ISSN PRINT 2319 1775 Online 2320 7876

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Prediction Of The Stable Genotypes Based On Analysis Of Genotype × Environment Interaction In Soybean (*Glycine Max* (L.) Merrill)

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Abstract

Soybean plays a major role in the world food systems. Soybeans are legumes that are grown for oil and protein around the world. Indian agriculture is studded with several landmarks. The "yellow revolution" is one of them, associated with increased oilseed production and soybean has significant contribution in this The present experiment was carried out for estimation of the stability of twenty elite soybean genotypes under varying environmental conditions for grain yield and yield contributing characters. The field experiment 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. Eberhart and Russell model identified the genotype PS 1502 as the most desirable and stable for yield per plot and number of primary branches per plant, while it exhibited 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. Genotype PS 1347 was found to be stable for seed yield per plot and harvest index.

Keywords: Stability, phenotypic stability, genotype, seed yield and harvest index.

Introduction

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 (Kang, 1998). 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

ISSN PRINT 2319 1775 Online 2320 7876

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breeding new cultivars with improved adaptation to the environmental constraints prevailing in the target environments.

Material and methods

In order to meet out the objectives of the study the present investigation was carried out with 20 advanced breeding lines of soybean (including two checks). Phenotypic stability in twenty genotypes of soybean for grain yield and twelve other related characters was studied for two consecutive years in eight different environments. The experimental material was planted and evaluated, in Randomized Complete Block Design (RCBD) with three replications, for two consecutive years in four different locations i.e., Pantnagar, Majhera, Delhi and Ranchi. Each replication was divided into 20 plots, each plot of 5 rows, 4m long and spaced 45 x 7-10 cm meter length. 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 plot mean was used for statistical analysis. The stability analysis was done according to Eberhart and Russell (1966). 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 environment.

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 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 (Allard and Bradshaw,

ISSN PRINT 2319 1775 Online 2320 7876

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1964; Eberhart and Russell, 1966). 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 ($\bar{X}i$ >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 terms cultivars differentially responsive for poor yielding conditions cannot be ignored.

Conclusion

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 environments.The genotype PS 1502 was found to be most desirable and stable for yield per plot (with least deviation in stability parameters ($\bar{X}i$ >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 1510 was appeared to be most desirable and stable for days to 50% flowering, plant height, number of seeds per pod, number of primary branches per plant and harvest index while it exhibited specific adaptability to rich environment for number of pods per plant and to poor environment for hundred seed weight, yield per plot and oil content. 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

ISSN PRINT 2319 1775 Online 2320 7876

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protein content and suitability to rich environment for number of nodes per plant and yield per plot.

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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	19.00	21.81***	17.87***	185.52***	0.67	1.57***	187.24	0.07*
Environments	7.00	495.55***	293.72***	4757.81***	122.61***	188.53***	7947.09***	0.11*
Var.× Env.	133.00	5.87**	6.48*	31.82**	0.64**	0.72	109.78**	0.04*
Env.+ (Var.×Env.)	140.00	30.35***	20.84***	268.12***	6.74***	10.11***	501.65***	0.04
Environments (Lin.)	1.00	3468.82***	2056.03***	33304.69***	858.30***	1319.71***	55629.63***	0.74***
Var.× Env.(Lin.)	19.00	9.08*	8.45	48.78*	0.69	1.25**	52.93	0.04
Pooled Deviation	120.00	5.07***	5.84***	27.54***	0.60***	0.60	113.29***	0.04***
Pooled Error	304.00	1.37	1.86	10.72	0.21	0.54	23.94	0.02
Total	159.00	29.33	20.48	258.25	6.01	9.09	464.08	0.05

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ISSN PRINT 2319 1775 Online 2320 7876

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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	19.00	3.43***	138.75**	17.30*	31.01***	0.04**	5.24***	7.30***
Environments	7.00	37.41***	3562.82***	426.07***	148.62***	0.30***	13.77***	29.45***
Var. × Env.	133.00	0.77**	85.41**	10.16**	10.15**	0.02**	2.02**	3.33*
Env.+ (Var. × Env.)	140.00	2.60***	259.28***	30.95***	17.07***	0.03***	2.61*	4.64**
Environments (Lin.)	1.00	261.90***	24939.71***	2982.49***	1040.32***	2.08***	96.40***	206.14***
Var. × Env.(Lin.)	19.00	1.41**	110.65	6.94**	13.39**	0.02*	2.86*	5.70*
Pooled Deviation	120.00	0.63***	77.14***	10.16***	9.13***	0.02***	1.78***	2.79***
Pooled Error	304.00	0.26	20.47	2.32	3.91	0.01	0.17	0.63
Total	159.00	2.70	243.20	28.80	18.74	0.03	2.92	4.95

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

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Table2: Suitable genotypes for different characters under favourable environments

S.No.	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

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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

ISSN PRINT 2319 1775 Online 2320 7876

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Table 3: Stability attributes of the soybean genotypes for different characters

S. No.	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	None	PS 1493, PS 1497, PS 1498, PS 1499, PS 1500, PS 1505	PS 1347

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		1503, PS 1504, PS 1506, PS 1507, PS 1508, PS 1509, PS 1510, PS 1092			
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

SI. No.	**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	

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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