Range Mgmt. & Agroforestry 31 (1) : 41-47, 2010
ISSN 0971-2070

Effect of different fertilizer levels on root nodulation and fodder quality in Rice bean (*Vigna umbellata*) genotypes

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Received:20th January, 2009 Accepted: 12th May, 2010

Studies were conducted to determine the effect of different levels of N, P and K on nodulation and quality traits of fodder in rice bean genotypes. The treatments consisting of NPK levels *viz;* 0:0:0 (T_0) control or 10:30:10 (T_1) and 20:60:20 (T_2) kg/ha exhibited significant differences amongst the genotypes in nodulation. Genotypic response of rice bean (*Vigna umbellata* (Thunb) Ohwi and Ohashi) to *Rhizobium spp*. was studied in terms of nodule number and fresh weight (g) under different fertilizer treatments. Genotype IC-140796 was observed to have significantly high number of nodules and fresh weight (g), whereas, IC-137200 and JCR-107 had significantly lower number of nodules in comparison to the check (BRS-2). Fertilizer treatments significantly affected nodule number and weight. Crude fibre and total ash increased significantly in the fodder samples with increasing rates of N, P and K, whereas, crude protein content showed non-significant effects. Number and nodule weight showed significant positive of correlation between T_1 and control, whereas plant biomass and days to flowering showed significant positive between association T_2. Plant biomass showed positive correlation with crude fibre in T_2, whereas, crude protein and ash content had positive correlation in T_1 and T_2. Ash and nodule number showed positive association in control only. Among the three treatments under study, T_2 treatment with NPK ratio @ 20: 60:20 Kg ha ï1 was observed promising for nodulation and quality traits.

Keywords : Rice bean, Fertilizer treatment, Fodder quality, Nodulation, NPK

Introduction

Rice bean (*Vigna umbellata* (Thunb) Ohwi and Ohashi has been identified as one of the promising fodder crop. It produces more palatable and highly nutritious fodder than other fodder legumes like cowpea (*Vigna unguiculata*) and moth bean (*Vigna aconitifolius*) particularly being rich in protein, calcium and phosphorus (Chatterjee and Das, 1989) contents. The green fodder yield of rice bean is also high which could meet the supply of green forage during lean periods (Mukerjee *et al*., 1980). Besides enhancing the quality with respect to protein content, the vegetative growth of a crop is increased by application of nitrogen particularly when a suitable and proper amount of fertilizer is used. Rice bean, mainly grown under rainfed condition with little or no fertilizers has not yet received due attention for its agronomic requirements.

Like other leguminous crops, rice bean plays a vital role in nitrogen enrichment of soil. It possesses nodules on its roots, containing nitrogen-fixing bacteria *Rhizobium* species that fix nitrogen in symbiotic association with plant and release a significant amount for plant growth and development. The nodulation is dependent on genotype, environment and availability of mineral nutrients. Recognition of the host, attachment and curling of root hairs, formation of infection thread and its growth, nodule development, maintenance and host specificity are important features in nodulation in host (Nutman, 1959). Host infection ranges from complete lack of nodulation to varying amount and type of nodulation with varying degree of nitrogen fixation. The reason could be attributed to genetic constitution of legume as well as *Rhizobium*. The nodulation in legumes varies from species differentiation of host plant. Genetic variability within the host species plays an important role in differential symbiotic behaviour (Rathnaswamy *et al*., 1986). The determinate types of rice bean cultivars produce profuse growth and nodulation (Singh and Verma, 1988). The different chemical fertilizers affect the nodulation in legumes (Hossain, 1977; Chawdhary *et al*., 1998). Phosphorus fertilization in legumes is of greater importance, as it affects the nodulation, growth and yield (Thakuria and Ioi ï Khan, 1991; Balchander *et al*., 2003). In literature, there is scanty information on the genotypic response of rice bean to nodulation under varying level of fertilizer treatments. In the present investigation, an attempt was made to study the response of rice bean genotypes to nodulation and its correlation to growth and fodder yield under different fertilizer treatments on the acidic (pH 5.5) and clay loam soils of Himachal Pradesh.

Materials and Methods

Field experiment was conducted in the Research Farm of CSKHPKV, Palampur during *Kharif* season to study the synergistic effect of application of different fertilizer treatments on *rhizobial* nodulation and fodder quality traits in the fodder of eleven rice bean genotypes. The experiment was laid out in RBD factorial design. The genotypes under study were IC-140796, JCR-152, IC-137195, IC-016789, JCR-20, IC-137195, IC-137200, JCR-107, JCR-162, IC-137190 and one check, BRS-2. The treatments consisted of three NPK levels *viz.,* 0:0:0 (T_0), 10:30:10 (T_1) and 20:60:20 (T_2) kg/ha respectively. Each treatment was replicated thrice. After 80 days of sowing and at 25% flowering of each genotype, five plants from each treatment and replication were randomly uprooted carefully for nodule count and weight (g). Each experimental plot with a size of 1.5m ´ 1.0m had plant-to-plant and row-to-row spacing of 10cm and 50cm respectively. Crude protein, crude fibre and ash were determined as per (AOAC, 1970) methods. Data were analyzed as per Panse and Sukhatme (1984).

Results and Discussion

Table 1 and Table 2 depict significant inter-genotypic differences for nodule number and weight indicating potential for improvement of these components through breeding. The nodule number ranged from 72.25 (IC-137200) to131.33 (IC-140796). The nodule count was observed maximum in IC-140796 (131.33) followed by JCR-152 (111.88) and JCR-162 (110.62), whereas, the minimum nodule number was observed in IC-137200(72.25) and JCR-107(78.48). Genotype IC-140796 produced significantly higher nodule number, whereas, IC-137200 and JCR-107 produced significantly lower nodule number as compared to the check BRS-2. All other genotypes were found to be statistically at par with the check. This differential response of rice bean genotypes to nodulation is mainly attributed to the differences in their genetic make up. Significant variation in nodule number was also observed in case of varying doses of fertilizer treatments and control. T_1 and T_2 treatments for this character were statistically at par with each other, but differed significantly with control (T_0). Maximum nodule number was recorded in T_2 (112.19) followed by T_1 (104.65) and T_0 (87.69). Interactions between fertilizer levels and genotypes were non significant. The positive correlation between nodule weight and days to flowering could be attributed to the reason that when legumes receives inorganic sources of nitrogen at the early stages, the nodulation capacity is reduced as the plants meet out their nitrogen requirement from applied fertilizers. A similar observation was also recorded by Sharma and Ramesh (2002), who observed that mineral nitrogen application, reduced the biological nitrogen fixation in pulses. Similarly, the study conducted by Hossain (1977) revealed that N in combination with P and K produced little amount of nodules at early stages of growth, while at later stages NPK treated plants produced high amount of nodules in *Vigna mungo*, thus, the results of present study are in conformity with the earlier findings. The significant positive correlation was observed between nodule number and nodule fresh weight in control (T_0) and T_1 treatment and for plant biomass and days to flowering in T_2. The results of present study are in agreement with previous results (Anthoni ***et al***., 1989; Tikle and Gupta, 2006), which revealed significant positive correlation between nodule number and nodule weight and for plant biomass and age of plant and negative correlation between nodule number and plant biomass in chickpea and pigeon pea producing indeterminate type of nodules like rice bean.

Mean nodule weight varied between 0.74g and 1.93g (Table 2). Significantly higher nodule weight (g) was recorded in IC-140796 (1.93g), JCR-152 (1.85g), JCR-162 (1.62g) and IC-137190 (1.60g) in comparison to the check BRS-2 (1.05g). All other remaining genotypes were statistically at par with the check. Significant variation for nodule weight was also observed among various fertilizer treatments. T_1 was statistically at par with T_2 and control, but T_2 differed significantly from the control (T_0). Maximum nodule weight was recorded in T_2 (1.47g) followed by T_1 (1.30g) and T_0 (1.10g). Interactions between fertilizer levels and genotypes were insignificant (Table 2). Significant difference for nodule number and weight was observed in eleven genotypes of rice bean indicating potential for improvement of these components through breeding. Significant variations for nodule number and weight were also observed by Mondal ***et al***. (1999) in cowpea (*Vigna unguiculata*) and Sharoar ***et al.*** (2006) in black gram (*Vigna mungo*). A systematic trend was observed between fertilizer treatments and number and fresh weight of nodules. With an increase in fertilizer dose, there was corresponding increase in number and fresh weight of nodules. Maximum number and weight was recorded in T_2 treatment followed by T_1 and T_0. Thus, from the present study, it may be concluded that fertilizer application in rice bean affects nodulation and T_2 treatment produced

Table 1: Nodule number in rice bean genotypes at different fertilizer levels

Fertilizer levels	Genotypes											
	IC-140796	JCR-152	IC-137195	IC-016789	JCR-20	IC-137195	IC-137200	JCR-107	JCR-162	IC-137190	BRS-2	Mean
T_0 0:0:0	121.11	97.88	80.00	70.44	91.88	88.33	66.66	81.11	101.22	88.88	77.10	87.69
T_1 10: 30:10	134.44	109.44	110.22	114.33	98.55	88.33	75.55	74.33	125.33	100.00	120.66	104.65
T_2 20: 60:20	138.44	128.33	114.99	120.44	129.11	103.33	74.55	80.00	105.33	111.44	128.10	112.19
G.M	131.33	111.88	101.74	101.74	106.51	93.33	72.25	78.48	110.62	100.11	108.62	
Parameters												
Factors	CD	CV										
Fertilizers	10.72	21.46										
Genotypes	20.54											
Fert.x Geno.	NS											

Table 2 : Nodule weight (g) of rice bean genotypes at different fertilizer levels

Fertilizer levels	Genotypes											
	IC-140796	JCR-152	IC-137195	IC-016789	JCR-20	IC-137195	IC-137200	JCR-107	JCR-162	IC-137190	BRS-2	Mean
T_0 0:0:0	1.44	1.84	1.04	0.77	0.90	0.78	0.60	1.32	1.33	1.30	0.82	1.10
T_1 10: 30:10	1.87	1.84	1.37	0.93	0.91	0.90	0.74	1.08	1.72	1.75	1.23	1.30
T_2 20: 60:20	2.49	1.89	1.50	0.96	1.56	1.15	0.90	1.09	1.80	1.75	1.11	1.47
G.M	1.93	1.85	1.31	0.88	1.12	0.94	0.74	1.16	1.62	1.60	1.05	
Parameters												
Factors	CD	CV										
Fertilizers	0.23	36.31										
Genotypes	0.44											
Fert.x Geno.	NS											

Table 3 : Variation of crude protein (%) in fodder of rice bean genotypes at different fertilizer levels

Fertilizer levels	Genotypes											
	IC-140796	JCR-152	IC-137195	IC-016789	JCR-20	IC-137195	IC-137200	JCR-107	JCR-162	IC-137190	BRS-2	Mean
T_0 0:0:0	26.83	23.62	23.33	23.62	24.78	22.45	23.04	24.79	24.78	23.03	24.20	24.04
T_1 10: 30:10	23.91	24.79	25.08	27.41	25.66	25.37	20.99	24.50	23.62	25.08	22.45	24.44
T_2 20: 60:20	23.91	23.62	25.08	25.37	23.62	23.91	24.49	25.08	24.20	24.78	23.62	24.33
G.M	24.88	24.01	24.49	25.46	24.69	23.91	22.84	24.79	24.20	24.30	23.42	
Parameters												
Factors	CD	CV										
Fertilizers	NS	7.00										
Genotypes	NS											
Fert.x Geno.	NS											

Table 4 : Variation of crude fibre (%) in fodder of rice bean genotypes at different fertilizer levels

Fertilizer levels	Genotypes										
	IC-140796	JCR-152	IC-137195	IC-016789	JCR-20	IC-137195	IC-137200	JCR-107	JCR-162	IC-137190	BRS-2	Mean
T_0 0:0:0	22.53	26.20	25.76	24.16	24.56	25.26	25.33	28.96	28.10	25.46	31.13	26.13
T_1 10: 30:10	25.50	27.63	27.53	26.86	29.96	28.03	25.83	27.66	24.80	28.60	26.93	27.21
T_2 20: 60:20	27.96	28.16	28.10	25.10	27.20	27.40	28.53	28.33	28.43	28.13	28.50	27.80
G.M	25.33	27.33	27.13	25.37	27.24	26.90	26.56	28.32	27.11	27.40	28.85	
Parameters												
Factors	CD	CV										
Fertilizers	0.97											
Genotypes	1.85											
Fert.x Geno.	3.21											

Table 5 : Variation in total ash (%) in fodder of rice bean genotypes at different fertilizer levels

Fertilizer levels	Genotypes										
	IC-140796	JCR-152	IC-137195	IC-016789	JCR-20	IC-137195	IC-137200	JCR-107	JCR-162	IC-137190	BRS-2	Mean
T_0 0:0:0	2.53	2.33	2.66	3.00	2.93	2.73	2.80	2.73	2.73	3.53	2.06	2.73
T_1 10: 30:10	2.80	2.80	2.80	3.13	2.93	2.73	3.20	3.06	2.93	3.53	2.06	2.90
T_2 20: 60:20	3.06	2.80	3.53	3.46	3.20	3.66	3.60	4.00	4.33	3.93	2.20	3.43
G.M	2.80	2.64	3.00	3.20	3.02	3.04	3.20	3.26	3.33	3.66	2.11	
Parameters												
Factors	CD	CV										
Fertilizers	0.35	23.80										
Genotypes	0.67											
Fert.x Geno.	NS											

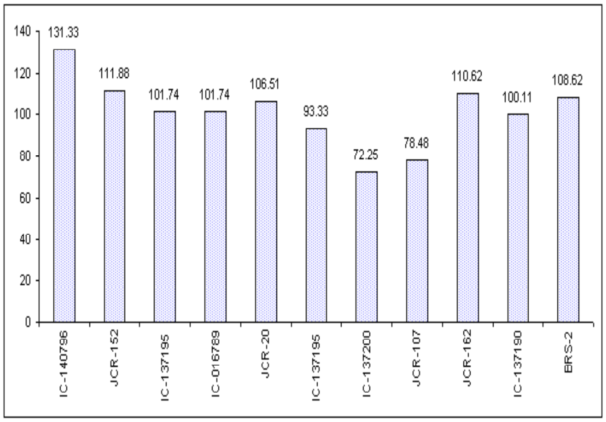

Fig. 1 : Nodule number in different rice been genotypes

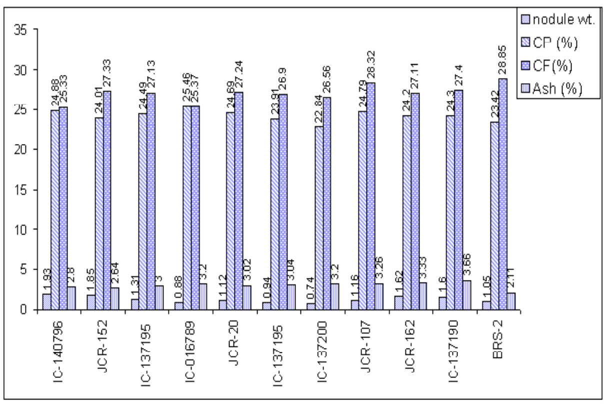

Fig. 2 : Nodule weight, crude protein (CP%), crude fibre (CF%) and ash content of different rice bean genotypes

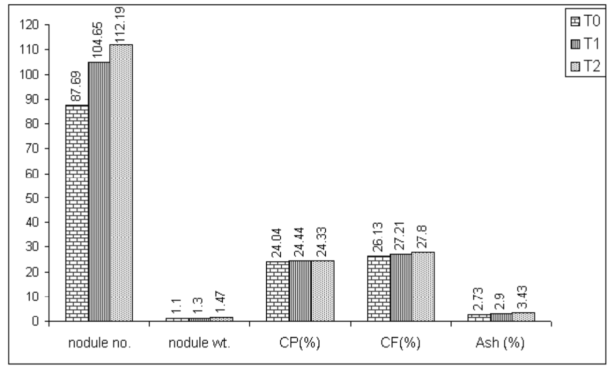

Fig. 3 : Effect of fertilizer treatments on nodulation and quality parameters in rice bean fodder

maximum number and higher fresh weight of nodules. Arya and Singh (1996) in rice bean have also reported high average fresh weight of *Rhizobium*, when single super phosphate is applied at the rate of 60 Kg P /ha. Chovatia *et al.* (1993) reported that root nodules/plant were significantly increased with increase in phosphorus level from 0-40 kg/ha in *Phaseolus radiatus,* whereas Chawdhary *et al.* (1998) recorded significant increase in nodulation in mungbean after application of P up to 75 kg ha^{-1}. Agbenin *et al.* (1990) reported that cowpea genotypes responded positively to nodulation after application of N fertilization up to 30 Kg ha ï1. The earlier results are in agreement with the present study as maximum number and weight of nodules are obtained in T_2 treatment in which phosphorus is applied at the rate of 60 kg /ha and nitrogen is applied at the rate of 20 kg/ha.

Non- significant variation was observed among rice bean genotypes for crude protein (per cent) in forage samples (Table 3). The crude protein per cent varied from 22.84 in IC-137200 to 25.46 in IC-016789. All the genotypes except IC-137200 had more crude protein as compared to BRS-2 (23.42 per cent). Fertilizer treatments affected crude protein insignificantly. Maximum crude protein content was observed in T_1 (24.44 per cent) followed by T_2 (24.33 per cent) and control (24.04 per cent). Interactions between fertilizer levels and genotypes were observed insignificant. Data regarding crude protein content in fodder of rice bean (Table 3) also revealed that increase in N fertilizer gave more protein percentage. Highest crude protein percentage in rice bean was recorded in plots fertilized with NPK ratio @ 10:30: 10 Kg ha-^{1}, which was statistically similar to NPK ratio @20:60:20Kg ha-^{1}. N is an essential component of protein which might had resulted in more crude protein in plants receiving more NPK (Jamriska, 1987). The addition of phosphorus increases the nitrogen percentage in legumes. This is attributed to better root development and plant metabolism. More crude protein content could also be attributed to phosphorus, which improves the protein synthesis because it is an essential component of nucleo-protein. Crude fibre content was maximum in plots fertilized with NPK ratio @20:60:20Kg ha-^{1} followed by NPK ratio @ 10:30: 10 Kg ha-^{1}. More crude fiber content with NPK ratio @20:60:20Kg ha-^{1} might had resulted from better absorption of NPK and their utilization towards growth. Higher ash content at higher NPK dose may be attributed to more plant biomass. Similar results were also reported by Ali *et al.* (1998).

Significant variation was observed among genotypes for crude fibre (per cent) in forage samples. The crude fibre content varied from 25.33 per cent in IC-140796 to 28.85 per cent in BRS-2. All the genotypes except JCR ï 107 (28.32 per cent), IC-137190 (27.40 per cent), JCR-152 (27.33 per cent), JCR-20 (27.24 per cent) and IC-137195 (27.13 per cent) were observed to have significantly lower crude fibre (per cent) as compared to the check (Table 4).

Table 6 : Correlation coefficients of nodulation parameters with the days to flowering and plant biomass in rice bean under different fertilizer treatments

Parameters	Fertilizer levels		
	T_0	T_1	T_2
Nodule number x days to flowering	-0.013	-0.396	-0.443
Nodule fresh weight x days to flowering	0.092	0.303	0.319
Nodule number x Nodule fresh weight	0.824*	0.628*	0.423
Nodule number x Plant biomass	-0.058	-0.150	-0.313
Nodule fresh weight x Plant biomass	-0.07	-0.27	-0.029
Plant biomass x days to flowering	0.449	0.200	0.684*
Plant biomass x crude fibre	-0.355	-0.041	0.491
Plant biomass x crude protein	-0.040	-0.254	0.171
Crude fibre x nodule number	-0.057	-0.150	-0.31
Crude fibre x nodule weight	-0.07	-0.27	-0.029
Crude protein x nodule number	-0.057	-0.150	-0.313
Crude protein x nodule weight	-0.073	-0.271	-0.294
Crude fibre x crude protein	-0.098	0.503	-0.341
Crude fibre x ash	-0.449	0.122	0.001
Crude protein x ash	-0.281	0.248	0.562
Ash x nodule number	0.562	-0.128	-0.400
Ash x nodule weight	0.039	0.056	0.144

* Significant at 5 % level

Significant variation for crude fibre (per cent) was also observed among various fertilizer treatments and interactions between fertilizer levels and genotypes. Significantly high crude fibre (per cent) was recorded in T_2 (27.80 per cent) and T_1 (27.21 per cent), as compared to control (26.13 per cent).

Significant variation was observed among rice bean genotypes for total ash per cent. The total ash percentage varied between 2.11 in BRS-2 to 3.33 in JCR-162. All remaining genotypes except JCR-152 (2.64 per cent) had significantly high ash content as compared to the check (Table5). Fertilizer treatments significantly affected total ash content. Maximum ash content was observed in T_2 (3.43 per cent) followed by T_1 (2.90 per cent).

The correlation coefficients among different traits showed negative association of nodule number with days to flowering, plant biomass and nodule fresh weight and plant biomass, whereas, positive correlation was observed between nodule weight and days to flowering, nodule number and nodule fresh weight and for plant biomass and days to flowering under all fertilizer treatments. Plant biomass had positive correlation with crude fibre in T_2, whereas, crude protein and ash content showed positive correlation in T_1 and T_2. Ash and nodule number had positive association in control only (Table 6).

Study of the effects of different fertilizers doses in the present investigation revealed that nodule number, nodule weight and quality traits of rice bean responded to NPK treatment @20:60:20Kg ha^{-1}. Significant variation was also observed for nodulation among rice bean genotypes indicating importance of genetic makeup of the host genotype in promoting nodulation. The results also revealed that the genotypes JCR-107, IC-137190, JCR-20 and IC-137190 were nutritionally superior and IC-140796, JCR-152 and JCR-162 were more efficient in development of root nodules.

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