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Studies on performance of different rainy season legumes with respect to their nodulation, NPK content, uptake and residual soil fertility in the Entisol of West Bengal

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ABSTRACT

A field experiment with rainy season legumes, viz., greengram cv. T 44, blackgram cv. B 76, soybean cv. PK 327, groundnut cv. JL 24 (all for seed), ricebean cv. K 1 (for green fodder) and cowpea cv. Luffa (for green pod), along with direct-sown rice cv. MW 10 was conducted at Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India during rainy season of 1998 and 1999. It revealed that, groundnut produced maximum number of nodule per plant that continued upto last stage (105 DAS). Soybean recorded the highest volume and dry weight of nodule per plant (at 63 DAS). Greengram and cowpea showed poor performance in these respects. Ricebean and blackgram were intermediate between them. Nitrogen content in leaf (2.16 to 2.77%) and stem (0.77 to 1.37%) of legumes were higher than rice (1.37% and 0.60%, respectively). Removal of nitrogen by rice was lower than soybean, groundnut and ricebean, but higher than other legumes. Removal of potassium by rice was higher than legumes. Rice equivalent yield (t ha^{-1}) of soybean (11.77), cowpea (8.47), groundnut (5.27), blackgram (5.20), ricebean (3.88) and greengram (3.79) were higher than rice grain yield (2.52), indicating the possibility of legumes to be a substitute of conventional direct-sown rice in the upland situation. Total nitrogen content in the soil after ricebean was 0.108%, soybean 0.088% and groundnut 0.085% which were better than rice (0.052 %).

Key words: Rainy season legumes, nodulation, equivalent yield, nutrients

Legume crops improve nutrient status (Ahlawat *et al* 1981 and El. Debaby *et al.* 1984) physical properties, and maintain the health of soil. They sustain agricultural production through fixation of atmospheric nitrogen and addition of organic matter to soil in the form of shed leaves. As a result, they have proved their suitability for inclusion in different cropping systems (Boruah *et al.*, 1984). This suitability depends on nodulation behaviour, nutrient removal and addition of legumes, which differ from crop to crop. In the present study, the comparative performance of different legumes was assessed during rainy season in terms of their nodulation, nutrient content and removal, and residual soil fertility status in upland Gangetic alluvial soil of West Bengal.

MATERIALS AND METHODS

The experiment was conducted during *kharif* (rainy) season of 1998 and 1999 at Viswavidyalaya Farm, West Bengal (India) on well drained sandy loam gangetic alluvial soil (entisol)having pH 6.43, 0.76% total N, 17.78 kg ha^{-1} of available P_2O_5 and 127.59 kg ha^{-1} of available K_2O. During the growing season, rainfall was much higher in the second year than the first year (Fig.1). The experiment was conducted in randomised block design with three replications, consisting of six rainy season legumes, viz., greengram cv. T 44 (69 days), blackgram cv. B 76 (133 days), soybean cv. PK 327 (122 days) and groundnut cv. JL 24 (111 days) for seed, ricebean cv. K 1 (133 days) for green fodder and cowpea cv Luffa (69 days) for green pod, along with direct-seeded rice cv MW 10 (105 days) as a basis of some comparison. The gross plot size was 5m x 4.6m. The crops were sown on fourth week of June. The doses of N: P_2O_5: K_2O (kg ha^{-1}) were 20:40:0 for greengram and cowpea, 20:40:20 for blackgram and ricebean, 20:60:40 for soybean, 20:30:45 for groundnut and 60:30:30 for rice. The roots of plants along with soil from each legume plots were collected up to a depth of 15 cm. The soil was then washed out carefully by spraying water. The nodules were collected and their number was counted. Volume of nodules was estimated with the help of a graduated measuring cylinder, by dipping the nodules in partly filled water. Dry weight was recorded in a sensitive balanced after drying in a hot air oven. Dried plant samples (leaf and stem at flowering stage) of different crops were preserved plot wise for chemical analysis. To get a valid comparable basis, economic yields of legumes were converted into rice equivalent yield from their respective economic yields and prevailing market price. The crops were sown in the fourth week of June and raised with recommended package of practices. After harvesting of these crops and before sowing of next crop soil samples were taken plot wise for chemical analysis. Modified macro Kjeldahl method, Olsen's method and Flame photometer methods were used to analyse the N, P and K.

RESULTS AND DISCUSSION

Nodulation

Number, volume and dry weight of nodule per plant of greengram and cowpea increased upto 42 DAS and reached the peak (Fig. 2). Leaf growth of greengram declined after 42 DAS (Fig. 3) and new vegetative growth stopped almost totally thereafter. As a result, carbohydrate synthesized in the existing leaves was perhaps mostly utilized for reproductive growth, rest for maintaining vegetative growth, and was not available for rhizobium bacteroid in the nodules, that resulted in absence of nodules in greengram at 63 DAS. In case of cowpea, some effective nodules were available at this stages (68 DAS), because of continuation of vegetative growth, although at low rate, and thus carbohydrate was perhaps partly available to rhizobium bacteroid till 63 DAS. In blackgram number, volume and dry weight of nodule per plant increased at 42 DAS, which was very much apparent during the second year, then declined sharply at 63 DAS and continued to grow at very low rate upto 84 DAS. This could also be related with higher leaf growth upto 84 DAS, which declined thereafter (Fig. 3). Nodulation were partly related with respective LAI (Fig. 3). In case of ricebean the number attained the peak at 42 DAS, which decreased at the next stage, but increased again at 84 DAS during the second year. Probably due to regrowth of ricebean after first cutting (at 63 DAS), there was new active supply of carbohydrate to rhizobium bacteroid, which maintained nodule number in the first year, but caused increase in the second year at 84 DAS. Dry weight and particularly the volume of nodule per plant of ricebean showed their peak at 63 DAS. Number (except in second year), volume and dry weight of nodule per plant of soybean and groundnut increased upto 63 DAS, and declined thereafter. During the second year, there was probably a depressive effect of high rainfall (Fig. 1) at this stage (63 DAS) on number of nodule. At 84 DAS, volume of nodule per plant did not vary between these two crops, but the dry weight was much higher in soybean than groundnut. Groundnut recorded much higher number of nodule per plant than other legumes, particularly at the later stages. On the other hand, soybean recorded much higher volume and dry weight of nodules than other legumes. Continuation of nodulation till 105 DAS of groundnut and soybean was probably due to continuation of leaf growth (Fig. 3), which ensured a steady supply of carbohydrate to nodules. Size of nodules of soybean was larger than that of other legumes throughout the growing period. Legume crops were repeated during the second year in the same respective plots, which probably increased the population of required rhizobium bacteria in the rhizosphere, and ultimately increased the number, volume as well as dry weight of nodule per plant during the second year over the first year, except groundnut, which had probably sufficient bacteria in the soil even during the first year.

Nutrient content and removal

Nitrogen content in leaf was much higher than in stem in all *kharif* crops (Table 1). Nitrogen content in both leaf and stem were the highest in groundnut and lowest in rice. Leguminous plants contained more nitrogen in leaf than in stem which were higher than that of rice. Whereas, potassium content in both leaf and stem was the highest in rice and lowest in blackgram. Phosphorus content in leaf and stem, although lowest in rice, did not show any definite trend of variation among the *kharif* crops.

Ricebean recorded highest amount of nitrogen removal from soil (Table 1) mainly due to the highest leaf growth (Fig. 3). It was followed by soybean and groundnut probably due to high biomass production (Table 1) and/or high content of nitrogen in plant parts. Greengram and cowpea removed less among of nitrogen than that of rice, probably due to their lower growth than rice. Ricebean removed much higher amount of phosphate than all other crops, whereas, potassium removal was the highest in case of rice, mainly due to high potassium content in plant parts (Table 1). Nutrient (N, P_2O_5, K_2O) removals were the lowest in cowpea mainly due to the low growth and biomass of the crop.

Economic and rice equivalent yield

Different parts of plants were considered to be the economic yields of different crops, and as such were not comparable. Among the seed yielding legumes, soybean recorded the highest seed yield, followed by groundnut and blackgram, greengram producing the lowest seed yield (Table 1). Grain yield of rice was more or less, similar to the seed yield of soybean, but much higher than other seed yielding legumes.

Table 1 N P K content in leaf and stem, NPK removal, economic yield, rice equivalent yield and biomass yield of different *kharif* crops [mean/pooled of two years]

Crop	NPK cotnent (%) [mean of two years]						NPK removal (kg ha^{-1}) [pooled of two years]			Yield (t ha^{-1}) [pooled of two years]		
	Leaf			Stem								
	N	P	K	N	P	K	N	P_2O_5	K_2O	Economic	Rice equivalent	Biomass*
Greengram	2.16	0.26	1.23	1.02	0.22	1.31	36.89	13.48	48.65	0.48	3.79	2.57
Blackgram	2.41	0.31	0.96	0.77	0.23	0.80	49.45	23.14	43.34	0.79	5.20	6.48
Soybean	2.65	0.18	1.02	0.81	0.15	1.44	90.94	22.96	65.83	2.49	11.77	10.14
Groundnut	2.77	0.28	1.12	1.37	0.28	1.09	72.17	19.08	38.91	1.07	5.27	4.93
Ricebean	2.45	0.29	0.98	1.09	0.36	1.02	95.02	41.24	65.79	58.93	3.88	6.61
Cowpea	2.55	0.17	1.21	0.80	0.18	1.39	20.66	6.66	17.61	5.36	8.47	1.89
Rice	1.37	0.15	1.40	0.60	0.14	1.66	63.01	19.54	78.81	2.52	2.52	7.00
CD at 5%							6.21	2.65	5.35	0.78	0.45	0.42

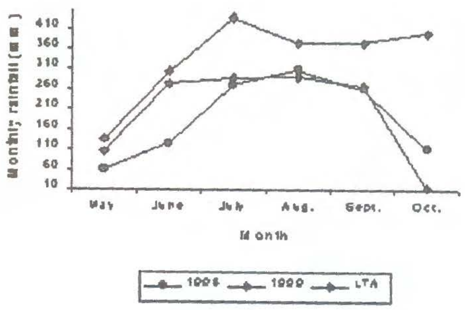
*Biomass: sundried weight of stover/straw+seed/grain

All the *kharif* crops, producing different types of economic yields, recorded significantly higher rice equivalent yield (Table 1) than rice indicating the legume crops to be more productive than the direct seeded rice in upland sandy laom in soil of gangetic alluvial zone of West Bengal, where direct-sown rice is the conventional crop. This result corroborated the findings of Verma *et al.* (1978) and Srivastava *et al.* (1985). On the basis of rice equivalent yield, soybean was found to be the most productive one, followed by cowpea, groundnut and blackgram. Superiority of soybean to other legumes was similarly regarded by Patra (2001).

Nitrogen and Potassium status of soil

Nitrogen and potassium status of soil after *kharif* cropping improved in the second year over that of first year (Table 2). This improvement in N- status was low after cowpea and rice. During the first year N-status was similar in ricebean, soybean and groundnut plots, during the second year ricebean exceeded the other crops in this respect, probably due to the fact that it was not grown for seed production. There was not much differences among different crops in respect of subsequent K-status of soil although rice showed slightly lower values than that of other crops during both the years.

Fig. 1 Monthly distribution of rainfall during the cropping season



[*LTA = Long term average of preceding 30 years]

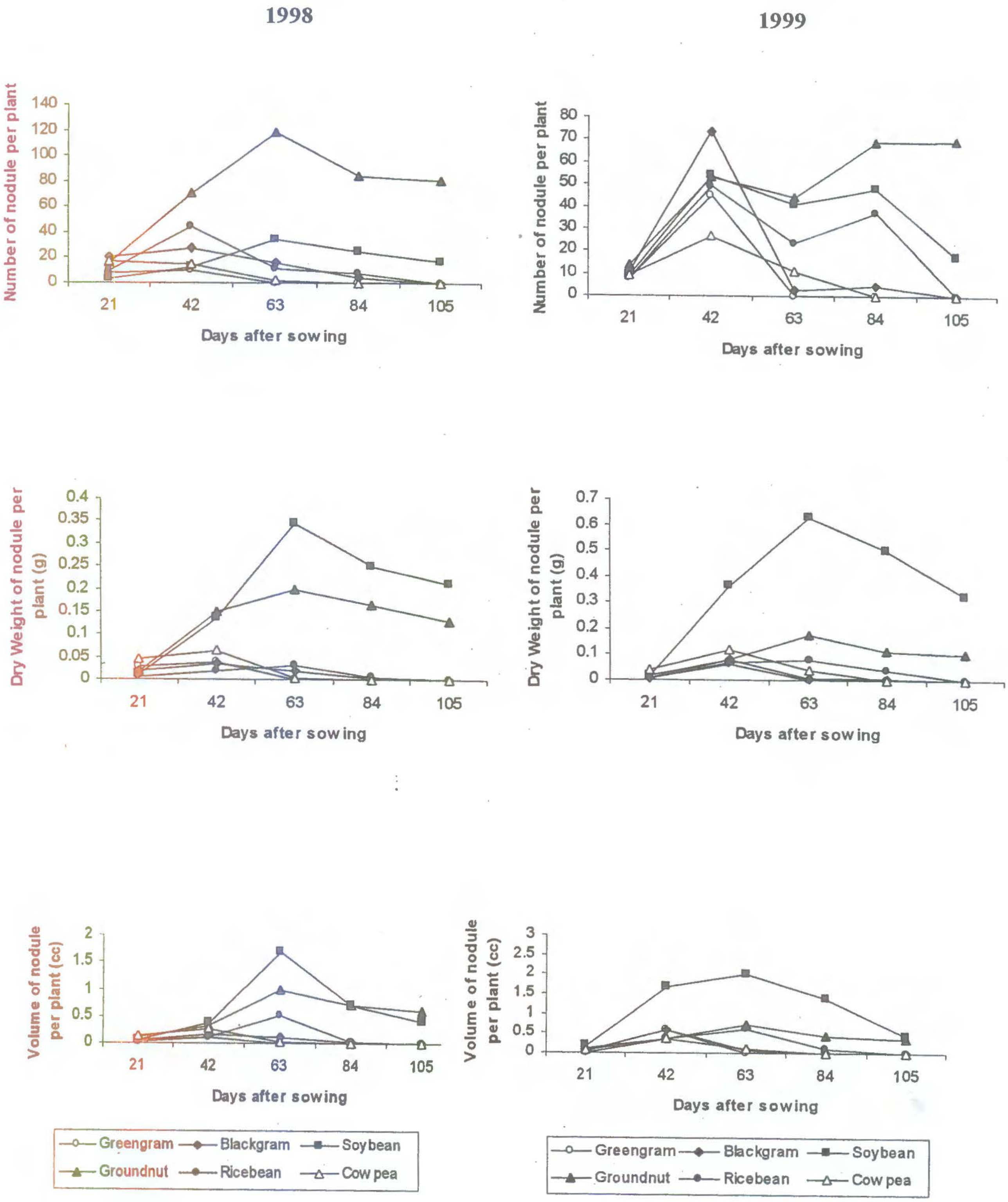


Fig. 2 Number, dry weight (g) and volume (cc) of nodule per plant of different legumes at different growth stages

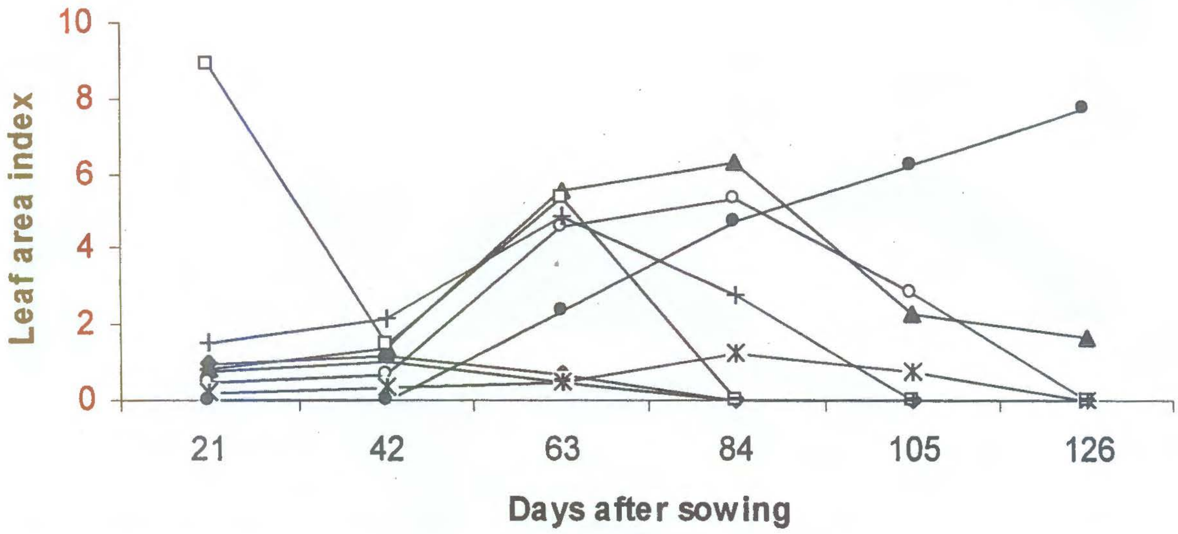


Fig. 3 Leaf area index of different *kharif* crops at different growth stages (mean of two years).

Crop	Total N (%)		Available K_2O (kg ha^{-1})	
	1998	1999	1998	1999
Greengram	0.049	0.063	130.1	163.7
Blackgram	0.058	0.084	134.4	158.9
Soybean	0.067	0.088	143.6	153.9
Groundnut	0.067	0.085	142.6	155.9
Ricebean	0.067	0.108	143.6	155.9
Cowpea	0.042	0.052	146.3	157.8
Rice	0.040	0.052	132.8	146.1

Initial soil status: vide materials and methods

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