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Genotypic Variability and Combining Ability for Nodule Number in Common Bean

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A greater number of functional nodules could potentially enhance nitrogen fixation in bean plants. The objectives of this study were; i) to determine genotypic variability for nodule number among a group of black bean lines, ii) to identify lines with good combining ability for nodule number and iii) to evaluate the potential for increasing nodule number by recurrent selection. Ten black bean lines (Table 1) were grown in modified Leonard jars in a growth room and evaluated in 3 separate experiments for nodule number. Factorial treatment designs were utilized in experiments 1 and 2 to study interactions between inoculum concentration and strains of Rhizobium leguminosarum biovar phaseoli. In experiment 1, genotypes were inoculated with 10,100 and 1,000 cells per plant Rhizobium strains Kim 5, Ciat 899 and CNF 280. In experiment 3, genotypes were evaluated along with 45 F1 plants which resulted from a diallel mating design (without reciprocals) among 10 lines. Plants were inoculated with the Rhizobium strain Kim 5. Nodules were counted 26 days after planting in all experiments. Statistical analyses of general combining ability (GCA) and specific combined ability (SCA) were performed according to method 4 (Griffing, 1956).

Genotypic differences for nodule number were significant in experiments 1 and 2, but non-significant in experiment 3, perhaps due to the use of only 2 replications. Genotype x inoculum concentration and genotype x strain interactions were non-significant. Linear correlation coefficients of nodule number among experiments were also highly significant ranging from .76 to .92. These results demonstrate the repeatability between experiments (Table 1).

Diallel analysis of nodule number revealed highly significant variation for GCA, whereas variation for SCA was non-significant in this set of genotypes. Crosses involving Puebla 152, UW 22-34 and Bat 76 had the highest mean nodule numbers, respectively (Figure 1). Those three genotypes, known to be good fixers in field studies showed the only positive GCA effects, indicating that they consistently transmitted genetic merit for nodule number to the progenies (Table 2). Significant variation for GCA and non-significant SCA suggest that additive gene action is important for nodule number and that recurrent selection should be effective in increasing nodule number. The correspondence between high nodule number and field performance for nitrogen fixation suggests that enhanced N_2-fixation should result from an increase in nodule number.

References

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Austr. J. Biol. Sci 9:463-493.

Table 1. Number of nodules on seedlings of black bean lines (26 days after planting) grown in modified Leonard jars in a growth room.

Cultivar or line	Nodule number and ranking: Expt. 1 No.	Rank	Expt. 2 No.	Rank	Expt. 3 No.	Rank	Combined No.	Rank
Puebla 152 bl.	203	1	148	1	101	1	146	1
U.W. 22-34	180	2	123	2	86	2	130	2
BAT 76	145	3	73	7	84	3	101	3
ICA Pijao	142	4	87	5	72	7	100	4-5
Porrillo Sint.	139	5	79	6	84	4	100	4-5
Bl. Turtle Sp.	131	6	91	4	74	6	99	6-7
U.W. 22-03	118	7	98	3	80	5	99	6-7
U.W. 21-58	109	8	63	9	62	8	78	8
Rio Tibagi	104	9	64	8	58	9	75	9
Negro Argel	100	10	63	10	41	10	68	10
mean	137		89		74		100	
$LSD_{.05}$	21		22		64			

Table 2. GCA Effects of each parent over 9 crosses in a diallel mating design.

Cultivar or line	Line Number	GCA Effect
Negro Argel	1	-9.14
Blk. Turtle Sp.	2	-2.69
U.W. 21-58	3	-13.88
U.W. 22-03	4	-6.13
U.W. 22-34	5	+19.75
Porillo Sint.	6	-14.81
Rio Tibagi	7	-4.75
ICA Pijao	8	-1.25
Puebla 152 bl.	9	+22.10
BAT 76	10	+9.13

Figure 1. Mean nodule number of F_1 plants resulting from crosses of each parental line with all other lines (8 of 9 crosses) for the bean lines: 1, Negro Argel; 2, Black Turtle Sp.; 3, U.W. 21-58; 4, U.W. 22-03; 5, U.W. 22-34; 6, Porrillo Sintetico; 7, Rio Tibagi; 8, ICA Pijao; 9, Puebla 152, bl.; 10, BAT 76.