	2.5	2.17	8	1.06	4	5.74	7	5.71	11	1.62	9
Hybrid 4	15.62	12	3703.70	1	19.75	1	5.81	4	2.77	14	1.35	13
Hybrid 5	16.01	9	2.39	6	1.02	10	6.03	2	1.62	17	1.28	16
Hybrid 6	16.19	6	0.47	17	1.03	9	4.92	15	1.14	19	1.02	19
Hybrid 7	16.58	2.5	1.20	12	1.05	5	5.52	9	5.18	12	1.53	12
Hybrid 8	16.23	5	0.30	18	1.03	8	4.89	16	6.49	8.5	1.54	11
Hybrid 9	15.53	14	0.65	15	0.98	15	5.12	13	6.21	10	1.55	10
Hybrid 10	16.14	8	3.50	5	1.04	7	5.24	12	37.04	2	4.57	2
Hybrid 11	16.43	4	4.53	3	1.06	3	5.40	11	12.05	6	2.17	6
Hybrid 12	15.57	13	1.47	9	0.99	14	4.63	18	4.67	13	1.31	14
Hybrid 13	15.38	15	2.26	7	0.98	16	4.18	19	15.38	5	2.27	5
Hybrid 14	14.93	17	1.31	11	0.95	19	5.50	10	7.81	7	1.78	7
Hybrid 15	16.80	1	0.87	13	1.07	2	5.79	6	6.49	8.5	1.70	8
KBSH1	15.08	16	0.67	14	0.96	17	5.39	14	16.95	4	2.65	4
MSFH17	14.57	19	20.00	2	1.02	11	5.80	5	19.61	3	2.98	3
PAC1091	15.84	11	0.55	16	1.00	13	6.04	3	1.20	18	1.24	17
Sungene85	15.01	17	1.35	10	0.96	18	5.89		40.00	1	4.98	1
Grand Mean	15.82		197.44				5.39		10.29			

Table 2: Continued (III part)

Hybrid	Seed yield (q/ha)						Oil content (%)						Oil yield (q/ha)					
	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index (I)	Rank	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index (I)	Rank	Mean (x)	Rank	$1/\sigma^2_i$	Rank	Stability index (I)	Rank
Hybrid 1	40.00	2	0.090	5	2.215	5	39.52	12	62.50	1	39.72	1	15.78	4	0.55	7	1.93	6
Hybrid 2	30.04	17	0.008	16	0.966	17	38.10	16	2.67	8	2.61	8	11.45	17	0.06	19	0.92	19
Hybrid 3	37.69	5	0.027	11	1.408	9	41.30	6	0.74	14	1.50	13	15.56	5	0.13	5.5	1.31	s
Hybrid 4	38.28	4	0.205	3	3.517	3	41.61	3	3.32	7	3.10	7	16.03	3	1.03	3	2.64	3
Hybrid 5	39.20	3	0.224	2	3.766	2	41.42	4	-37.04	18	-21.91	18	16.26	2	0.92	4	2.50	4
Hybrid 6	40.18	1	0.018	13	1.374	12	40.47	9	4.76	6	3.97	6	16.33	1	0.10	17	1.33	11
Hybrid 7	37.28	7	0.027	11	1.396	10	39.33	14	0.13	17	1.07	17	14.51	8	0.13	15.5	1.24	13
Hybrid 8	37.62	6	0.011	15	1.221	14	37.65	17	14.28	2	9.80	2	14.20	9	0.08	18	1.14	16
Hybrid 9	36.28	8	0.149	4	2.801	4	42.61	1	9.09	4	6.70	4	15.46	6	0.84	5	2.32	5
Hybrid 10	31.85	14	0.027	11	1.239	13	42.36	2	0.68	15	1.49	14	13.69	11	0.14	14	1.19	15
Hybrid 11	33.11	11	0.581	1	7.785	1	39.98	11	2.38	9	2.48	9	13.25	13	4.95	1	8.05	1
Hybrid 12	32.88	12	0.003	17	0.984	16	41.36	5	1.06	11	1.70	11	13.65	12	0.48	8	1.68	7
Hybrid 13	27.05	19	0.076	6	1.676	7	40.89	7	0.78	13	1.51	12	11.29	18	0.21	12	1.12	17
Hybrid 14	36.23	9	0.028	9	1.377	11	39.40	13	9.80	3	7.06	3	14.06	10	1.77	2	3.55	2
Hybrid 15	36.06	10	0.067	7	1.831	6	40.75	8	-52.63	19	-31.58	19	14.69	7	0.41	10	1.65	8
KBSH1	30.67	16	0.015	7	1.064	15	40.31	10	0.28	16	1.19	16	12.37	15	0.22	11	1.21	14
MSFH17	28.77	18	0.058	14	1.514	8	32.39	19	0.88	12	1.36	15	9.62	19	0.65	6	1.63	9
PAC1091	31.54	15	0.002	8	0.938	19	36.76	18	5.56	5	4.37	5	11.54	16	0.18	13	1.09	18
Sungene85	32.00	s	0.002	18	0.946	18	38.63	15	1.43	10	1.86	10	12.44	14	0.42	9	1.50	10
Grand Mean	34.56		0.085		2.000		39.28		1.61				13.80		0.70			

yield and oil yield under the present study necessitated to identify most stable and high yielding genotypes through Bajpai and Prabhakaran (2000) stability model.

Results (Table 2) indicated that the ranking of genotypes, in general, were more or less similar based on $(1/\sigma^2{}_i)$ and stability index (I_i) for all the characters. However, the same was not true with respect to mean performance. Further, the genotypes, which showed high mean performance were not stable across the seasons as indicated by low magnitudes of $(1/\sigma^2{}_i)$ for most of the characters.

As far as days to 50% flowering is concerned, the hybrids 13 and 14 and the checks MSFH 17 and Sungene 85 were not only early but were also highly stable as indicated by their stability indices. The hybrid 12 and the check KBSH-1 were identified to be highly stable for dwarfness as indicated by their mean plant height and stability indices. On the other hand, the hybrid 8 was highly stable for higher plant height. The hybrids 1, 3 and 4 were found to be highly stable for thick stem, whereas, the hybrid 13 and the check MSFH 17 were identified as stable for thin stem.

The hybrids 11, 15 and 3 were identified to be stable for large heads. On the other hand, the hybrid 4, although highly stable, possessed small heads. The check Sungene 85 along with hybrid-10, MSFH-17 and KBSH-1 were identified to be stable for high test weight.

The hybrids 11, 5, 4, 9 and 1 were highly stable regarding seed yield per hectare, coupled with high oil content. As far as oil yield was concerned, the hybrids 11, 14, 4, 5 and 9 were stable for high oil yield per hectare.

From the above discussion, it could be summarized that none of the hybrids were stable for all characters under investigation. Nevertheless, the hybrid 9 was stable for as many as four characters, namely, plant height, seed yield, oil content and oil yield. Similarly, the hybrid 14 was stable for volume weight, oil content, oil yield and earliness. Apart from this, the hybrids 4 and 11 were stable for three characters, viz., head diameter, seed yield and oil yield. The hybrid 5 was stable for seed and oil yields.

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REFERENCES

Bajpai, P.K. and Prabhakaran, V.T., 2000. A new procedure of simultaneous selection for high yielding and stable crop genotypes. Indian J. Genet. 60: 141-146.

Eberhart, S.A. and Russell, W.A., 1966. Stability parameters for comparing varieties. Crop Sci. 6: 36-40.

F.A.O., 1998. Agriculture Production Yearbook. Food and Agriculture Organization of United Nations, Rome.
Kang, M.S., Miller, J.D. and Darrah, L.L., 1993. A note on relationship between stability variance and ecovalence. J. Heredity 78: 107.
Shukla, G.K., 1972. Some statistical aspects of partitioning genotype environmental components of variability. Heredity 29: 237-245.
Wricke, G., 1962. Uber eine methode zur Erfassumg der Ökologisehen streubreite in Feldversuchen. Der Pflanzenzüchtung 47: 92-96.

ANÁLISIS DE ESTABILIDAD DE LOS HÍBRIDOS DE GIRASOL MEDIANTE EL MODELO NO-PARAMÉTRICO

RESUMEN

La investigación fue realizada en las parcelas experimentales del Instituto de Genética y Selección de Plantas de la Estación de Investigaciones Principal de la Universidad de Ciencias Agrícolas de Hebal, Bangalor, La India, con el fin de determinar la estabilidad de 15 híbridos de girasol nuevos formados y cuatro controles a lo largo de cuatro campanas, utilizando el modelo no-paramétrico de estabilidad para la selección simultánea sobre la altura y la estabilidad del rendimiento. Los altamente significantes medios de los cuadrados, por causa de interacción del genotipo × el entorno, han indicado la reacción diferencial de híbridos a lo largo de cuatro campanas en todas las características, excepto la altura de la planta, diámetro del tallo, diámetro del capítulo y el peso de 1000 granos. El híbrido 9 era estable en cinco características, en la altura de la planta, peso en hectolitros, contenido de aceite, rendimiento de aceite y la madurez temprana. Aparte de este híbrido, los híbridos 4 y 11 eran estables en tres características, en el diámetro del capítulo, rendimiento de semilla y rendimiento de aceite. El híbrido № 5 era estable en cuanto al rendimiento de semilla y de aceite.

ANALYSE DE STABILITÉ DES HYBRIDES DE TOURNESOL PAR LE MODÈLE NON PARAMÉTRIQUE

RÉSUMÉ

Une recherche a été effectuée sur les parcelles expérimentales du Département de génétique et de culture des plantes, à la Station de recherches principale de l'Université des sciences de l'agriculture, à Hebbal, Bangalore, en Inde pour évaluer la stabilité de quinze nouveaux hybrides de tournesol et de quatre contrôles au cours de quatre saisons et à l'aide d'un modèle de stabilité non paramétrique pour la sélection simultanée d'hybrides stables et à grand rendement. Des moyennes de carré grandement significatives dues à l'interaction génotype × environnement ont indiqué une réaction différentielle des hybrides au cours des quatre saisons pour toutes les caractéristiques sauf la hauteur de la plante, le diamètre de la tige, le diamètre de la tête et le poids de 1 000 graines. L'hybride 9 a été stable pour cinq caractéristiques, la hauteur de la plante, le poids de l'hectolitre, le contenu d'huile, le rendement d'huile et la précocité. De plus, les hybrides 4 et 11 étaient stables pour trois caractéristiques, le diamètre de la tête, le rendement de graines et le rendement d'huile. Un autre hybride, le numéro 5, était aussi stable pour les rendements de graines et d'huile.