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Genetic analysis and path coefficient studies of biological nitrogen fixation traits in soybean

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Thirty soybean genotypes were evaluated in RBD during *Kharif*, 1992 for estimating GCV, PCV, h^2, genotypic and phenotypec correlations and path coefficients for biological nitrogen fixation traits. High heritability along with high genetic advance was recorded for number of nodules in the primary root, number of nodules in the secondary roots, total number of nodules in the primary root, number of nodules in the secondary roots, total number of nodule, weight of nodules in the primary root, weight of nodules in the secondary roots and total weight of nodules indicating the presence of additive gene action. High heritability along with low genetic advance observed in days of fifty per cent flowering and nitrogen fixation per plant indicating non-additive gene action. Significant positive correlation was observed for number of nodule in the primary root, total number of nodules, weight of nodules in the primary root, weight of nodules in the secondary roots and total weight of nodules with nitrogen fixation and grain yield. However, nitrogen fixation itself showed negative correlation with grain yield. Path coefficient analysis recorded positive direct effect for all the nodular characters except the number of nodule in the secondary root with nitrogen fixation per plant. These observations indicated the interference of nodule number and nodule weight of leguminous plant in the selection of better plant type.

Key words : Soybean, genotypes, biological nitrogen fixation traits

INTRODUCTION

Yield is the production of interaction of various yield condributing components. Information about their interrelationship would be useful for developing efficient breeding strategy. So far for leguminous crop plant breeder utilized the genetic variability of conventional characters with yield potential as their selection criteria. However, very little attention has been given to improve the nitrogen nutrition of legumes by breading for increased biological nitrogen fixation along with yield. Estimates of genetic associations along with the phenotypic correlation not only display a clear picture of the extent of inherent association but also indicate how much of the phenotypically expressed correlation is influenced by the environment. Furthermore, the relationship between nitrogen fixation components can be analysed by the method of path coefficients.

The objective of the present investigation is (i) the genotypic and phenotypic correlation between all possible pairs of ten characters and (ii) the degree to which certain characters or combination of characters may be useful as indicator of high nitrogen fixation as well as yield.

MATERIALS AND METHODS

A field experiment comprising of thirty genotypes of soybean [*Glycine max*(L.) Merril] was conducted at Central Research Farm, Goyeshpur, BCKV during the *kharif* 1992. The material was grown in "Randomise Block Design" with two replications. Each treatment was accommodated in two row plot of 2.5 meter length with line to line spacing of 45 cm and plant to plant 5-7 cm. All recommended package of practices, including inoculation of the seed at the time of sowing with *Bradyrhizobium japonicum* strain nos. Bu-4 and Bu-6 in a mixture, were followed to raise a healthy crops. Five plants were randomly selected from each replication at 50% flowering stage. Plants were uprooted carefully from the well irrigated field, washed thoroughly to remove the adhering soil particles withour damaging the nodules. Then the moisture was removed by using soft tissue paper. Observations were recorded on biological nitrogen fixation traits such as days to 50% flowering, number of nodules in the primary root, total nodule weight, plant dry weight, nitrogen content in plant and grain yield in plant. Nitrogen content in the plant was estimated by Kjeldahl method. The data were analysed statistically and coefficient of variation (GCV and PCV) were worked out by adopting the method suggested by Panse and Sukhatme (1967), heritability in broad sense was estimated as per Wolf (1968). Genetic advance and correlation coefficients (genotypic and phenotypic) were calculated according to Singh and Choudhury (1977). Path analysis was done as per Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance estimated on the characters contributing to biological nitrogen fixation are presented in Table 1. The relative magnitude of difference of phenotypic and genotypic coefficient of variation showed that three characters such as number of nodules in the secondary roots, weight of nodules in the secondary roots and plant dry weight registered relatively wider magnitude of phenotypic coefficient of variatiion (PCV) and genotypic coefficient of variation (GCV) indicating the greater influence of environment rather than genetic factors over these characters. The narrow relative magnitude of PCV and GCV of other characters such as number and weight of nodules in the primary root, total number and weight of nudules, number of days to 50% flower and nitrogen content in plant indicating that these characters were greatly influenced by the genetic factor rather than environment.

It is known that GCV alone will not provide a correct estimate of the amount of heritable variation and effectiveness of selection for any character. Sreekumar and Manikantan Nair (1996) while working with cowpea suggested that GCV along with heritability would give a better idea about the amount of genetic advance to be expected by phenotypic selection. Excepting the plant dry weight almost all the characters recorded high heritability. The highest heritability was recorded by number of days to flower (95.89) followed by total nodule weight (86.30) and nitrogen content in plant (84.26). The low heritability of plant dry weight indicated high degree of nonheritable variation of the character.

Aher *et al.* (1998) advocated that the resultant effect of heritability and genetic advance are more reliable in predicting effective selection than heritability alone. High value of heritability together with genetic advancc indicated additive gene action. Genetic advance as per cent of mean recorded to be high for all the nodulation characters such as number of nodules in the primary root, number of nodules in the secondary roots, total nodule number, weight of nodules in the primary root, weight of nodules in the secondary roots and total nodule weight. As such these characters were under the control of additive genes.

It was found that although the number of days to flower and nitrogen content in plant possessed high heritability, the genetic advance of these two characters was low. The estimate of high heritability association with low genetic advance (Sreekumar *and Manikantan Nair* 1966). High heritability association with low genetic advance might be attributed to the presence of non-additive gene action which included epistasis, dominance and genotype x environment interactions (Johnson *et al.*, 1955), hence their response to selection would be poor. Low heritability together with low genetic advance as recorded by the plant dry weight confirmed the high influence of environment on the expression of character. It indicates little improvement by selection.

The genotypic correlation coefficient and phenotypic correlation coefficient represented in the Table 2 showed that in most of the cases the genotypic correlation coefficient was higher than phenotypic correlation coefficient. This observation is corroborative with the earlier reports by Johnson *et al.* (1955), Ma (1983) and Sreekumar and Manikantan Nair (1996). This confirms the considerable role of environment in modifying the

Table 1 : Mean, range, components of variance, coefficient of variation, heritability, genetic advance and genetic gain for various biological nitrogen fixation characters in soybean [*Glycine max* (L). Merril.]

Characters	Mean	Range	Variance		Coefficient		Heritability (%)	Genetic advance	Genetic advance as per cent of mean
			Genotypic	Phenotypic	Genotypic	Phenotypic			
Number of nodules in the primary root	18.52	12.3-31.6	17.06	25.72	21.39	27.14	64.36	7.12	38.44
Number of nodules in the secondary root	24.26	10.6-17.4	79.63	131.84	39.80	50.61	60.98	7.12	62.57
Total number of nodules	43.37	28.7-80.5	105.58	165.01	26.29	33.48	6.49	15.18	42.79
Weight of nodules in the primary root (g)	2.44	0.89-4.72	0.37	0.546	37.62	42.94	77.24	18.56	69.26
Weight of nodules in the secondary root (g)	1.21	0.53-3.95	0.24	0.31	46.37	58.66	77.92	1.69	84.47
Total nodule weight (g)	3.67	1.87-7.49	0.72	0.83	40.96	43.63	86.30	1.01	74.93
Number of days to 50% flower	48.94	45.6-56.3	10.23	10.82	9.26	9.93	95.89	2.75	16.30
Plant dry weight (g)	29.78	20.61-62.77	2.29	7.59	32.16	45.28	34.15	7.98	19.44
Nitrogen content in plant (%)	4.65	4.91-4.92	0.04	0.04	7.89	8.16	84.26	5.79	14.62

Table 2 : Genotypic and phenotypic correlation of biological fixation characters in soybean [*Glycine max* (L). Merril.]

No. of nodules in the primary root	No. of nodules in secondary root	Total no. of nodules	Wt. of nodules in the primary root	Wt. of nodules in the secondary root	Total nodule weight	No. of days to 50% flower	Nitrogen content per plant	Plant dry weight	Grain yield per plant
—	0.204	0.574**	0.427**	−0.096	0.289*	−0.215	0.305**	−0.485**	0.392**
0.194	—	0.945**	−0.371**	0.459**	0.038	−0.138	0.084	−0.035	0.168
0.526**	0.928**	—	0.098	0.408**	0.478**	−0.112	0.275*	−0.092	0.235*
0.511**	0.257*	0.124	—	0.421**	0.910**	0.174	0.896**	0.202	0.264*
−0.110	0.505**	0.398**	0.248*	—	0.718**	0.463**	0.722**	0.489**	0.228*
0.348**	0.136	0.216	0.909**	0.707**	—	0.329**	0.986**	0.338**	0.276*
−0.179	−0.148	−0.153	0.169	0.122	0.184	—	0.207	0.465**	−0.198
0.309**	0.110	0.289**	0.872**	0.565**	0.968**	0.296**	—	0.319**	−0.174
−0.360**	−0.076	−0.156	0.232	0.284**	0.230*	0	0	—	−0.129
0.384*	0.194	0.315**	0.294*	0.276*	0.367*	0.202	0.183	0.145	—

* Significant at 5% level
** Significant at 1% level
The upper diagonal values are the genotypic correlation coefficients and the lower diagonal values are the phenotypic correlation coefficients

Table 3 : Direct and indirect effects of the components of nitrogen content in plant in soybean [*Glycine max* (L). Merril.]

Compoents	No. of nodules in the primary root	No. of nodules in secondary root	Total no. of nodules	Weight. of nodules in the primary root	Wt. of nodules in the secondary root	Total nodule weight	Plant dry weight	Genotype correlation with nitrogen content in plant
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	
X_1	0.381	−0.018	1.612	0.526	−0.114	0.095	0.037	0.305
X_2	−0.050	−0.063	1.837	−0.142	0.494	0.146	0.012	0.084
X_3	0.448	0.109	2.574	−0.059	0.273	0.343	0.036	0.275
X_4	−0.026	0.682	0.083	0.841	0.355	−0.156	−0.107	0.896
X_5	0.047	−0.246	0.693	0.442	0.732	−0.004	0.109	0.722
X_6	−0.009	−0.167	0.521	0.928	0.673	1.237	−0.067	0.986
X_7	0.584	0.205	−0.379	0.283	0.398	—	0.069	0.319

Residual effect = 0.0682

total expression of the genotype.

Total number of nodules as well as number of nodules in primary root recorded very high positive and significant genotypic and phenotypic correlation with nitrogen content per plant and grain yield per plant. Similarly total nodule weight along with weight of nodules in the primary root showed very high positive and significant genotypic and phenotypic correlation with nitrogen content per plant as well as grain yield per plant. The number and weight of nodules in the secondary root also were positively genotypic and phenotypic correlated with nitrogen content and grain yield per plant. This observation supported the findings of Ma (1983) and Singh and Phul (1999). In cowpea (*Unguiculata*), Sreekumar and Manikantan Nair (1996) reported that plant dry weight and days to 50% flowering had negative- genotypic and phenotypic correlation with nitrogen content per plant and grain yield per plant. The negative correlation between nitrogen fixation with grain yield was to sacrifice of the carbon to grain yield (Bergersen, 1971).

Number and weight of nodules both in the primary and secondary root recorded positively correlated with total number and weight of nudules. Again these two nodular characters are positively associated with nitrogen content and grain yield per plant. Hence both number and weight of nodules are equally important in biological nitrogen fixation and grain yield per plant. These observations were in close conformity with the results obtained by Singh and Phul (1999) in soybean. However, Sreekumar and Monikantan Nair (1996) while working with cowpea suggested the importance of nodule weight is more than nodule number.

Path coefficient values based on genotypic correlations showing direct and indirect effects of seven characters on nitrogen content per plant are presented in Table 3 Total number of nodules had maximum direct effect (2.574) on nitrogen content per plant followed by total weight of nodules (1.237) and weight of nodules in the primary root (0.841). Except nodule number in the secondary root and plant dry weight other nodular characters showed positive direct effect. Residual effect in the present study was (0.0682) very low indicating that the number of characters chosen for the study were appropriate.

High positive genotypic correlation was recorded for nodulse number in the primary root and total number of nodule with nitrogen content per plant confirmed by positive direct effect of total nodule number (2.574) and number of nodule in the primary root (0.381). Similarly very high genotypic correlations of weight of nodules in the primary and secondary roots as well as total nodule weight (0.896; 0.722 and 0.986 respectively) with nitrogen content per plant have also been confirmed by the direct positive effect of these characters with nitrogen content per plant (values are 0.841, 0.732 and 1.237 respectively). It has also been observed that all the nodular characters are positively genotypic correlated with grain yield per plant. Hence, while we are going to select a soybean cultivar for high symbiotic association as well as for good grain yield we must consider nodule number and nodule weight of the plant as selection criteria.

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