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Effect of phosphorus rate on growth, nodulation and biomass yield of green manure crops

M. Y. A. Pramanik[1], M. A. R. Sarkar, M. S. Uddin[1] and G. M. Faruk[1]
Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[1]Department of Agriculture Extension, Khamarbari, Dhaka, Bangladesh

Abstract

The effect of phosphorus rate on plant height, biomass yield and nodulation of green manure crops was investigated. Seven green manure species viz. *Sesbania rostrata, Sesbania aculeata, Crotalaria juncea, Vigna unguiculata, Phaseolus mungo, Vigna radiata* and *Glycine max* and three phosphorus rates viz. 18, 27 and 36 kg P ha^{-1} were used. Plant height was different for each green manure crops during the growth period though phosphorus fertilization had no significant effect on plant height and biomass yield. On the other hand, phosphorus fertilization had significant effect on nodulation of green manure crops. The number of nodules $plant^{-1}$ increased significantly with the age of the plants up to 60 days after sowing (DAS) and thereafter declined sharply at 75 DAS. The highest number of nodules $plant^{-1}$ was produced at 36 kg P ha^{-1} followed by 27 kg P ha^{-1}. The lowest number of nodules $plant^{-1}$ was produced at 18 kg P ha^{-1}.

Keywords: Green manure crops, Phosphorus, Growth, Nodulation, Biomass yield

Introduction

Legumes have played an important role in the agricultural economy in sustaining the productivity of soil. Abrol and Palaniappan (1988) and Nambiar (1995) cautioned about the non-sustainability of the rice-wheat/ or rice- rice system due to occurrence of multi-nutrient deficiencies in intensively cropped soils, an overall decline in soil productivity and escalating prices of inorganic fertilizers. They emphasized that there should be an increase in use of farmyard manure (FYM), green manure and other legumes, along with inorganic fertilizers, as a possible means of sustaining the productivity of intensive cropping system.

Phosphorus is the second most critical plant nutrient over all, but for legumes it assumes primary importance. The soil of Indo-Gangetic Plain are generally low to medium in available P content and therefore, application of 17-26 kg P ha^{-1} has shown favourable effects in grain legumes (Ahlawat and Ali, 1993).Compared with other pulses, chickpea is more efficient in taking up P from soil as it secretes acid exudates from roots which helps in solublizing Ca-P (Ae *et al.,* 1991). In pigeonpea, response to applied P varies considerably from 17-43 kg P ha^{-1} depending upon P status of soil (Chauhan and Singh, 1981). Kasturi (1995) reported that application of 26.4 kg P ha^{-1} significantly improved seed yield, nodulation and nitrogenase activity in pea. In summer mung bean, application of 26 kg P ha^{-1} significantly increased nodulation and yield (Sarkar and Banik, 1991). Crop recovery of inorganic fertilizer P is often very low and it ranges from 8% to 33% depending upon the nature of crop and soil (Mattingly, 1975). Aulakh and Pasricha (1991) reported that 28% of fertilizer P to be in the labile fraction and 44% of fertilizer P in the semi-labile fraction, when phosphatic fertilizer was applied to both groundnut and wheat. Beri and Meelu (1981) found that P applied to green manure crops in soils with low P status increased green manure production, N accumulation in green manure and succeeding rice yield more than P applied directly to rice. In P rich soils, legumes are capable of drawing their P requirements entirely from soil P or residual P. Another beneficial effects of green manure on rice yield is increased mineralization of N in green manure because of increased P content of green manure (Nguluu *et al.*, 1997).

In Bangladesh, a few research work was done scatteredly but intensive work should be undertaken to study growth behaviour, nodulation pattern as well as biomass yield of legume green manure crops. Phosphorus has a profound effect on nodulation behaviour of legumes. So, the experiment was undertaken to study the effect of Phosphorus rate on growth, nodulation and biomass yield of some green manure crops.

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to investigate the effect of phosphorus rate on plant height, biomass yield and nodulation of green manure crops. The experiment consisted of seven green manure species viz. *Sesbania rostrata, Sesbania aculeata, Crotalaria juncea, Vigna unguiculata, Phaseolus mungo, Vigna radiata* and *Glycine max* and three phosphorus rates viz. 18, 27 and 36 kg P ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.0m $\times$ 2.5m.

The land was prepared by a power-tiller with several ploughings and cross ploughings followed by laddering to level the land. Weeds and other plant residues were collected and removed from the field. At final land preparation phosphorus at 18, 27 and 36 kg ha^{-1} were applied in the form of triple super phosphate as per treatment specification. Seeds of green manure species were sown on 5 April 2004 in all unit plots. Five plants were randomly selected in each plot for each destructive sampling to record the data on plant height, fresh biomass and number of nodules $plant^{-1}$ at 15 day intervals beginning from 30 days after sowing (DAS) up to 75 DAS. Collected fresh samples were oven dried in an electrical oven at 65^0C for 72 hours to record the dry biomass yield. Central five square metres area in each plot was harvested to record the fresh biomass yield $plot^{-1}$, which was converted to ton ha^{-1}. The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of the computer package M-STAT. Means were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height: A significant difference in plant height was observed among the green manure crops throughout the growth period (Table 1). At 30 DAS, *C. juncea* produced the tallest plant. *S. aculeata* and *S. rostrata* exhibited similar performance and occupied the second position. *P. mungo, V. radiata* and *V. unguiculata* produced similar plant height and occupied the third position. *G. max* gave the shortest plant. At 45 DAS, *S. aculeata, C. juncea* and *S. rostrata* produced similar plant height. Again *P. mungo, V. radiata, V. unguiculata* and *G. max* exhibited lower but similar performance in this regard. At 60 DAS, *S. rostrata* gave as the tallest plant. *S. aculeata* produced almost similar plant height followed by *C. juncea* and *P. mungo*. *G. max* and *V. radiata* exhibited similar performance and occupied third position. *V. unguiculata* appeared as the shortest species in this regard. At 75 DAS, *S. rostrata* and *S. aculeata* produced statistically similar plant height followed in order by *C. juncea* and *P. mungo* and *V. radiata*. *G. max* and *V. unguiculata* showed similar and the lowest performance regarding plant height. It was observed that plant height increased progressively with the age of the plants up to 75 DAS. *S. rostrata* showed slow growth rate at early stage but later on superseded all at 60 DAS. *C. juncea* showed reverse behaviour as was observed in *S. rostrata.* Variation of plant height over the growth period occurred probably due to individual genetic makeup of the green manure crops.

Table 1. Plant height of green manure crops at different days after sowing (DAS)

Green manure crops	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
Sesbania rostrata	38.42^{b}	99.96^{a}	154.47^{a}	170.67^{a}
Sesbania aculeata	41.31^{b}	104.26^{a}	150.06^{ab}	164.62^{a}
Crotalaria juncea	45.51^{a}	102.22^{a}	143.26^{b}	156.04^{b}
Vigna unguiculata	24.42^{c}	39.36^{b}	55.38^{d}	61.62^{d}
Vigna radiata	26.98^{c}	41.80^{b}	60.36^{cd}	67.71^{cd}
Phaseolus mungo	27.62^{c}	43.71^{b}	64.42^{c}	74.56^{c}
Glycine max	20.42^{d}	37.11^{b}	60.73^{cd}	64.16^{d}
CV(%)	8.30	7.40	5.85	5.11
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letter do not differ significantly whereas figures having dissimilar letter(s) differ significantly (as per DMRT).

Plant height of green manure crops was not significantly influenced by phosphorus fertilization throughout the growth period up to 75 DAS (Table 2). Interaction of green manure crops and phosphorus fertilization had no significant effect on plant height.

Table 2. Plant height of green manure crops as affected by phosphorus rate at different days after sowing (DAS)

Phosphorous rate (kg ha^{-1})	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	75 DAS
18	32.18	66.13	97.19	107.60
27	31.74	66.93	98.51	108.89
36	32.37	67.69	99.46	108.95
CV(%)	8.30	7.40	5.85	5.11
Level of significance	NS	NS	NS	NS

Nodule production

A significant variation on nodule production plant^{-1} was observed among green manure crops up to 75 DAS (Table 3). At 30 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *C. juncea* and *P. mungo* produced similar number of nodules plant^{-1} and occupied the second position followed in order by *S. rostrata, V. radiata* and *G. max*. The lowest number of nodules plant^{-1} was observed in *V. unguiculata*. At 45 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *S. rostrata, C. juncea* and *P. mungo* exhibited similar performance and occupied the second highest position. *V. radiata,* and *G. max* occupied the third and the fourth position, respectively. The lowest number of nodules plant^{-1} was observed in *V. unguiculata*. At 60 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *S. rostrata* and *P. mungo* produced similar number of nodules plant^{-1}and occupied the second highest position. *C. juncea* and *V. radiata* produced similar number of nodules plant^{-1}and occupied the third highest position followed by *G. max*. The lowest number of nodules plant^{-1} was produced by *V. unguiculata*. At 75 DAS, the highest number of nodules plant^{-1} was observed in *S. aculeata*. *C. juncea* and *S. rostrata* exhibited similar behaviour and occupied the second position. *P. mungo* and *V. radiata* also showed similar performance and occupied the third position followed by *G. max*. The lowest value was observed in *V. unguiculata*. An increasing trend of nodulation was observed with the age of the plant up to 60 DAS irrespective of green manure crops and thereafter nodulation rate declined at 75 DAS. It may be concluded that the decreasing trend of nodulation at 75 DAS might be due to the aging of the plants and due to adverse environmental condition (continuous rainfall) prevailed at that time. Variation of number of nodules plant^{-1} might be due to the individual genetic characteristics of green manure crops.

Table 3. Number of nodules plant^{-1} of green manure crops at different days after sowing (DAS)

Green manure crops	Number of nodules (plant^{-1})			
	30D AS	45 DAS	60 DAS	75 DAS
Sesbania rostrata	16.69^{bc}	26.80^{b}	31.39^{b}	18.87^{b}
Sesbania aculeata	21.99^{a}	32.87^{a}	39.18^{a}	32.42^{a}
Crotalaria juncea	17.44^{b}	24.66^{b}	26.26^{c}	20.60^{b}
Vigna unguiculata	11.40^{e}	14.06^{e}	15.71^{e}	8.53^{e}
Vigna radiata	15.00^{cd}	21.24^{c}	23.69^{c}	14.02^{c}
Phaseolus mungo	17.69^{b}	25.69^{b}	28.91^{b}	16.02^{c}
Glycine max	13.20^{dc}	17.42^{d}	20.64^{d}	11.42^{d}
CV(%)	9.58	7.95	7.70	9.26
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letters do not differ significantly where as figures bearing dissimilar letter(s) differ significantly (as per DMRT).

Number of nodules plant^{-1} was significantly influenced by phosphorus fertilization throughout the growth period (Table 4). The highest number of nodules plant^{-1} was observed at 36 kg P ha^{-1} irrespective of green manure species followed by 27 kg P ha^{-1}. The lowest number of nodules plant^{-1} was observed at 18 kg P ha^{-1}. Sarkar and Banik (1991) reported that application of 26 kg P ha^{-1} significantly increased nodulation and yield of summer mungbean. Kasturi (1995) reported that application of 26.4 kg P ha^{-1}significantly improved seed yield, nodulation and nitrogenase activity in pea. In the experiment it was observed that number of nodules plant^{-1} increased with higher doses of phosphorus fertilization up to 60 DAS and thereafter the nodulation rate declined and it might be due to aging of the plants and also due to adverse environmental condition (continuous rainfall) prevailed at that time. Results revealed that phosphorus emerged out as a promising plant nutrient for the enhancement of nodulation of legumes.

Table 4. Number of nodules plant^{-1} of green manure crops as affected by phosphorous fertilization at different days after sowing (DAS)

Phosphorous rate (kg ha^{-1})	Number of nodules plant^{-1}			
	30 DAS	45 DAS	60 DAS	75 DAS
18	14.24^{c}	20.37^{c}	23.84^{c}	15.28^{c}
27	16.06^{b}	23.4^{b}	26.39^{b}	17.53^{b}
36	17.00^{a}	25.98^{a}	29.40^{a}	19.43^{a}
CV(%)	9.58	7.95	7.70	9.26
Level of significance	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) or without letters do not differ significantly where as figures bearing dissimilar letter(s) differ significantly (as per DMRT).

Number of nodules plant^{-1} was not significantly influenced by the interaction of green manure crops and phosphorus fertilization during the growth of green manure crops. But numerically an increasing trend of nodulation was observed with higher doses of phosphorus and green manure combination irrespective of green manure crops.

Fresh biomass yield

A significant variation was observed among the green manure crops in respect of fresh biomass yield (Table 5). At 30 DAS, the highest fresh biomass yield was observed in *C. juncea* followed in order by *S. aculeata, S. rostrata, P. mungo, V. radiata* and. *V. unguiculata*. The lowest fresh biomass yield was observed in *G. max*. At 45 DAS, the highest fresh biomass yield was observed in *C. juncea*. *S. aculeata* was as good as *C. juncea* followed by *S. rostrata*. *Phaseolus mungo* and *V. radiata* were at par in producing biomass. *Vigna unguiculata* and *G. max* showed similar but lower performance than that of *P. mungo* and *V. radiata*. At 60 and 75 DAS, the highest fresh biomass yield was observed in *S. rostrata*. *Sesbania aculeata* and *C. juncea* exhibited similar performance and occupied the second position. *P. mungo* occupied the third highest position. *Vigna radiata* and *V. unguiculata* produced similar fresh biomass. The lowest fresh biomass yield was observed in *G. max*. It was observed that in case of *S. rostrata, S. aculeata* and *C. juncea* fresh biomass yield increased apparently with the age of plant up to 75 DAS but in case of *P. mungo, V. radiata, V. unguiculata* and *G. max* fresh biomass yield declined after 60 DAS due to aging and leaf abscission. This variation of fresh biomass yield might be due to individual genetic makeup of the green manure crops.

Fresh biomass yield of green manure crops was not significantly influenced by phosphorus fertilization at different DAS but numerically an increasing trend was observed with the higher levels of P (Table 6).

Fresh biomass yield was also not significantly affected by the interaction of green manure crops and phosphorus fertilization during the growth period but numerically an increasing trend was observed with the higher levels of P and green manure combination.

Table 5. Fresh biomass yield of green manure crops at different days after sowing (DAS)

Green manure crops	Fresh biomass yield (t ha^{-1})			
	30 DAS	45 DAS	60 DAS	75 DAS
Sesbania rostrata	2.73^{c}	8.08^{b}	18.87^{a}	26.62^{a}
Sesbania aculeata	3.03^{b}	8.49^{ab}	16.98^{b}	25.38^{ab}
Crotalaria juncea	3.54^{a}	8.90^{a}	15.98^{b}	23.84^{b}
Vigna unguiculata	2.14^{e}	5.13^{d}	8.26^{d}	7.86^{de}
Vigna radiata	2.23^{de}	5.49^{cd}	8.80^{cd}	8.71^{cd}
Phaseolus mungo	2.41^{d}	5.74^{c}	9.91^{c}	9.58^{c}
Glycine max	1.86^{f}	4.82^{e}	6.78^{e}	6.57^{e}
CV(%)	6.31	10.18	7.27	7.78
Level of significance	0.01	0.01	0.01	0.01

* In a column, figures having similar letter(s) or without letters do not differ significantly where as figures bearing dissimilar letter(s) differ significantly (as per DMRT).

Table 6. Fresh biomass yield of green manure crops as affected by phosphorus fertilization at different days after sowing (DAS)

Phosphorus rate (kg ha^{-1})	Fresh biomass yield (t ha^{-1})			
	30 DAS	45 DAS	60 DAS	75 DAS
18	2.43	6.17	11.88	15.45
27	2.41	6.24	12.01	15.63
36	2.48	6.29	12.13	15.61
CV(%)	9.24	4.70	6.15	9.55
Level of significance	NS	NS	NS	NS

From the experiment it can be concluded that among the seven green manure crops, *Sesbania rostrata* exhibited the highest growth performance in terms of plant height and fresh biomass yield followed in order by *Sesbania aculeata* and *Crotalaria juncea.* Vegetative growth of green manure crops were similar at different rates of phophorus. Root nodulation was the highest in *Sesbania aculeata.* Fertilization with P at 36 kg ha $^{-1}$ maximized nodulation in green manure crops.

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