Stability Analysis of different cultivars in Soybean (*Glycine max* Merrill.)

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Abstract

The present investigation was conducted to study the nature of stability of different genotypes in soybean. Three genotypes KDS 344, MAUS 608, KS 132 were found promising and since had stable performance in three different check environments. Moreover, these genotypes were also found to be stable for characters such as number of branches, protein content (KDS 344), seeds per pod, oil content (KS 132), number of days to 50% flowering & maturity, plant height and 100 seed weight (MAUS 608). Genotype KDS 798 had wider stability for days to flowering and days to 50% flowering. Two genotypes namely AMS 59 and AMS 56 had showed wide adaptability for early flowering. The genotype MACS 1311 had wider adaptability for days to maturity. Two genotypes *viz.*, JS 335 and MAUS 608 showed below average stability for maturity as bi >1and non-significant S^2di values. The genotype KDS 708 showed below average stability for seeds per pod as bi>1, whereas, KS 129, KDS 378 and MAUS 608 were observed to have below average stability for 100 seed weight. Use of genotype with wide stability (KDS 344, MAUS 608 and KS 132) or specific stability (KDS 705, AMS 59, AMS 56, MACS 1311, JS 335, MAUS 608, KS 129 and KDS 378) in development of new varieties with desired nature of adaptability was suggested.

Keywords : Stability, adaptability, soybean cultivars.

Introduction

The process of identification of stable genotype is difficult because of G x E interaction. Although the plant breeder has observed the genetic differences for adaptability, they have been unable to fully exploit these differences in breeding stable genotypes. This has been largely due to the problem of defining and measuring the phenotypic stability. Various attempts were made to characterize the behaviour of genotypes in response to varying environments. Lewis (1954) introduced stability factor to measure the phenotypic stability. Plaisted and Paterson (1959) suggested calculation of mean s^2gl in order to detect stable genotype. A genotype with smallest s^2gl is regarded as most stable genotype. Statistical approach of Finely and Wilkinson (1963) proved considerably useful to measure the phenotypic stability in the performance of genotype. He considered the linear regression sole (bi) as measure of stability. This regression analysis proposed by Finely and Wilkinson (1963) was improved by Eberhart and Russel (1966) by introduction of one more parameter, (S^2di) which accounts for unpredictable irregularities in response of genotypes to varying environments. Later on Paroda and Hays (1971) stressed that linear regression of variety be considered for evaluating the potential, whereas deviation around regression gives a measure of stability of genotype over environments. Bais and Gupta (1972) proposed that most stable genotype would be one with high mean performance and regression coefficient as well as deviation mean squares approaching to zero. They further proposed that the genotypes where mean yields were less than grand mean were considered as poorly adapted irrespective of their regression coefficient and deviation mean squares. The progenies where the performance was observed to be within the range amongst those having mean performance value higher than range value were classified having mean performance higher than range values were classified as with average stability.

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Considering all the above points, present investigation was undertaken in soybean with an object to estimate stability parameters for grain yield and its important components.

Material and Methods

The experimental materials comprised of 19 promising newly developed cultivars of soybean developed at different centres of Maharashtra and five checks *viz*., MAUS 71, MAUS 81, JS 335, JS 93-05 and MAUS 158 were used. These genotypes were sown on three different sowing dates during *khaif* 2011, which created three environments as E1 (Parbhani, Maharshtra), E2 (Aurangabad, Maharshtra), E3 (Somnathpur, Maharshtra), respectively. The experiment was laid in randomized block design with three replications maintaining 45 x 5 cm spacing between rows and plants, respectively. Observations were recorded on 12 characters *viz*., number of ays to flowering, 5% flowering & maturity, plant height, number of branches, pods per plants, seeds per pods, 100 seed weight, protein content (%), oil content and seed yield per plant. Stability analysis was done as per the procedure suggested by Eberhart and Russel (1966).

Results and Discussion

The analysis of variance representing the mean sum of square due to different sources of variation as per Eberhart and Russel (1966) stability analysis is presented in table 1. Pooled analysis of variance over three different environments showed genotypic variance, when tested against G x E interaction were significant for characters *viz.,* number of days to flowering, days to 50% flowering & days to maturity, plant height, number of pods, protein content, oil content and seed yield. Similarly genotypic variances when tested against pooled deviation were significant for various characters *viz.*, number of days to flowering, days to 50% flowering, & days to maturity, plant height, oil content and seed yield. Environmental variances were significant for all characters except seeds per pod. Further, results also showed the significance of G x E interaction for all the characters. The pooled deviation effects for all characters except seed per pod were significant when tested against pooled error. Environment linear effects for all characters were significant except for protein content when tested against pooled deviation.

Table1 : Analysis of variance for stability with three environments.

Characters	Genotype	Environ-ment	G x E	Env + (G x E)	Env (L)	G x E (L)	Pooled deviation	Pooled error
DF	23	2	46	48	1	23	24	144
Days to flowering	16.17**++	26.30**	5.21@@	6.08	52.58++	5.06	5.13@@	0.42
Days to 50% flowering	17.27**++	540.2**	5.60@@	27.91	1080.80++	6.12	4.87@@	0.32
Days to maturity	15.91**+	841.2**	7.90@@	42.64	1683.54++	7.48	7.96@@	0.36
Plant height (cm)	188.8**++	4033.26**	35.19@@	201.7	8065.97++	35.37	33.88@@	2.96
Number of branches per plant	0.75	41.82**	0.54@@	2.21	83.65++	0.39	0.67@@	0.07
Number of pods per plant	188.2**	545.2**	112.7@@	130.21	1090.1++	109.92	109.65@@	5.95
Seeds per pods	0.011	0.010	0.012@@	0.011	0.021+	0.010	0.012	0.007
100 seed weight	1.38	13.53**	0.69@@	1.22	27.07++	0.62	0.72@@	0.27
Protein content (%)	4.80**	0.92**	4.023@@	3.89	1.92	3.97	3.90@@	0.58
Oil content (%)	3.77**++	0.73**	0.32@@	0.33	1.45++	0.29	0.33@@	0.05
Yield per plant (g)	8.96**+	82.29**	5.02@@	8.24	164.58++	4.06	5.73@@	0.60

GxE=*, pooled error=@, pooled deviation=+; Also see Eberhart and Russel, (1966)

Table 2 . Estimates of environmental indices for each character under different environment.

Observations	Environments		
	E1 (Parbhani)	E2 (Aurangabad)	E3 (Somnathpur)
Days to flowering	-0.63	-0.59	1.2
Days to 50% flowering	-2.99	-2.55	5.48
Days to maturity	-2.64	-4.15	6.78
Plant height (cm)	9.42	14.68	-5.49
Number of branches per plant	-0.11	1.37	-1.27
Number of pods per plant	-3.71	-0.97	5.57
Seeds per pods	-0.02	0.02	0.005
100 seed weight	-0.86	0.31	0.54
Protein content (%)	-0.05	-0.17	0.22
Oil content (%)	-0.014	0.19	-0.06
Yield per plant (g)	-1.84	-0.05	1.86

Environmental indices for 11 characters given in table 2 showed that E1 environment was not favourable environment for all characters. E2 environment was favourable for characters like plant height, number of branches, seed per pod, 100 seed weight and oil content whereas, E3 environment was favourable for number of days to flowering, days to 50 % flowering & days to maturity, number of pods, 100 seed weight and yield per plant.

On the basis of results of stability parameters (Table 3 a b c), the nature of stability of 24 genotypes for different characters has been discussed. Out of the 24 genotypes, 9 genotypes recorded high mean performance while 7 genotypes exhibited significant S^2di values indicating their unsuitability for days to first flowering. The genotype KDS-708 was found to be stable for late flowering as it had non significant S^2di values and bi values near unity. One genotype namely KDS-378 had low relative bi values indicating that they might perform better under poor environment (above average stability). Two genotypes namely AMS-59 and AMS-56 had broad adaptability for earliness as they had non-significant S^2 di and bi around unity with low mean values. The nonlinear component was significant and of higher magnitude indicating its major contribution for expression of trait. Holker *et al*. (2008) however reported both linear and nonlinear component of G x E were significant.

High Mean Performance : Nine out of 24 genotypes recorded high mean performance while 8 genotypes exhibited S^2di values for number of days to 50 % flowering. The genotypes KDS-708 was suitable for rich environment as it exhibited high mean with bi>1 and non significant S^2di value. Eight genotypes (MACS-1039, AMS-59, MACS-1311, MAUS-608, KDS-693, AMS-155, AMS-56, and JS-335) had broad adaptability for earliness as they had non-significant S^2di with bi around unity and low mean value. The rest of eight genotypes was found to be unstable with high mean and significant S^2di. The non linear component was significant which indicate the unpredictable performance over the environments. Joshi *et al*. (2005) showed that non linear component significant for days to 50 % flowering in soybean.

Maturity: For days to maturity, the genotype MACS-1311 exhibited greater adoptability as their S^2di values were non significant along with high mean and bi

Table 3a : Stability parameters (Eberhart and Russell, 1966) for eleven characters in soybean.

Variety	Days to flowering			Days to 5% flowering			Days to maturity			Plant height		
	X	bi	S^2di	X	Bi	S^2di	X	bi	S^2di	X	bi	S2di
AMS 59	35.44	2.11	-0.395	39.66	0.975**	-0.284	91.33	0.928**	7.480**	52.39	0.945**	-2.614
KS 112	39.11	0.20	3.108**	44.88	0.638*	1.839**	94.22	1.024**	2.132**	59.48	1.185**	9.425**
MACS 1039	34.11	-0.082	0.078	40.11	1.205**	1.389	95.55	0.577	1.267**	55.64	1.940**	14.13**
KDS 708	37.88	0.653	0.048	42.56	0.754**	-0.079	95.88	0.539	3.765**	63.85	0.429	53.26**
KDS 344	37.44	-2.320	2.076**	43.77	0.698*	3.102**	93.77	0.970**	8.333**	65.67	1.427**	22.26**
MACS 1140	33.33	1.084	1.667**	38.77	1.178**	1.984**	90.00	1.449**	1.963**	49.13	0.824*	85.57**
MACS 1311	35.11	2.669	-0.401	39.55	1.240**	-0.196	95.88	0.633	1.013	47.92	1.095**	96.74**
KS 129	39.33	-1.338	9.211**	44.88	0.345	9.948**	92.44	1.135**	24.915**	56.88	0.813*	11.65**
KDS 378	39.33	-2.200	-0.138	45.66	0.314	2.118**	95.55	0.673*	1.018	57.32	0.717*	135.93**
KDS 705	38.11	0.139	10.49**	42.22	0.425	11.401**	95.44	0.469	7.895**	61.88	0.586	8.098**
MACS 1281	38.11	0.526	23.91**	43.33	0.640*	24.75**	93.22	1.056**	34.361*	52.40	0.958*	2.74**
KS 132	39.44	0.507	11.97**	44.66	0.569	11.079**	93.33	1.169**	14.658**	72.42	1.058*	23.59**
MAUS 608	33.66	3.017*	1.81**	39.00	1.517**	0.125	91.88	1.357**	0.468	49.42	0.578	-0.374
KDS 693	34.44	3.46**	3.52**	40.88	1.231	0.799	95.44	0.544	1.359**	71.61	1.999**	44.74**
MAUS 612	34.44	1.25	5.30**	39.66	1.447**	1.948**	95.00	0.467	2.307**	46.37	1.170**	-0.278
AMS 155	34.44	3.201**	1.19**	38.77	1.250**	1.367	87.66	1.459**	17.185**	49.65	0.610*	35.079**
MAUS 614	34.66	2.193	0.58**	39.88	1.166**	2.733**	91.66	1.151**	1.518**	50.41	1.210**	-2.622
AMS 56	35.22	1.471	-0.42	40.77	1.069**	0.704	90.44	1.406**	8.627**	50.95	0.979**	-2.493
MAUS 611	34.00	1.065	7.75**	39.00	1.141**	5.673**	92.11	0.946**	2.988**	49.66	1.568**	20.327**
MAUS 71	35.00	1.959	3.83**	40.44	1.267**	2.008	94.66	1.032**	9.65**	43.55	1.301**	99.99**
JS 335	32.88	0.906	0.51**	38.77	1.190**	0.775	90.44	1.318**	-0.137	50.75	1.221**	9.91**
MAUS 81	32.22	2.048	2.907**	37.55	1.495**	4.382**	89.88	1.151**	8.082**	56.38	0.479	-1.547
JS 93-05	35.88	0.311	17.65**	41.33	0.945**	20.073**	93.11	1.116**	10.598**	42.95	1.312**	68.61**
MAUS 158	32.33	1.414	7.38**	38.33	1.591**	1.734	90.88	1.389**	11.201**	51.62	0.837*	5.17**
Grand mean	35.68			41.02			92.91			54.53		
SE±	1.60			1.56			1.99			4.00		
SE (b)±	1.53			0.32			0.33			0.31		

Table 3b : Stability parameters (Eberhart and Russell, 1966) for eleven characters in soybean.

Variety	Number of branches			Pods per plants			Seeds per pods			100 seed weight		
	X	Bi	S^2di	X	Bi	S^2di	X	Bi	S^2di	X	bi	S2di
AMS 59	6.15	0.772	0.039	58.20	3.55*	62.11**	2.42	0.338	-0.005	10.88	0.598	-0.160
KS 112	7.05	0.917*	0.185**	44.22	2.14	-1.638	2.48	1.367	-0.016	11.88	-0.576	-0.131
MACS 1039	7.63	1.656**	0.001	43.64	1.38	24.35**	2.51	0.681	0.013**	10.77	1.889*	1.551**
KDS 708	7.28	0.697	2.501**	64.71	-1.328	243.24**	2.46	3.081**	-0.007	10.82	0.388	2.739**
KDS 344	7.17	1.616**	-0.061	49.92	-0.226	187.042**	2.57	9.938vv	0.031**	11.11	0.781	0.444
MACS 1140	6.96	0.798	0.338**	52.02	-0.177	84.92**	2.51	-0.347	0.031**	12.33	0.829	-0.162
MACS 1311	6.51	0.965*	-0.064	53.33	1.380	138.68**	2.44	-0.347	-0.005	12.11	1.889*	1.551**
KS 129	6.45	0.886*	-0.071	43.67	0.860	82.52**	2.40	-1.033	0.001	12.33	1.658*	0.179
KDS 378	6.80	1.587**	0.122**	46.07	0.013	-2.36	2.42	-1.719	-0.007	12.33	2.622**	0.190
KDS 705	6.86	1.095**	3.177**	56.57	1.803	22.43**	2.46	-3.090	-0.007	11.11	1.405	0.239
MACS 1281	6.66	0.592	0.743**	50.77	3.122*	101.44**	2.44	-0.347	-0.005	11.55	1.082	-0.189
KS 132	7.32	1.008**	-0.059	50.67	0.876	28.11**	2.44	4.796**	-0.008	12.33	0.899	0.369**
MAUS 608	6.18	0.933*	0.497**	45.96	-1.294	13.73**	2.35	1.367	-0.006	11.66	1.588*	-0.232
KDS 693	7.52	1.824**	0.392**	47.35	0.550	204.43**	2.63	2.053	-0.003	11.00	-0.070	-0.059
MAUS 612	6.67	0.676	1.159**	41.37	1.411	17.76**	2.44	4.796**	-0.008	10.66	0.275	0.306**
AMS 155	6.54	1.126**	0.925**	66.48	-0.871	554.34**	2.37	-2.404	0.008**	10.89	0.807	0.841**
MAUS 614	5.88	0.571	0.058	51.00	0.277	-2.151	2.46	2.053	0.024**	10.44	0.436	0.028
AMS 56	6.41	1.032**	0.167**	58.27	2.964	553.49**	2.44	-5.490	0.013**	11.11	0.092	-0.211
MAUS 611	6.43	0.998*	0.074	41.88	-0.751	-5.861	2.42	3.425**	-0.006	11.00	0.759	-0.259
MAUS 71	6.24	0.966*	1.882**	52.97	4.025**	172.93**	2.51	1.710	-0.007	10.77	0.711	1.450**
JS 335	5.83	0.821*	0.952**	39.11	0.883	-4.130	2.44	-5.490	0.013**	12.55	2.050*	2.166**
MAUS 81	5.76	1.462**	-0.42	46.76	3.335*	1.867	2.55	0.338	-0.005	11.55	1.287	0.596**
JS 93-05	6.55	0.631	1.496**	32.75	0.356	2.963	2.60	6.167**	0.074**	11.33	1.588	-0.232
MAUS 158	6.84	0.827	0.117**	42.05	0.603	8.671	2.40	2.053	-0.003	11.88	1.012	-0.246
Grand mean	6.65			48.52			2.46			11.41		
SE±	0.50			2.40			0.07			0.60		
SE (b)±	0.43			1.54			0.37			0.80		

Table 3c : Stability parameters (Eberhart and Russell, 1966) for eleven characters in soybean.

Variety	Protein content (%)			Oil content			Seed yield per plant		
	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di
AMS 59	33.51	5.814	1.218**	21.77	2.591	-0.048	14.84	2.44*	0.349
KS 112	36.05	13.59	2.571**	20.46	2.492	0.664**	12.47	0.912	0.186
MACS 1039	34.33	-7.149	2.201**	21.87	-0.081	1.004**	11.56	1.438	-0.017
KDS 708	35.64	-7.910	5.592**	18.36	3.761	0.088**	15.18	-0.374	46.50**
KDS 344	34.93	-1.731	-0.546	18.71	-2.056	0.199**	13.42	0.138	0.032
MACS 1140	33.33	-2.319	9.654**	22.28	-0.919	0.110**	14.99	0.351	6.262**
MACS 1311	34.24	7.004	5.167**	22.47	-3.224	0.118**	14.86	0.605	11.77**
KS 129	36.77	0.559	17.691**	20.50	3.255	0.011	12.70	1.244	-0.117
KDS 378	33.44	-6.817	5.090**	20.09	3.538	0.286**	13.15	6.876**	2.894**
KDS 705	32.95	-3.497	-0.385	18.60	-0.849	0.227**	13.11	1.588	5.92**
MACS 1281	36.55	-6.374	-0.217	19.70	2.818	-0.034	13.17	1.659	5.64**
KS 132	34.85	4.603	10.752**	20.14	2.543	0.019	13.95	0.923	1.11
MAUS 608	35.33	5.194	5.547**	20.77	-2.059	0.17**	12.06	-0.207	-0.59
KDS 693	35.11	16.673*	-0.414	19.50	-0.695	-0.057	12.56	0.199	8.24**
MAUS 612	35.44	3.920	2.032**	20.96	2.825	0.291**	10.54	0.849	2.08**
AMS 155	35.44	0.390	-0.297	20.08	2.468	0.384**	16.65	1.242	6.01**
MAUS 614	35.88	14.795*	2.783**	21.15	-3.328	1.763**	10.86	0.628	0.930**
AMS 56	32.33	3.727	2.970**	21.046	0.220	0.052**	14.74	2.075*	13.41**
MAUS 611	33.88	-7.091	-402	20.05	0.429	1.219**	10.59	-0.105	1.208**
MAUS 71	34.79	-2.99	-0.465	20.46	0.599	-0.052	13.42	2.189*	9.38**
JS 335	35.03	-1.240	6.258**	21.46	1.414	-0.047	11.86	0.852	2.84**
MAUS 81	35.55	-4.632	2.657**	20.96	1.678	0.039	13.15	2.135*	-0.259
JS 93-05	35.44	-2.867	-0.056	21.15	2.628	0.085**	9.61	0.565	-0.362
MAUS 158	37.22	2.402	0.352	20.90	3.422	-0.040	11.36	0.971	-0.422
Grand mean	34.95			20.65			12.95		
SE±	1.39			0.40			1.69		
SE (b)±	7.02			0.33			0.91		

around unity. Two genotypes (JS-335, and MAUS-608) suited to favourable environment as they exhibited bi>1 (below average stability) and non significant S^2di and genotype KDS-378 showed above average stability as bi<1. Non linear component was significant and of higher magnitude indicating its major contribution for expression of traits. Joshi *et al*. (2005) noticed that non linear component significant for days to maturity.

Plant Height: Ten genotypes recorded higher mean plant height than grand mean out of which, MAUS-81 had a stable performance as it had bi near unity and non significant S^2di indicating its suitability to varied environments. Nine genotypes were found to be unstable as their S^2di values were significant. Significance of non linear component of G x E interaction indicated unpredictable genotypic performance over the environments. Tyagi *et al*. (2009) stressed that both linear and nonlinear component were significant for G X E interaction. Three genotypes (MACS-1039, KDS-344 and KS-112) were found to have adaptability for number of branches to favourable environments as their S^2 di values were non significant, bi>1 and high mean. Nine genotypes with high mean performance were found to be unstable. Aremu *et al*. (2005) confirmed both linear and non linear component were significant for number of branches. As regards number of pods, 12 genotypes exhibited high mean performance than general mean. The genotype MAUS-614 had high mean, bi near unity and non significant S^2di indicating wider adoptability for this trait. Eleven genotypes with high mean performance were found to be unstable. The significance of non linear component of G x E interaction indicated unpredictable genotypic performance over the environments. Other observations also reported significance of linear and non linear components for this trait (Mondal *et al*. 2005; Tyagi *et al* 2009).

Seeds per pod: For seeds per pod, four genotypes (KS-132, KDS-705, MAUS- 71, and MAUS-81) showed high mean, bi, around unity and non significant S^2di value, suggesting their wider adaptability. Six genotypes were found to be unstable as their S^2di values were significant. The genotype viz KDS-708 suggested its suitability to favourable environment (below average stability) stressed, both linear and non linear components were reported as significant for this trait by others (Mondal *et al*. 2005 and Ramana *et al* 2006) . As far as 100 seed weight is concerned, eleven genotypes recorded higher mean than grand mean, out of which four genotypes (MACS-1240, MACS-1281, MAUS-158, and KS-112) showed stable performance as it had bi value near to unity and non significant S^2di values. Three genotypes (KS-129, KDS-378 and MAUS-608) were suited to rich environments as bi exhibited more than 1. Rest of four genotypes (MACS-1311, JS-335, MAUS-81 and KS-132) found to be unstable as their S^2di values were significant. Significant non linear component of G x E contributed major portion of G x E. Tyagi *et al*. (2009) reported that both linear and non linear components were significant for this trait. Further, thirteen genotypes recorded higher mean than grand mean for protein content, out of which two genotypes namely MAUS-158 and MACS-1281 were found to be stable as their bi values near unity and non significant s^2di values. The genotype KDS-693 showed below average stability as bi>1. Eleven genotypes with lower mean performance were graded as poorly adopted, irrespective of their stability parameters. The non linear component was significant for this character. Ramana *et al*. (2006) observed that both linear and non linear component were significant for this trait.

Oil Content: Twelve genotypes exhibited higher mean than general mean for oil content. Five genotypes namely AMS-59, JS-335, MAUS-71, MAUS-81 and MAUS-158 were found to be stable for the trait protein content, as their bi values near unity and non significant s^2di values. Seven genotypes observed to be unstable due to significant S^2di values. Rests of twelve genotypes with lower mean performance were graded as poorly adopted irrespective of their stability parameters. The significance of non linear component of G x E interaction indicated unpredictable genotypic performance over environments. Singh (2003) and Ramana *et al*. (2006) noted both linear and non linear component were significant for this traits.

From the present study it was revealed that thirteen genotypes exhibited higher mean seed yield than grand mean. Eight genotypes exhibited significant S^2di values indicating their unstable performance for this trait, while only three genotypes namely KDS-344, KS-132 and MAUS-608 recorded stable performance as their stability parameters were in the desired directions. Two genotypes namely, AMS-59 and MAUS-81 showed below average stability as their bi showed values more than 1. The pooled deviation was significant suggesting its importance in expression of character. Mondal *et al.* (2005), Tyagi *et al*. (2004) and Ramana *et al*. (2006) reported both linear and non linear components showed significant for these traits.

Conclusion

Promising genotypes may be released as new varieties after further testing or as parents for generating new varieties with wide adaptability such as KDS 344, KS 132 and MAUS 608 over environments or with specific adaptation (KDS 705, AMS-59, AMS-56, MACS-1311, JS 335, MAUS-608, KS-129 and KDS-378) to a particular environment for desirable attributes.

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