

Genetic analysis of traits governing nitrogen fixation in fieldpea

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ABSTRACT

Genetics of quantitative traits responsible for nitrogen fixation viz, number of nodules/plant, nodules volume/plant, nodules dry weight/plant, main root length, 100-seed weight, seed protein content, straw protein content, grain yield and nitrogen fixation/plant in fieldpea was studied using a half diallel cross involving eight genotypes. Data from the parents and F_1 s were analyzed using Hayman method of diallel analysis. The estimate of H_1 was significantly higher than D for all the traits indicating non-additive gene effect for all the characters. The values of H_1 , H_2 and $H_2/4H_1$ indicated that there were unequal frequencies of the alleles at all the loci. The value of F and KD/KR ratio showed that all the parents carried more dominant alleles than recessive ones. The value of average degree of dominance (H_1/D)^{0.5} was more than one indicating over-dominance for all the traits. Seed yield and number of root nodules showed high heritability coupled with high genetic advance while other traits had low heritability and low genetic advance.

Key words: Fieldpea, Gene effect, Nitrogen fixation, *Pisum sativum*

Fieldpea (*Pisum sativum* L.) plays an important role in improving soil health by virtue of its ability to fix atmospheric nitrogen in symbiotic association with *Rhizobium*. Unfortunately, the yield of fieldpea has remained stagnant. Recently, more emphasis has been given on research towards nitrogen fixation. A working knowledge on the gene effects controlling the traits related to nitrogen fixation is desirable before undertaking any major endeavour in fieldpea improvement. The present communication reports the gene effects controlling nitrogen fixation traits in fieldpea.

MATERIALS AND METHODS

Eight diverse fieldpea genotypes (JP 4, HUDP 7, EC 1, Pant P 21, S 143, DDR 23, Pant P 13 and Pant P 14) were crossed in half diallel fashion resulting in 28 F_1 s. These F_1 hybrids along with their parents were grown in a randomized block design during Rabi 2001-02. The recommended package of practices was followed to raise a good crop. The observations were recorded on five random plants per treatment per replication for different characters (Table 1). The genetic parameters were estimated as per Hayman's analysis of diallel crosses (4). Nitrogen fixation was worked out by N difference method (5). Nitrogen content in grain and straw was estimated by autokjeldhal method.

N_2 fixed = Total N uptake by pea plant – Total N uptake by reference cereal (barley)

Total N uptake (g/plant) by both crops = N uptake by grain + N uptake by straw

RESULTS AND DISCUSSION

The dominance components H_1 and H_2 were significantly higher than D for all the characters (Table 1). This indicates that the component of variation due to non-additive gene effects were important for all the characters (3, 7, 8). The positive values of H_1 and H_2 for all the traits indicated that there were unequal frequencies of alleles. Further proof for

Table 1. Estimates of genetic components of variation for nitrogen fixation traits in fieldpea

Character	D	H_1	H_2	h^2	F	E
No. of root nodules/plant	72.86 ± 30.95	256.15* ± 71.15	199.72* ± 61.90	120.15* ± 41.52	35.12 ± 73.14	0.03 ± 10.32
Nodules volume / plant (ml)	0.06** ± 0.01	0.061* ± 0.02	0.04** ± 0.01	0.01 ± 0.01	0.02 ± 0.02	0.00001 ± 0.002
Nodule dry weight /plant (mg)	133.15** ± 45.00	547.45** ± 103.45	426.65** ± 90.00	220.26 ± 60.36	159.09 ± 106.33	1.24 ± 15.00
Main root length (cm)	3.21 ± 2.29	13.33* ± 5.26	10.57 ± 4.58	2.06 ± 3.07	5.44 ± 5.41	0.002 ± 0.76
100-seed weight (g)	12.43** ± 3.28	24.73* ± 7.53	19.01* ± 6.55	3.26 ± 4.40	13.68 ± 7.74	0.23 ± 1.09
Seed protein content (%)	0.56 ± 0.34	2.70* ± 0.79	2.53** ± 0.69	1.64* ± 0.46	-0.36 ± 0.81	0.14 ± 0.11
Straw protein content (%)	0.48 ± 0.27	3.23** ± 0.63	2.93** ± 0.55	0.89* ± 0.37	0.30 ± 0.65	0.16 ± 0.09
Grain yield/plant	9.58 ± 6.15	50.94* ± 14.14	38.47* ± 12.30	5.70 ± 8.25	1.08 ± 14.58	0.16 ± 2.05
Nitrogen fixation/plant (%)	0.05* ± 0.01	0.14** ± 0.03	0.11 ± 0.26	0.07** ± 0.02	0.04 ± 0.03	0.0002 ± 0.004

*, ** = significant at 5% and 1% probability levels

the unequal distribution of alleles over loci was obtained by the values of $H_2/4H_1$ ratio which were in the range of 0.16 to 0.24 (Table 2). This indicates that the positive and negative alleles at loci exhibiting dominance were not in equal proportion in the parents of interest. However, these estimates did not

Table 2. Ratios of genetic components for nine nitrogen fixation traits in fieldpea

Character	$(H_1/D)^{0.5}$	$H_2/4 H_1$	KD/KR	H_{ii}	Genetic advance (% of mean)
No. of root nodules/plant	1.88	0.20	1.30	40.47	83.56
Nodules volume/plant (ml)	1.01	0.16	1.40	38.78	137.50
Nodules dry weight/plant (mg)	2.03	0.20	1.84	23.58	64.82
Main root length (cm)	2.04	0.20	2.42	9.20	4.52
100-seed weight (g)	1.14	0.19	2.28	31.29	35.61
Seed protein content (%)	2.20	0.24	0.73	36.57	9.03
Straw protein content (%)	2.60	0.23	1.27	18.37	25.00
Grain yield per plant	2.31	0.19	1.05	42.69	111.08
Nitrogen fixation/plant (%)	1.75	0.21	1.73	28.95	60.61

*,** = significant at 5% and 1% probability levels

throw light on the type of alleles occurring more frequently. The estimates of F were positive for almost all the characters except protein content. This indicated predominance of dominant alleles than recessive alleles in the parents studied. Value more than one for KD/KR ratio confirmed this fact for all the traits except seed protein content. Hence, the eight parents used in the study carried excess dominant alleles.

The estimate of average degree of dominance, as indicated by the ratio of $(H_1/D)^{0.5}$ was more than one indicating over-dominance when averaged over all loci for all the traits of interest. The estimates of narrow sense heritability were very low for all the traits except seed yield per plant and number of root nodules per plant. Low estimates might be expected, since the genetic system controlling the inheritance of the characters related to nitrogen fixation in fieldpea had been under the control of non-additive gene effects (7, 9). All the characters except seed yield and number of root nodules per plant showed low genetic advance coupled with low heritability suggesting that genotypic variation for these characters may possibly be due to non-additive factors.

An overall examination of results revealed the importance of both additive and non-additive gene actions in the genetic control of nitrogen fixation and seed yield in fieldpea. Further improvement in these traits would be difficult to achieve through simple pure line or pedigree selection. Hence, improvement can be expected by resorting to intermating of segregants followed by recurrent selection (2). Diallel selective mating system can also be adopted (6).

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