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1) Phenotypic stability of soybean in Peru.

Introduction: In countries like Peru, where soybean is an introduced crop, it is necessary to utilize high technology suitable for the coast and jungle ecological conditions, in order to achieve productive success. Besides mechanization, it is very important to use seed of high genetic value, stored under optimum conditions. These two conditions would contribute to minimize the risks that very often affect the farmers. The basic idea is to consider the variety to be used and its possible interaction with the environment.

There are two ways for evaluating the adaptive capability of a species; the first, related to survival, commonly used by the evolutionists, and the second, one which considers the stability and consistency of performance, mostly used by plant breeders.

There are several methods of stability evaluations in use; the earliest one was described by Finlay and Wilkinson (1963). Eberhart and Russell (1966) modified the previously indicated interpretation because, in general, the hybrids having regression coefficients smaller than "1" had productive performances below the general average. They established that a variety is stable if it has a regression coefficient equal to "1", a high average, and the regression variance of deviation should be small or equal to "0".

Materials and methods: The study involved the results of several soybean varieties trials conducted from 1975 to 1976 at five locations in Peru. The locations (Coordinates 5° to 9° South Latitude) were in the jungle: Huarangopampa, El Porvenir, Pucacaca and Tulumayo; and Mallares in the Northern Coast.

Trials were set as randomized block design (at five locations). The plots consisted of four 5 m-long furrows, separated 0.60 m and planted in a density of 400,000 to 450,000 plants per ha. The performance was evaluated using the two central furrows. Data of plant number, blooming date, and seed production were recorded and analyzed. Previous to planting, the seeds were inoculated with Nitragin "S".

The studied varieties were: 'Jupiter', 'Hampton 266a', 'Hardee', 'Improved Pelican', 'Cobb', 'Bossier', 'Davis', 'Tracy', 'Forrest', 'Columbus', 'Clark 63', 'Woodworth', and 'Williams'.

The method used in the calculations and the interpretation was that of Eberhart and Russell (1966), which is a modification of Finlay and Wilkinson (1963) methodology. The statistical model used for defining the stability parameters was:

$$Y_{ij} = M_i + \beta_i I_j + \sigma_{ij},$$

where:

Y_{ij} = Average performance of i^{th} variety under the j^{th} environment ($i = 1,2,...v$) and ($j = 1,2,...n$);

M_i = Mean of i^{th} variety under all the environments;

β_i = Regression coefficient which measures the response of i^{th} variety to the different environments;

σ_{ij} = Regression deviation of i^{th} variety under the j^{th} environment;

I_j = Environmental index at j^{th} environment, defined in terms of environment deviation from the mean of all environments.

Results and discussion: A Barttlett test confirmed homogeneity of variance among varieties; therefore, the error mean squares were considered as estimators of the population variance. Also, the analyzed responses were independent of density and there was no need of data adjusting.

Table 1 shows the 13 varieties' average responses and their environmental index for the five locations.

The average production of these 13 varieties ranged between 1,754 and 3,101 kg/ha; these extremes corresponded to Woodworth and Improved Pelican, respectively.

The environmental average for the five localities ranged from 1,706 kg/ha to 2,479 kg/ha for plots at Pucacaca (Jaen Province) and Sullana locations, respectively. Environmental indexes ranged from -0.325 at Pucacaca location to 0.139 at Sullana.

Table 2 presents the variance analysis showing high significant difference among varieties and influence of variety x location interaction (linear). The interaction can be interpreted as the existence of genetic differences among varieties according to their regression on the environmental indexes.

Table 3 presents the stability parameters for the 13 soybean varieties. The better varieties for yield under the five environments were Improved Pelican and Jupiter. In a second order group were Forrest, Davis, and Hardee.

The regression coefficient reached values between -1.09 and 2.50 for Clark 63 and Jupiter, respectively. The wide range of variation allowed the Clark 63 variety to show a slope of the regression line highly significant and different to 1.

The regression deviation indicative of the degree of consistency to environmental changes showed values between -0.018 and 0.148 for Clark 63 and Cobb varieties, respectively. The Jupiter and Cobb varieties showed highly significant differences while the Forrest, Davis, and Bossier were only significantly different of zero. That suggests that the significant variety-environment interactions could be due to lack of consistency in response of some of the varieties to the different environmental conditions.

Table 1. Average yield of 13 soybean varieties tested at five different locations

Variety	Localities Production in kg					Average	
	Sullana	Huaran-gopampa	El Porvenir	Pucacaca	Tulumayo	kg/plot	kg/ha
Jupiter	2.051	2.342	1.540	1.051	2.189	1.835	3,058
Hampton 266-A	1.442	1.372	1.252	0.932	1.146	1.229	2,048
Hardee	1.713	1.770	1.379	1.145	1.336	1.469	2,448
Improved Pelican	2.226	1.772	1.971	1.222	2.110	1.860	3,101
Cobb	1.150	1.820	1.106	0.810	0.881	1.153	1,922
Bossier	1.030	1.076	1.204	0.805	1.559	1.135	1,891
Davis	2.056	1.409	1.394	0.854	1.722	1.487	2,478
Tracy	1.039	1.172	1.280	0.900	1.184	1.115	1,858
Forrest	1.936	1.304	1.717	1.139	1.516	1.522	2,537
Columbus	1.404	1.407	1.375	1.084	1.259	1.306	2,176
Clark-63	0.965	1.148	1.078	1.501	1.051	1.149	1,914
Woodworth	1.086	0.929	1.086	0.892	1.269	1.052	1,754
Williams	1.244	1.044	1.370	0.972	1.469	1.220	2,033
Average	1.488	1.428	1.365	1.024	1.438	1.349	2,248
Environmental Index	0.139	0.079	0.016	-0.325	0.089		

Table 2. Variance analysis used for estimation of stability in the performance of 13 soybean varieties

Source of variation	df	ss	MS	F
Total	64	9.189		
Varieties (V)	12	2.303	0.358	7.458**
Environments (E)	52	4.886		
VxE				
- Environmental (linear)	1	1.745		
- Var. x Envir. (linear)	12	1.279	0.106	2.208*
- Pooled deviations	39	1.862	0.048	
Error	180		0.080	

Table 3. Average yield kg/ha, b and S^2d stability parameters and classification of 13 soybean varieties

Varieties	Yield	Duncan test	b_i	S^2di	Classification+ Group	Description
Imp. Pelican	3,101	a	1.95	0.011	2	Stable
Jupiter	3,058	a	2.50	0.067**	1	Generally good response, nonconsistent
Forrest	2,537	b	1.18	0.050*	1	Generally good response, nonconsistent
Davis	2,478	bc	2.12	0.036*	1	Generally good response, nonconsistent
Hardee	2,448	bc	1.05	0.022	2	Stable
Columbus	2,176	cd	0.63	-0.013	2	Stable
Hampton 266-A	2,048	de	0.92	-0.005	2	Stable
Williams	2,033	de	0.66	0.019	2	Stable
Cobb	1,922	de	0.98	0.148**	1	Generally good response, nonconsistent
Clark 63	1,914	de	-1.09**	-0.018	3	Better response under unfavorable environment, consistent
Bossier	1,891	de	0.89	0.045*	1	Generally good response, nonconsistent
Tracy	1,858	de	0.50	-0.003	2	Stable
Woodworth	1,754	e	0.46	0.000	2	Stable
General aver.	2,248					

+According to stability parameters.

According to Eberhart and Russell (1966) methodology, varieties showing regression coefficients close to one and deviations near to zero are ideal. These characteristics added to performances above the general average allow us to draw some conclusions; however, the general average is useless because the majority of these varieties have no optimum adaptive advantage in terms of performance. Moreover, they are varieties introduced from other environments and selected to perform in environments quite different to that of our country. Therefore, the ideal varieties for our conditions would be Hardee and Improved Pelican.

The classification and description reported in Table 3 give some orientation; however, its confirmation requires testing a wider range of environments.

Conclusion: In general, selection is made considering those traits indicative of vigor that are highly correlated to productive performance. The use of stability should make that criteria change. What is necessary are stable varieties, or varieties having average stability, instead of varieties having high performance but low stability.

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