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Research Article

PREDICTING THE BEST GENOTYPE THROUGH STABILITY ANALYSIS IN SOYBEAN (*Glycine max* (L.) Merrill)

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Abstract: The present investigation was taken up to work out the stability of twenty elite soybean genotypes under varying environmental conditions for grain yield and yield contributing characters along with genetic variability, correlation and path coefficient, fatty acid profiling and molecular marker diversity analysis using thirty SSR primers. The field experiment with twenty genotypes of soybean was laid down in randomized complete block design with three replications at four different locations (Norman E. Borlaug Crop Research Centre at G. B. Pant University of Agriculture and Technology, Pantnagar, ARS, Majhera, IARI, New Delhi and BAU, Kanke, Ranchi) during *Kharif* 2010 and *Kharif* 2011. The Analysis of variance was found significant for all the characters undertaken and pooled analysis for phenotypic stability, environments (linear) also differed significantly. As per the criteria of Eberhart and Russell model, genotype PS 1502 was most desirable and stable for yield per plot and number of primary branches per plant, while it showed specific adaptability to rich environment for dry matter weight per plant, oil content and specific adaptability to poor environment for number of seeds per pod. Among all the genotypes, PS 1347, PS 1506 and PS 1510 showed specific adaptation to poor environments for oil content. Genotype PS 1347 showed stability for seed yield per plot and harvest index.

Keywords: *Stability, Pooled analysis, Adaptability, Genotype and Harvest index*

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Introduction

Soybean plays a major role in the world food systems. Soybeans are legumes, native to East Asia, that are grown for oil and protein around the world. In Indian agriculture, the "yellow revolution" is associated with increased oilseed production and this crop has significant contribution in this. As crop yield fluctuates due to suitability of varieties to different growing seasons or conditions, specific genotype does not always exhibit the same phenotypic characteristics under all environments. Gene expression is subjected to modification by the environment; therefore, phenotypic expression of the genotype is environmentally dependent [1]. The development of new cultivars involves breeding of cultivars with desired characteristics that add value to the product and the stability of these traits in target environments. Inconsistent genotypic responses to environmental factors from location to location and year to year are a function of genotype x environment (GxE) interactions. Identification of yield contributing traits, knowledge of Genotype x Environment interactions and yield stability are important for breeding new cultivars with improved adaptation to the environmental constraints prevailing in the target environments.

Material and Methods

The experimental field trials were conducted at four locations namely, Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, ARS, Majhera, Distt. Nainital, IARI, New Delhi and BAU, Kanke, Ranchi, Jharkhand, during two consecutive kharif seasons of 2010 and 2011.Trials were carried out with 20 advanced breeding lines of soybean (including two checks). The experimental material was planted and evaluated, in Randomized Complete Block Design (RCBD) with three replications. The observation on days to 50% flowering and days to maturity were recorded on plot basis, whereas, 100-seed weight, oil and protein contents were recorded on the sample derived from composited seed of plot, all other characters viz., plant height, number of nodes per plant, number of primary branches per plant, number of pods per plant, number of seeds per pod, dry matter weight per plant and seed yield per plant were observed on five individual plant basis selected randomly in each plot and harvest index is derived character. The mean values for different quantitative traits for each genotype were used for phenotypic stability analysis by Eberhart and Russell (1966)[2] model. This model provides three parameters of stability, mean performance ($\overline{Xi}$), regression coefficient (bi) and deviation from regression (S^2di). A genotype is said to be stable if it had high mean performance above the average of all the genotypes, regression coefficient (bi≈1) *i.e*., does not differ from unity and deviation from regression approaching to zero ($S^2di\approx0$). Genotypes with bi significant and lesser than unity do not respond favourably to improved environmental conditions and hence could be regarded as specifically adapted to poor environments when their mean performance is more than average. On the other hand, a genotype is said to be specifically adapted to favourable [3-8].

Results and Discussion

In pooled analysis of phenotypic stability for the fourteen characters studied, mean square due to environments were highly significant for all the characters indicating sufficient differences among environments and effectiveness of environments in influencing the performance of genotypes. The mean squares due to G × E interaction were significant for all the traits except number of nodes per plant. The mean squares due to environment (linear) were highly significant for all the characters. Genotype x environment (linear) mean squares showed significant differences for all the characters except dry matter weight per plant, days to maturity, number of primary branches per plant, number of pods per plant and number of seeds per pod indicating variable expression of these traits across the

Table-1 *Pooled stability ANOVA for important economic characters in soybean based on Eberhart and Russell model*

Source of Variation	Degree of freedom	Mean Sum of Squares						
		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of primary branches per plants	No. of nodes per plant	No. of pods per plant	No. of seeds per pod
Varieties	19	21.81***	17.87***	185.52***	0.67	1.57***	187.24	0.07*
Environments	7	495.55***	293.72***	4757.81***	122.61***	188.53***	7947.09***	0.11*
Var.× Env.	133	5.87**	6.48*	31.82**	0.64**	0.72	109.78**	0.04*
Env.+ (Var.×Env.)	140	30.35***	20.84***	268.12***	6.74***	10.11***	501.65***	0.04
Environments (Lin.)	1	3468.82***	2056.03***	33304.69***	858.30***	1319.71***	55629.63***	0.74***
Var.× Env.(Lin.)	19	9.08*	8.45	48.78*	0.69	1.25**	52.93	0.04
Pooled Deviation	120	5.07***	5.84***	27.54***	0.60***	0.6	113.29***	0.04***
Pooled Error	304	1.37	1.86	10.72	0.21	0.54	23.94	0.02
Total	159	29.33	20.48	258.25	6.01	9.09	464.08	0.05

Source of Variation	Degree of freedom	Mean Sum of Squares						
		100 seed weight (g)	Dry matter weight per plant (g)	Seed yield per plant (g)	Harvest Index (%)	Seed yield per plot (kg)	Oil content (%)	Protein content (%)
Varieties	19	3.43***	138.75**	17.30*	31.01***	0.04**	5.24***	7.30***
Environments	7	37.41***	3562.82***	426.07***	148.62***	0.30***	13.77***	29.45***
Var. × Env.	133	0.77**	85.41**	10.16**	10.15**	0.02**	2.02**	3.33*
Env.+ (Var. × Env.)	140	2.60***	259.28***	30.95***	17.07***	0.03***	2.61*	4.64**
Environments (Lin.)	1	261.90***	24939.71***	2982.49***	1040.32***	2.08***	96.40***	206.14***
Var. × Env.(Lin.)	19	1.41**	110.65	6.94**	13.39**	0.02*	2.86*	5.70*
Pooled Deviation	120	0.63***	77.14***	10.16***	9.13***	0.02***	1.78***	2.79***
Pooled Error	304	0.26	20.47	2.32	3.91	0.01	0.17	0.63
Total	159	2.7	243.2	28.8	18.74	0.03	2.92	4.95

** Significant at 5 % probability level, **Significant at 1 % probability level, *** Significant at 0.1 % probability level*

Table-2 *Suitable genotypes for different characters under favourable environments*

SN	Character	Favourable environment	Suitable genotypes for respective environments
1	Days to 50% flowering	E1, E3, E4, E5, E7, E8	PS 1494, PS 1496, PS 1499, PS 1501, PS 1503, PS 1504, PS 1509, PS 1510, PS 1092
2	Days to maturity	E1, E3, E4, E5, E6, E7, E8	PS 1493, PS 1494, PS 1496, PS 1497, PS 1498, PS 1501, PS 1509
3	Plant height	E1, E2, E5, E6	PS 1495, PS 1496, PS 1497, PS 1498, PS 1499, PS 1500, PS 1501, PS 1502, PS 1503, PS 1505, PS 1506, PS 1507, PS 1508, PS 1510, PS 1092
4	Number of primary branches per plant	E1, E2, E5, E6	PS 1493, PS 1495, PS 1498, PS 1499, PS 1501, PS 1502, PS 1503, PS 1505, PS 1506, PS 1508, PS 1509, PS 1510
5	Number of nodes per plant	E1, E2, E5, E6	PS 1493, PS 1495, PS 1496, PS 1498, PS 1499, PS 1500, PS 1501, PS 1502, PS 1503, PS 1504, PS 1505, PS 1506, PS 1507, PS 1508, PS 1510, PS 1347, PS 1092
6	Number of pods per plant	E1, E2, E5, E6	PS 1493, PS 1494, PS 1496, PS 1499, PS 1510
7	Number of seeds per pod	E1, E2, E3, E4, E5, E6, E7, E8	PS 1493, PS 1497, PS 1499, PS 1502, PS 1503, PS 1504, PS 1505, PS 1509, PS 1347
8	Hundred seed weight	E1, E2, E3, E6, E8	PS 1493, PS 1494, PS 1495, PS 1496, PS 1497, PS 1505, PS 1506, PS 1092
9	Dry matter weight per plant	E1, E2, E5, E6, E8	PS 1493, PS 1494, PS 1495, PS 1496, PS 1497, PS 1499, PS 1500, PS 1501, PS 1503, PS 1505, PS 1506, PS 1507, PS 1509, PS 1510
10	Seed yield per plant	E1, E2, E5, E6, E8	PS 1493, PS 1494, PS 1495, PS 1496, PS 1508, PS 1509
11	Harvest index	E1, E2, E3, E4, E5, E6, E7, E8	PS 1493, PS 1495, PS 1499, PS 1509, PS 1510, PS 1347, PS 1092
12	Seed yield per plot	E1, E2, E3, E4, E5, E6, E8	PS 1494, PS 1495, PS 1496, PS 1497, PS 1510, PS 1347, PS 1092
13	Oil content	E1, E2, E4, E5, E6, E7, E8	PS 1493, PS 1500, PS 1508, PS 1509, PS 1510, PS 1347, PS 1092
14	Protein content	E2, E4, E5, E6, E7, E8	PS 1493, PS 1496, PS 1498, PS 1499, PS 1501, PS 1502, PS 1508, PS 1509, PS 1510, PS 1347, PS 1092

E1, E2,E3 and E4 are Trials planted at Pantnagar, Majhera, Delhi and Ranchi in the year 2010 respectively
E5, E6,E7 and E8 are Trials planted at Pantnagar, Majhera, Delhi and Ranchi in the year 2011 respectively

environments [Table-1]. Mean performance and environmental indices are desirable attributes of stability parameter. The cultivars must have the genetic potential for superior performance under ideal growing conditions and must also produce acceptable yields under less favourable environments. Genotypes with high mean performance ($xi>\overline{X}$) in favourable environments can be considered as suitable for those environments. Therefore, a stable genotype can be referred to as the one that is capable of utilising the resources available in high yielding environments and has a mean performance that is above average in all environments [3]. List of suitable genotypes for different characters under favourable environments has been presented in [Table-2].

The genotype PS 1502 was found to be most desirable and stable for yield per plot (with least deviation in stability parameters ($\overline{X}$ >0.94, bi≈1.16 and S^2di≈0.00)) and number of primary branches per plant while it exhibited specific adaptability to rich environment for dry matter weight per plant and oil content and specific adaptability to poor environment for number of seeds per pod. The genotype PS 1347 exhibited highly stable and desirable performance for number of seeds per pod and hundred seed weight whereas, it showed suitability to poor environment for harvest index, oil and protein content and suitability to rich environment for number of nodes per plant and yield per plot. Among the test materials, genotype PS 1500 was appeared to be most desirable and stable for yield per plant, dry matter weight per plant and number of seeds per pod while it was found suitable to rich environment for harvest index. Genotype PS 1506 exhibited general adaptation for hundred seed weight, number of nodes per plant and number of seeds per pod while it showed suitability to rich environment for protein content and suitability to poor environment for oil content. Based on stability parameters, components have been classified into four groups [Table-3].

In the first group, none of the two components were significant, hence, indicated total absence of the G x E interactions. Second category consisted of the genotypes, where only linear component was significant. Thus, the performance of these genotypes in varying environments can be predicted. Third group comprised of the genotypes, where only non- predictable component was significant and in the fourth group, both the components were significant. Summary of phenotypically stable and suitable genotypes for different characters has been presented in [Table-4].

Though consistency in the performance of a particular genotype over a range of environment is desirable, however, those varieties are equally important which properly respond to the high yielding environments. In the similar term's cultivars differentially responsive for poor yielding conditions cannot be ignored.

Table-3 *Stability attributes of the soybean genotypes for different characters*

SN	Character	Linear (bi) and non-linear (S^2di) both non significant	Linear (bi) significant and non-linear (S^2di) non-significant	Linear (bi) non-significant and non-linear (S^2di) significant	Linear (bi) and Non-linear (S^2di) both significant
1	Days to 50% flowering	PS 1495, PS 1499, PS 1500, PS 1503, PS 1510	PS 1494, PS 1502	PS 1493, PS 1496, PS 1497, PS 1498, PS 1501, PS 1504, PS 1505, PS 1506, PS 1507, PS 1508, PS 1509, PS 1347, PS 1092	None
2	Days to maturity	PS 1494, PS 1498, PS 1500, PS 1501, PS 1506, PS 1507, PS 1508	PS 1496, PS 1499, PS 1347	PS 1493, PS 1495, PS 1497, PS 1502, PS 1503, PS 1504, PS 1505, PS 1509, PS 1510, PS 1092	None
3	Plant height	PS 1499, PS 1501, PS 1503, PS 1510	PS 1503, PS 1505, PS 1509	PS 1493, PS 1494, PS 1495, PS 1496, PS 1497, PS 1498, PS 1500, PS 1502, PS 1506, PS 1507, PS 1508, PS 1347, PS 1092	None
4	Number of primary branches per plant	PS 1493, PS 1495, PS 1497, PS 1499, PS 1502, PS 1508, PS 1510, PS 1347, PS 1092	PS 1505	PS 1494, PS 1496, PS 1498, PS 1500, PS 1501, PS 1503, PS 1504, PS 1506, PS 1507, PS 1509	None
5	Number of nodes per plant	PS 1495, PS 1496, PS 1497, PS 1498, PS 1499, PS 1500, PS 1501, PS 1502, PS 1503, PS 1504, PS 1505, PS 1506, PS 1508, PS 1509, PS 1510, PS 1092	PS 1494, PS 1507, PS 1347	PS 1493	None
6	Number of pods per plant	PS 1498, PS 1501, PS 1505	None	PS 1493, PS 1494, PS 1495, PS 1496, PS 1498, PS 1499, PS 1500, PS 1502, PS 1503, PS 1504, PS 1506, PS 1507, PS 1508, PS 1509, PS 1510, PS 1347, PS 1092	None
7	Number of seeds per pod	PS 1493, PS 1494, PS 1496, PS 1498, PS 1500, PS 1501, PS 1504, PS 1505, PS 1506, PS 1507, PS 1508, PS 1509, PS 1510, PS 1347, PS 1092	None	PS 1495, PS 1497, PS 1499, PS 1502, PS 1503	None
8	Hundred seed weight	PS 1493, PS 1495, PS 1498, PS 1500, PS 1503, PS 1504, PS 1506, PS 1507, PS 1509, PS 1347, PS 1092	PS 1500, PS 1505, PS 1508	PS 1494, PS 1496, PS 1497, PS 1499, PS 1501, PS 1502, PS 1505, PS 1510	None
9	Dry matter weight per plant	PS 1493, PS 1496, PS 1500, PS 1501, PS 1508, PS 1509, PS 1347	PS 1494, PS 1497, PS 1504	PS 1495, PS 1498, PS 1499, PS 1502, PS 1503, PS 1505, PS 1506, PS 1507, PS 1510, PS 1092	None
10	Seed yield per plant	PS 1493, PS 1496, PS 1500, PS 1501, PS 1508	PS 1494, PS 1504	PS 1495, PS 1497, PS 1498, PS 1499, PS 1502, PS 1503, PS 1505, PS 1506, PS 1507, PS 1509, PS 1510, PS 1347, PS 1092	None
11	Harvest index	PS 1494, PS 1495, PS 1496, PS 1501, PS 1502, PS 1503, PS 1504, PS 1506, PS 1507, PS 1508, PS 1509, PS 1510, PS 1092	None	PS 1493, PS 1497, PS 1498, PS 1499, PS 1500, PS 1505	PS 1347
12	Seed yield per plot	PS 1502	PS 1498, PS 1506	PS 1493, PS 1494, PS 1495, PS 1496, PS 1497, PS 1499, PS 1500, PS 1501, PS 1503, PS 1504, PS 1505, PS 1507, PS 1508, PS 1509, PS 1510, PS 1347, PS 1092	None
13	Oil content	None	PS 1347, PS 1092	PS 1493, PS 1494, PS 1495, PS 1496, PS 1497, PS 1498, PS 1499, PS 1501, PS 1502, PS 1503, PS 1504, PS 1505, PS 1506, PS 1507, PS 1509, PS 1510	PS 1500, PS 1508
14	Protein content	PS 1495, PS 1499, PS 1500, PS 1504,	PS 1502, PS 1503, PS 1092	PS 1493, PS 1494, PS 1496, PS 1497, PS 1498, PS 1501, PS 1505, PS 1506, PS 1507, PS 1508, PS 1509, PS 1510	PS 1347

Table-4 *Summary of phenotypically stable and suitable genotypes for the respective characters*

SN	Character	PS 1493	PS 1494	PS 1495	PS 1496	PS 1497	PS 1498	PS 1499	PS 1500	PS 1501	PS 1502	PS 1503	PS 1504	PS 1505	PS 1506	PS 1507	PS 1508	PS 1509	PS 1510	PS 1347	PS 1092
1	Days to 50% flowering		P									S							S		
2	Days to maturity		S	R	R	P	S			S								R			R
3	Plant height (cm)							S				R		R		R			S		
4	Number of primary branches per plant	S		S				S			S			R					S		
5	Number of nodes per plant				S	S						S			S	R	S			R	
6	Number of pods per plant						R	R		S						R			R		P
7	Number of seeds per pod	S		R					S	S	P		S	S	S		S		S	S	
8	Dry matter weight per plant (g)		R		S	R			S		R					P	S	S			
9	Hundred seed weight (g)												S	P	S	S		S	P	S	S
10	Seed yield per plant(g)		R					R	S								S				
11	Harvest index (%)	R							R	S									S	P	S
12	Seed yield per plot (kg)		R		R			P	P		S	R		R					P		
13	Oil content (%)						R				R	R	R	R	R				R	P	P
14	Protein content (%)			S	P								R		R			R		P	P

S= stable across environments, R= rich environments, P= poor environments

Conclusion

The analysis of variance pooled over the eight environments exhibited significant differences among the genotypes for all the characters studied which indicated the presence of adequate variability in the material under study. The genotype PS 1502 was found to be most desirable and stable for yield per plot (with least deviation in stability parameters (>0.94, bi≈1.16 and S^2di≈0.00)) and number of primary branches per plant while it exhibited specific adaptability to rich environment for dry matter weight per plant and oil content and specific adaptability to poor environment for number of seeds per pod. The genotype PS 1347 exhibited highly stable and desirable performance for number of seeds per pod and hundred seed weight whereas, it showed suitability to poor environment for harvest index, oil and protein content and suitability to rich environment for number of nodes per plant and yield per plot.

Application of research: Adaptation favours those characters which are advantageous for survival and through which an individual acquires adaptive values or fitness.

Research Category: Genetics and Plant Breeding

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Study area / Sample Collection: Pantnagar, 263145, Uttarakhand, India

Cultivar / Variety name: Soybean(*Glycine max* (L.) Merrill)

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