Growth parameters of mungbean (cv. Binamoog-2) as influenced by plant density, and phosphorus and inoculum

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Abstract: A field experiment was carried out to evaluate some growth parameters of mungbean (cv. Binamoog-2) influenced by plant density, and phosphorus and inoculum. The experiment was laid out in RCBD with three replications comprising of four plant densities viz. 20 cm × 20 cm, 25 cm × 15 cm, 30 cm × 10 cm and 35 cm × 5 cm and five phosphorus fertilization and inoculum viz. 0 kg P_2O_5 ha^{-1}, 20 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and inoculum. It was observed that the highest plant heights 20.57 cm, 33.60 cm and 42.15 cm were found at 40, 50 and 60 DAS respectively at 35 cm × 5 cm spacing whereas, application of 40 kg P_2O_5 ha^{-1} gave the tallest plants (21.73, 34.77 and 42.52 cm) at 40, 50 and 60 DAS respectively and the interaction effect between the two treatments were non-significant. Plant dry weight m^{-2} and crop growth rate (CGR) were significantly influenced by plant density but neither by phosphorus fertilization nor by their interaction. Plant density of 35 cm × 5 cm produced the highest plant dry matter m^{-2} (35.50g, 79.09g and 243.91g respectively) at 40, 50 and 60 DAS respectively which were statistically identical to that of 25 cm × 15 cm and 30 cm × 10 cm spacings. The highest CGR 4.36 g m^{-2} day^{-1} and 16.63 g m^{-2} day^{-1} were recorded during 41-50 and 51- 60 DAS respectively with 35 cm × 5 cm spacing which were statistically similar to that of 30 cm × 10 cm and 25 ×15cm spacings. The highest number of nodules $plant^{-1}$ (20.35) as well as the highest nodule dry weight $plant^{-1}$ (144.73g) at 50 DAS were obtained from the spacing of 20 cm × 20 cm and the highest number of nodules $plant^{-1}$ (23.44) at 50 DAS, the highest dry weight of nodules (159.50 mg) $plant^{-1}$ at 50 DAS were obtained from the application of 40 kg P_2O_5 ha^{-1} while, the interaction between plant density, and phosphorus and inoculum for these two parameters were non-significant.

Keywords: Growth, mungbean, plant density, phosphorus, inoculum.

Introduction

Bangladesh is an agro-based country where many crops like rice, wheat, jute, pulses, sugarcane, vegetables etc. are grown well. Among them, pulses constitute the main source of protein for the people, particularly for the poor people of Bangladesh. These are also the best source of protein for domestic animal. These can help overcome the malnutrition which has been a major concern in context of nutritional security in Bangladesh. Daily per capita consumption of pulses in Bangladesh is only 14.30 g (BBS, 2013), while the World Health Organization (WHO) of United Nations (UN) recommended 45 g per day per capita for a balance diet (BARI, 1998). The average yield of mungbean in this country, 0.88 t ha^{-1}(BBS 2013), is lower than that of other countries. The low yield may be associated with inadequate growth of the plants due inappropriate doses of phosphorus application and improper plant densities. Phosphorus is one of the important plant macronutrients, making about 0.2% of a plant's dry weight (Abbas *et al*; 2011). Growth parameters of mungbean can be influenced by planting density. The farmers usually grow mungbean without maintaining proper planting density. They hesitate to grow mungbean in rows, although row planting facilitates easy intercultural operations resulting in higher yield (BARI, 1997). Therefore, the present study was undertaken to evaluate some growth parameters of mungbean (cv. Binamoog-2) as influenced by plant density, and phosphorus and inoculums.

Materials and Methods

The field experiment was laid out in a two factor RCBD with three replications consisting of twenty different treatments among which four plant densities viz. 20 cm × 20 cm, 25 cm × 15 cm, 30 cm × 10 cm and 35 cm × 5 cm and five Phosphorus fertilization and inoculum viz. 0 kg P_2O_5 ha^{-1}, 20 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and inoculum at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. The *Bradyrhizobium* strain used in the study was collected from the Biofertilizer Building, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. It was peat based BINA-MB mix culture of four strains viz. BINA-MB-301, BINA-MB-169, BINA-MB441 and BINA-MB-Sp 10. It was used as a substitute of phosphorus in this experiment as it helps in nodulation just like phosphorus and hence it was included as a treatment under phosphorus fertilization.The experiment consisted 20 unit plots (each of 4.0 m × 2.5 m) in each replication. All the fertilizers were applied at final land preparation. N and K_2O were applied @ 20 kg ha^{-1} in the form of urea and muriate of potash in all plots, respectively. The specified rates of P_2O_5 were applied at specific plots as triple superphosphate except the inoculum treated plots. Peat based *Bradyrhizobium* inoculum mixed with molasses was mixed with the seed at the ratio of 1:22 (inoculum : seed). Both the uninoculated and inoculated seeds were sown @ three seeds $hill^{-1}$ at the depth of 3 cm from the soil surface. First weeding was done at the time of thinning and second weeding was done at 35 DAS. No irrigation was given as there was no symptom of moisture deficiency during the experimentation. Four plants in each plot were randomly selected to record the data on nodulation and different growth parameters at 40, 50, 60 DAS and 85 DAS. The crops were harvested at 85 DAS at proper maturity (when about 80% of pods became black). The plants were carefully uprooted with the help of *Niri* each time so that no nodule was left in the soil. The roots were then washed in water and the effective nodules and different growth parameters were measured. The shoot root, nodule and leaf materials were oven dried at 65°C until constant weight was achieved to record their respective dry weights.

Crop growth rate (CGR) is the increase in plant dry matter per unit area of land per unit time (hunt, 1978). It was calculated by using the formula: $CGR = \{(W_2-W_1) \div (T_2-T_1)\} gm^{-2}d^{-1}$, Where, W_1 = Total dry weight at the time of T_1, W_2 = Total dry weight at the time of T_2.

The collected data were analyzed statistically using the 'Analysis of Variance' technique with the help of computer package M-STAT and mean differences were adjudged by 'Duncan's Multiple Range Test' (Gomez and Gomez, 1984).

Results and Discussion

Effect of Plant Density: Plant height and plant dry weight m^{-2} were significantly influenced by plant density at all sampling dates. The highest plant heights 20.57 cm, 33.60 cm and 42.15 cm were found at 40, 50 and 60 DAS respectively at 35 cm × 5 cm spacing (Table 1). As in the case of plant height, the spacing of 35 cm × 5 cm also produced the highest dry matter m^{-2} (35.50g, 79.09g and 243.91g respectively) at 40, 50 and 60 DAS which were statistically identical to that of 25 cm × 15 cm and 30 cm × 10 cm spacings (Table 1). Plant dry weight increased significantly with the increase of plant density. Similar results were reported elsewhere (Trung and Yoshida, 1985 and Tomar *et al*, 1995). The lowest dry matter m^{-2} 31.27g, 71.17g and 219.79g at 40, 50 and 60 DAS respectively which were statistically identical to that of 25 cm × 15 cm spacings. Crop growth rate (CGR) varied significantly during 41-50 and 51-60 DAS. CGR increased with the increasing age of plant and attained peak within the period 51-60 DAS at all plant densities (Table 1) but it declined during 61 DAS – harvest. The highest CGR 4.36 g m^{-2} day^{-1} and 16.63 g m^{-2} day^{-1} were recorded during 41-50 and 51-60 DAS respectively with 35 cm × 5 cm spacing which were statistically similar to that of 30 cm × 10 cm and 25 ×15cm spacings. The lowest CGR 3.92 g m^{-2} day^{-1} and 14.86 g m^{-2} day^{-1} were was obtained during 41-50 and 51-60 DAS respectively with 20 cm × 20 cm spacing which were statistically similar to that of 25 cm × 15 cm spacings. The CGR during 61 DAS - harvest also exhibited similar trend though not statistically significant. SaiBabu and Garg(1988) expressed similar views regarding CGR in mungbean. The highest number of nodules $plant^{-1}$ (20.35) at 50 DAS was obtained from the spacing of 20 cm × 20 cm, which was statistically similar to that of 25 cm × 15 cm spacing (Table 1). The highest nodule dry weight $plant^{-1}$ (144.73g) at 50 DAS was obtained from the spacing of 20 cm × 20 cm and the lowest (108.20g) from spacing of 35 cm × 5 cm. In general, number of nodules $plant^{-1}$ and nodule dry weight $plant^{-1}$ increased at lower plant density probably due to availability of more space, nutrition, air, water and light to the plant. Similar results were reported elsewhere (Shukla and Dixit, 1996a and 1996b; Hasanuzzaman, 2001).

Table 1. Effect of plant density on growth parameters of Mungbean (cv. Binamoog-2)

Plant Density (cm × cm)	Plant height (cm)			Plant dry weight m^{-2} (g)			Crop Growth rate ($gm^{-2}day^{-1}$)			Number of nodules $plant^{-1}$ at 50 DAS	Nodule dry weight $plant^{-1}$ at 50 DAS (mg)
	40 DAS	50 DAS	60 DAS	40 DAS	50 DAS	60 DAS	41-50 DAS	51-60 DAS	61 DAS - harvest		
20 × 20	17.55d	29.52d	38.67c	31.27b	71.17b	219.79b	3.92b	14.86b	6.21	20.35a	144.73a
25 × 15	18.33c	30.81c	40.44b	32.90ab	73.17ab	226.15ab	4.02ab	15.30ab	6.24	18.36ab	130.87b
30 × 10	19.37b	32.25b	41.26ab	35.16a	78.50a	242.29a	4.33a	16.45a	6.67	17.64b	127.93b
35 × 5	20.57a	33.60a	42.15a	35.50a	79.09a	243.91a	4.36a	16.63a	6.72	15.07c	108.20c
Sx	0.2318	0.3931	0.4159	0.9912	2.2458	6.9286	0.1228	0.4749	0.1958	0.7833	4.6442
Level of sign.	**	**	**	*	*	*	*	*	NS	**	**
CV (%)	4.74	4.83	3.96	11.39	11.52	11.52	11.43	11.63	11.74	16.99	14.06

Table 2. Effect of phosphorus and inoculum on growth parameters of Mungbean (cv. Binamoog-2)

Phosphorus (kg P_2O_5 ha^{-1}) and Inoculum	Plant height (cm)			Plant dry weight m^{-2} (g)			Crop Growth rate ($gm^{-2}day^{-1}$)			Number of nodules $plant^{-1}$ at 50 DAS	Nodule dry weight $plant^{-1}$ at 50 DAS (mg)
	40 DAS	50 DAS	60 DAS	40 DAS	50 DAS	60 DAS	41-50 DAS	51-60 DAS	61 DAS - harvest		
0	18.17c	31.12c	39.18c	33.00	73.59	226.54	4.06	15.38	6.22	14.36c	107.67c
20	19.66b	32.38b	41.54ab	34.49	76.92	237.66	4.24	16.07	6.57	20.44b	140.25b
40	21.73a	34.77a	42.52a	35.68	76.57	245.85	4.39	16.63	6.80	23.44a	159.50a
60	17.81c	30.34cd	41.03b	33.43	75.67	233.81	4.17	16.00	6.47	19.20b	135.67b
Inoculum	17.42c	29.10d	38.89c	31.92	71.66	221.34	3.93	14.97	6.23	11.83d	96.58c
Sx	0.2592	0.4395	0.4650	1.1082	2.5108	7.7464	0.1373	0.5310	0.2189	0.8757	5.1924
Level of sign.	**	**	**	NS	NS	NS	NS	NS	NS	**	**

NS = Not-significant, ** =Significant at 1% level of probability, In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

Effect of phosphorus and inoculum: The tallest plants (21.73, 34.77 and 42.52 cm) were found at 40, 50 and 60 DAS respectively from the application of 40 kg P_2O_5 ha^{-1} and the shortests (17.42, 29.10 and 38.89 cm) at 40, 50 and 60 DAS respectively from *Bradyrhizobium* inoculum (Table 2). This might be due to the lack of phosphorus in soil which reduced the cell division, carbohydrate and protein synthesis and also lowers the normal activities of the cambium tissue (Hamza *et al*., 2016). Plant dry weight was not significantly influenced by phosphorus and inoculum at all sampling dates. Similarly, Phosphorus and inoculurn had no significant influence on CGR at all durations (Table 2). Numerically, there was an increasing trend of CGR during all dates of sampling with the increasing rate of phosphorus and reached the peak at 40 kg P_2O_5 ha^{-1} and afterwards showed declining trend (Table 2). Application of 40 kg P_2O_5 ha^{-1} gave apparently the highest CGR (4.39, 16.63 and 6.80 $gm^{-2}day^{-1}$) and the lowest (3.93, 14.97 and 6.22 $gm^{-2}day^{-1}$) from inoculum, inoculum and control treatments during 41-50, 51-60 DAS and 61 DAS-harvest, respectively (Table 2). A gradual increase of phosphorus fertilizer up to 40 kg P_2O_5 ha^{-1} increased the number of nodules $plant^{-1}$, thereafter, it decreased with the increase of phosphorus level. This result is In agreement with the reports of Sharma *el al*. (1994) and Shukla and Dixit (1996a and 1996b).The highest number of nodules $plant^{-1}$ (23.44) was obtained at 50 DAS found from the application of 40 kg P_2O_5 ha^{-1}. The plants not treated with phosphorus (control) produced less number of nodules $plant^{-1}$ compared with

phosphorus treated plants and the lowest number of nodules plant^{-1} (11.83) was found from the *Bradyrhizobium* inoculum (Table 2). The inoculum treated plot produced less number of nodules plant^{-1} because of the application of nitrogen (20 kg N ha^{-1}) as basal doseThe highest dry weight of nodules (159.50 mg) plant^{-1} at 50 DAS was found from the application of 40 kg P_2O_5 ha^{-1}. The lowest dry weight (96.58 mg) of nodules plant^{-1} was found in the inoculated plots, which was statistically identical to that of the control (107.67 mg) (Table 2). The less dry weight of nodules plant^{-1} in the inoculated plants occurred mainly due to the lowest number of nodules plant^{-1}.

Interaction effects of plant density, and phosphorus and inoculum: The interaction between plant density, and phosphorus and inoculum at all sampling dates were significant on none of the growth parameters. It was also found that, numerically, the tallest plants (23.33, 37.29 and 44.05 cm) at 40, 50 DAS and at harvest were produced by the interaction between 35 cm × 5 cm spacing and 40 kg P_2O_5 ha^{-1}, respectively. Numerically, the highest plant dry weights were 37.41, 83.35 and 257.05 gm^{-2} at 40, 50 and 60 DAS respectively from the interaction of 35 cm × 5 cm spacing and 40 kg P_2O_5 ha^{-1} and the lowest dry weights 28.74, 67.02 and 206.97 gm^{-2} at 40, 50 and 60 DAS, respectively from the interaction between 20 cm × 20 cm spacing and *Bradyrhizobium* inoculum. Numerically the highest CGR (4.59, 17.37 and 7.16 g m^{-2} day^{-1}) were obtained from the interaction of 35 cm × 5 cm spacing and 40 kg P_2O_5 ha^{-1} and the lowest (3.68, 14.00 and 5.79 g m^{-2} day^{-1}) from the interaction between 20 cm × 20 cm, 20 cm × 20 cm and 25 cm × 15 cm spacings with *Bradyrhizobium* inoculum during 41-50, 51-60 DAS and 61 DAS-harvest, respectively (Table 3).

Table 3. Interaction effects of plant density, and phosphorus and inoculum on growth parameters of Mungbean (cv. Binamoog-2)

Interactions D (cm × cm) × P & I (kg P_2O_5 ha^{-1})	Plant height (cm)			Plant dry weight m^{-2} (g)			Crop Growth rate (gm^{-2}day^{-1})			Number of nodules plant^{-1} at 50 DAS	Nodule dry weight plant^{-1} at 50 DAS (mg)
	40 DAS	50 DAS	60 DAS	40 DAS	50 DAS	60 DAS	41-50 DAS	51-60 DAS	61 DAS - harvest		
(20 × 20) × (0)	16.62	29.70	37.32	30.52	68.01	210.03	3.75	14.20	5.88	16.33	113.33
(20 × 20) × (20)	18.28	30.55	39.41	32.84	73.38	225.99	4.03	15.28	6.33	23.00	162.00
(20 × 20) × (40)	20.39	31.32	40.59	34.24	76.31	235.66	4.21	15.93	6.60	27.11	182.00
(20 × 20) × (60)	16.26	28.70	38.59	30.01	71.34	220.31	3.93	14.90	6.17	21.45	160.67
(20 × 20) × (I)	16.21	27.31	37.44	28.74	67.02	206.97	3.68	14.00	6.06	13.89	105.67
(25 × 15) × (0)	17.48	30.87	39.43	31.98	71.33	220.54	3.94	14.92	6.09	14.89	115.00
(25 × 15) × (20)	19.11	31.16	41.57	33.36	74.41	230.04	4.09	15.56	6.35	21.33	143.39
(25 × 15) × (40)	21.39	33.72	42.26	35.13	78.36	242.29	4.32	16.39	6.68	24.00	160.00
(25 × 15) × (60)	16.38	29.57	40.54	33.12	73.88	228.42	4.08	15.46	6.30	20.45	139.00
(25 × 15) × (I)	17.29	28.72	38.40	30.91	67.85	209.48	3.69	14.16	5.79	11.11	97.00
(30 × 10) × (0)	19.14	31.39	39.55	34.60	77.25	234.77	4.27	16.19	6.51	13.78	112.00
(30 × 10) × (20)	20.19	32.79	42.74	35.54	79.34	245.58	4.38	16.62	6.68	20.33	137.00
(30 × 10) × (40)	21.83	36.75	43.18	35.95	80.25	248.40	4.43	16.82	6.76	23.22	162.00
(30 × 10) × (60)	18.40	30.95	41.49	35.53	79.32	245.52	4.38	16.62	6.95	18.89	134.00
(30 × 10) × (I)	17.32	29.36	39.35	34.18	76.31	236.20	4.21	15.99	6.69	12.00	94.67
(35 × 5) × (0)	19.44	32.51	40.43	34.90	77.76	239.81	4.28	16.20	6.43	12.45	90.33
(35 × 5) × (20)	21.03	35.01	42.43	36.24	80.75	248.02	4.45	16.83	6.94	17.11	118.67
(35 × 5) × (40)	23.33	37.29	44.05	37.41	83.35	257.05	4.59	17.37	7.16	19.45	134.00
(35 × 5) × (60)	20.20	32.15	43.49	35.07	78.14	240.90	4.30	17.02	6.46	16.00	109.00
(35 × 5) × (I)	18.85	31.03	40.37	33.87	75.46	232.70	4.169	15.73	6.37	10.33	89.00
Sx	0.5183	0.9301	0.9301	2.2163	5.0217	15.4828	0.2745	1.0619	0.4378	1.7515	10.3847
Level of sign.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.74	3.96	3.96	11.39	11.52	11.52	11.43	11.63	11.74	16.99	14.06

DAS= Days after sowing, D = Plant density, P & I = Phosphorus and Inoculum, * =Significant at 5% level of probability, In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

Apparently, a plant density of 20 cm × 20 cm with the application of 40 kg P_2O_5 ha^{-1} gave the highest number of nodules plant^{-1} (27.11) and the lowest from the interaction of plant density of 35 cm × 5 cm with *Bradyrhizobium* inoculum (Table 3). Interaction between plant density of 20 cm × 20 cm with 40 kg P_2O_5 ha^{-1} gave the highest dry weight of nodules plant^{-1} (182.00 mg) and interaction between density of 35 cm × 5 cm and *Bradyrhizobium* inoculum gave the lowest nodule dry weight Plant^{-1} (89.00 mg) (Table 3).

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