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Stability analysis for grain yield and it's components in sunflower

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Abstract
A field experiment was carried out at four environmental condition to study their stability during *kharif* 2014, with twelve sunflower hybrids. G×E interactions were found to be significant, indicating presence of sufficient genetic variability among hybrids and environments studied. The data was recorded and subjected to analysis of stability as per Eberhart and Russell (1966).

The hybrids SVSH-501, SVSH-481 and SVSH-497 were found to be superior and average stable, SVSH-495 was exhibited below average stability, SVSH-508 was exhibited above average stability for days to 50 per cent flowering. The hybrid SVSH-487 was found to be superior and having average stability for days to maturity. The hybrid SVSH-454 showed average stability, while SVSH-495 was exhibited below average stability for plant height. The hybrid SVSH-501 was found to be superior and with average stability for head diameter. The hybrid SVSH-481 was found to be superior and with average stability for no. of seeds/head.

The present study indicates that sowing of sunflower hybrids on the date E_1 (1st June) followed by E_2 (15th June) found to be most favourable for expression of yield and yield contributing traits. It is concluded that SVSH-481 from high yielding group and SVSH-480, SVSH-501 and SVSH-497 from average yield group were observed to be stable for yield and yield contributing characters.

Keywords: Sunflower, *Helianthus annuus* L. G x E interation, stability analysis

Introduction
Sunflower (*Helianthus annuus* L.) is an important oilseed crop in India popularly known as "Surajmukhi". It ranks second to Soybean among annual field crops grown for edible oil. Sunflower belongs to family Asteraceae [Compositae] and the genus name is derived from Greek word *Helios*, meaning "Sun" and *anthos*, meaning "Flower" and it`s chromosome no is 2n=34. The exploitation of sunflower (*Helianthus annuus* L.) as a source of edible oil in India dates back from 1972, with the help of sunflower introduction from USSR, sunflower emerged as an admirable crop for its quality oil in oilseed scenario of India. The introduction of sunflower "a crop of all seasons", in India, was taken up in view of its various advantages *viz*., photo and thermo insensitivity, short duration, high yield and better quality of oil, high oleic acid (52 %), linoleic acid (41 %), palmitic acid (4.6 %) and steric acid (2.3 %). Sunflower contains about 50 per cent of oil. Genotypes by environments (G x E) interaction is an important issue among plant breeders and agronomist. Eberhart and Russell (1966) identified the rainfall pattern and dates of planting as a source of environmental influence which induce G x E interaction. Genotype cannot therefore, be selected based on yield alone, but a method that combines yield and stability across a geographical area would be benefit to farmers. In the present investigation ten sunflower hybrids including two checks were evaluated at four environments (E_1 on 1st June 2014, E2 on 15th June 2014, E3 on 30th June 2014, E4 on 15th July 2014).

Materials and Methods
The experimental material for the present study consists of twelve hybrids of Sunflower (*Helianthus annuus* L.). *viz.*, SVS 487, SVSH-480, SVSH-508, SVSH-497, SVSH-481, SVSH-495, SVSH- 454, SVSH-501, PHULE RAVIRAJ(C), SVSH-509, SVSH-570, KBSH44(C) werw grown in randomized block design with three replications during *Kharif* 2014 under four different environments (E_1 on 1st June 2014, E2 on 15th June 2014, E3 on 30th June 2014, E4 on 15th July 2014). Each genotype was planted in four rows of 60 × 30 cm spacing.

The data was recorded for eight characters *viz.*, Days to 50% flowering, Days to maturity, Height of the plant (cm), Head diameter(cm), No. of seeds per head, 100 seed weight (gm), Seed yield per plant, Volume weight (gm/100). The data was recorded and subjected to analysis of stability was performed by model proposed by [1].

Results and Discussion

Analysis of variance for stability parameters was done (Table1) by following model of Eberhart and Rusell (1966), which revealed the presence of significant variation due to environment (E) for all the characters, indicating considerable additive environmental variance. Genotypic variances (G) were significant for all the traits, which indicated prevalence of genetic variability among the sunflower hybrids under study. These results are in agreement with the results reported by [2, 3] The G × E interaction when tested against pooled deviation it was found to be significant for the plant height, head diameter, no of seeds/head, 100 seed weight, seed yield per plant, volume weight and oil content when tested against pooled error was found to be significant for all the traits, explaining that the major portion of interaction was linear in nature and prediction over environments was possible. The similar results were reported earlier by [4]. Thus in present study, both linear and non-linear components were significant for yield and yield contributing characters. Similar findings were reported by [5]. Since G × E interaction was detected for all the characters except-Hull content, the stability parameters in respect of these traits were estimated and were presented in Table - 2. The hybrid SVSH-501 (54.33) was observed to be earliest, while KBSH-44 (67.58) was late for days to 50 per cent flowering among all the hybrids.The hybrids SVSH-501, SVSH-481 and SVSH-497 were average stable, indicating their adaptability to all environments. SVSH-508 was suitable for stress environment i.e. above average stability. SVSH-495 was suitable for favourable environment below average stability, for the trait under study. For the given traits, both linear (G×E) component found to be significant, which indicates that expression of the trait under study was found to be influenced by predictable components of environment. Similar findings were reported by [6] reported such behavior of flowering in sunflower.

The hybrid SVSH-501(85.25) was observed to be earliest, while KBSH-44 (107.50) was late for maturity among all the hybrids.SVSH-487 was average stable, indicating their adaptability to all environments for the trait under study.The expression of the given trait was controlled by the predictable and non-predictable components of environment. This is in agreement with [7].

The hybrid SVSH-508 (157.73) had produced minimum, while KBSH-44 (189.90) had produced maximum height of the plant over rest of the hybrids under investigation.The hybrid SVSH-454 was average stable, indicating their adaptability to all environments, SVSH-495 was suitable for favourable environment i.e. below average stability, for the trait under study. Similar results were reported by [8].

The hybrid KBSH-44 had maintained its dominance by producing maximum head diameter (17.28), while Phule raviraj expressed poor performance (13.19) among all the hybrids under study. The hybrid SVSH-501 was average stable, indicating their adaptability to all environments for the trait under study. The hybrid SVSH-497 had maintained its dominance by producing maximum No of seeds/head (1422.25), while Phule raviraj expressed poor performance (711.75) among all the hybrids under study. The hybrid SVSH-481 was average stable, indicating their adaptability to all environments, for the trait under study. The hybrid SVSH-487 (5.72) had produced maximum, while SVSH-454(2.20) had produced minimum grams of 100 seed weight over rest of the hybrids under investigation. The hybrid SVSH-501 average stable was suitable for all environment.

SVSH-497 and SVSH-480 were suitable for stress environment i.e. above average stability, for the trait under study. SVSH-487 had produced maximum seed yield/plant (76.28), while Phule raviraj expressed poor performance (31.19) among all the hybrids under study. The hybrids SVSH-481 and SVSH-495 were average stable, indicating their adaptability to all environments, for the trait under study. Yield and yield contributing traits of crop are influenced by genotype (G), environment (E), and their interaction (G×E).Every factor of the environment has a potential to cause differential performance associated with Interaction (G×E). These findings are in accordance with the earlier reports made by [9].

SVSH-454 had exhibited maximum volume weight (37.21), while SVSH-508 showed lower volume weight (21.28), over rest of the hybrids. The hybrids SVSH-570, and SVSH-480 were average stable, indicating their adaptability to all environments for the trait under study.SVSH-487 was suitable for rich environment i.e. below average stability. SVSH-454 and SVSH-509 were suitable for poor environment i.e. above average stability, for the trait under study.

The hybrid SVSH-495 (61.82) had maximum hull content, while SVSH-481 (23.66) had minimum hull content over rest of the hybrids under investigation. Genotype × Environment interaction was observed to be absent for this trait, indicating that this character was not influenced by changing environments. Similar reports on sunflower hull content were made by [10].

Table 1: Anova for stability as per Eberhart and Russell Model (1966) in Sunflower.

Sr. No.	Sources	G	E	G × E	E + G x E	E (Li)	G × E(Li)	Pooled deviation	Pooled error
1	Days to 50% flowering	70.48 ++,**,##	6.28 ++,**,##	0.32 ##	0.81 **,##	18.85 **,##	0.51 *,##	0.20	0.15
2	Days to Maturity	166.42 ++,**,##	5.32 ++,##	1.01 ##	1.37 ##	15.98 **,##	1.36 ##	0.76 ##	0.13
3	Plant height (cm)	308.13 ++,**,##	2041.92 ++,**,##	17.92 **,##	186.88 ++,**,##	6125.79**,##	41.00 **,##	5.86 ##	0.64
4	Head diameter (cm)	3.84 **,##	45.24 ++,**,##	2.75 **,##	6.29 ++,**,##	135.71 **,##	6.06 **,##	1.0 ##	0.02
5	No. of seeds/head	304765 ++,**,##	159154.2++, **,##	6567.34**,##	19282.92++,**,##	477462.70**,##	16140.95**,#	1632.16 ##	436.98

							#		
6	100 seed weight(g)	3.19 ++,**,##	0.50 ++,**,##	0.01 *,##	0.05 ++,**,##	1.51 **,##	0.01 **,##	0.003 ##	0.001
7	Seed yield/plant(g)	1133.19 ++,**,##	748.06 ++,**,##	18.24 **,##	79.06 ++,**,##	2244.18**,##	44.03 **,##	4.90 ##	0.73
8	Volume weight (g/100ml)	112.31 ++,**,##	2.04 ++,**,##	0.063 **,##	0.23 ++,**,##	6.12 **,##	0.15 **,##	0.02	0.02

+, ++ = Significant at 5% and 1% level of significance, respectively against G × E
*, * * = Significant at 5% and 1% level of significance, respectively against the pooled deviation (P.D.)
#, ## = Significant at 5% and 1% level of significance, respectively against the pooled error (P.E.)

Table 2: Stability parameters of genotypes for seed yield and yield components over environments

Hybrids	**Days to 50 % flowering**			**Days to maturity**			**Plant height (cm)**		
	X	bi	s^2di	X	bi	s^2di	X	bi	s^2di
SVSH-487	61.00	1.19	-0.04	93.00	0.99	-0.02	168.29	1.39*	0.86
SVSH-480	63.00	1.36	0.63**	94.58	0.94	0.09	175.75	1.09	1.72*
SVSH-508	55.50	0.46*	-0.14	86.75	0.47	0.42*	157.73	0.60	24.65**
SVSH-497	58.08	1.24	0.13	89.17	0.27	0.42*	180.92	1.18	2.06*
SVSH-481	55.41	1.05	-0.07	87.50	0.78	0.40*	177.08	0.89	5.18**
SVSH-495	62.17	1.73*	-0.11	94.17	1.02	0.11	178.14	1.35*	0.82
SVSH-454	64.42	-0.03	0.56**	93.75	0.51	0.17	178.25	0.97	0.22
SVSH-501	54.33	0.60	-0.09	85.25	0.34	0.38*	183.41	0.80	2.83**
Phule Raviraj (c)	62.08	2.00	0.09	103.00	3.40	4.96**	163.57	1.10	13.05**
SVSH-509	65.17	0.78	-0.12	94.50	0.11	0.13	170.50	1.32	7.57**
SVSH-570	61.83	1.10	-0.03	93.92	0.48	0.19	175.75	0.74	1.47*
KBSH-44(c)	67.58	0.55	-0.12	107.50	2.70	0.19	189.90	0.58*	1.90*
Mean	60.88	1.00		93.59	1.00		174.92	1.00	
S.E.±	0.26	0.36		0.50	0.76		1.4	0.1	

*, ** = Significant at 5% and 1% level of significance, respectively

Table 2: Contu....

Hybrids	**head diameter (cm)**			**No. of seeds per head**			**100 seed weight (g)**		
	X	bi	s^2di	X	bi	s^2di	X	bi	s^2di
SVSH-487	16.28	1.42	0.23**	1329.83	1.06	1053*	5.72	0.82	0.0038*
SVSH-480	16.48	1.86*	0.38**	1310.33	2.22*	2329**	5.10	0.69*	-0.0012
SVSH-508	14.73	0.03	2.52**	1409.17	0.38	5990**	2.95	0.92	-0.0010
SVSH-497	16.47	1.85	2.99**	1422.25	2.37	5767**	5.22	0.44*	-0.0007
SVSH-481	15.31	1.67	0.65**	1258.75	0.87	500.00	5.25	0.83	0.0040*
SVSH-495	13.86	0.94	0.38**	1006.83	0.65*	-312.00	2.38	1.35	0.0005
SVSH-454	16.80	1.34	0.65**	731.67	0.81	-287.68	2.20	1.20	0.052**
SVSH-501	16.33	0.80	0.03	865.00	0.78	-265.54	5.46	1.14	0.0003
Phule Raviraj (c)	13.19	0.65*	0.04	711.75	0.75*	-333.47	4.31	1.01	-0.0007
SVSH-509	15.85	1.23	0.21	975.16	1.02	273.84	3.35	1.09	0.0003
SVSH-570	16.97	-0.57	3.47**	767.58	0.60*	-375.61	4.07	0.99	-0.0010
KBSH-44(c)	17.28	0.78	0.11**	840.83	0.50*	103.13	5.24	1.53	0.0063**
Mean	16.05	1.00		1052.43	1.00		4.77	1.00	
S.E.±	0.58	0.30		23.30	0.20		0.03	0.14	

*, ** = Significant at 5% and 1% level of significance, respectively

Table 2: Contu.....

Hybrids	**seed yield per plant (g)**			**Volume weight**		
	X	bi	s^2di	X	bi	s^2di
SVSH-487	76.28	1.16	8.99**	32.90	1.49*	-0.01
SVSH-480	67.65	2.02*	8.45**	29.14	1.27	-0.01
SVSH-508	41.92	0.58	5.54**	21.28	0.44	0.00
SVSH-497	74.78	1.93	20.63**	22.60	1.09	-0.02
SVSH-481	66.09	0.97	1.01	24.10	1.15	0.00
SVSH-495	54.42	0.89	-0.39	24.09	0.42*	-0.02
SVSH-454	38.26	0.82	1.15	37.21	0.24*	-0.01
SVSH-501	47.51	0.89	-0.24	27.72	1.23	-0.01
PhuleRaviraj (c)	31.19	0.74*	-0.72	24.16	2.12	0.05*
SVSH-509	32.93	0.77*	-0.64	32.57	0.52*	-0.01
SVSH-570	31.36	0.56*	-0.52	32.99	0.75	-0.01
KBSH-44(c)	45.04	0.67	6.52**	34.10	1.29	0.05*
Mean	50.62	1.00		28.57	1.00	
S.E.±	1.28	0.16		0.07	0.19	

*, ** = Significant at 5% and 1% level of significance, respectively

Table 3: Estimation of environment index (Ij) under different environments

SN	Characters	Environmental index (Ij)			
		E_1	E_2	E_3	E_4
1	Days to 50% flowering	0.42	0.42	0.23	-1.08
2	Days to Maturity	-0.79	0.83	-0.15	0.10
3	Plant height (cm)	18.49	-0.94	-6.18	-11.38
4	Head diameter (cm)	2.54	0.38	-1.01	-1.92
5	No. of seeds/head	158.10	6.79	-58.43	-106.46
6	100 seed weight(g)	0.24	0.07	-0.07	-0.24
7	Seed yield/plant(g)	10.73	0.52	-3.56	-7.69
8	Volume weight (g/100ml)	0.53	0.13	-0.28	-0.37

Table 4: Nature of stability of sunflower hybrids under different environments

S. No	Character	Genotypes showing stability		
		Average stability (suitable for all environments)	Above average stability (bi<1) (suitable for poor environment)	Below average stability (bi>1) (suitable for rich environment)
1	Days to 50% flowering	SVSH-501, SVSH-481, SVSH-497	SVSH-508	-
2	Days to maturity	SVSH-487	_	-
3	Plant height (cm)	SVSH-454	_	SVSH-495
4	Head diameter (cm)	SVSH-501	_	_
5	No. of seeds/head	SVSH-481	_	_
6	100 seed weight(g)	SVSH-501	SVSH-497, SVSH-480	_
7	Seed yield/plant(g)	SVSH-481, SVSH-495	_	_
8	Volume weight (g/100ml)	SVSH-570, SVSH-480	SVSH-509, SVSH-454	SVSH-487

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