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Original Article

Influence of *Rhizobium* Inoculant and Mineral Nitrogen on Some Chickpea Varieties

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A field experiment was conducted at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh to study the response of five chickpea (*Cicer arietinum* L) varieties to *Rhizobium* inoculant and mineral nitrogen on nodulation, nitrogen fixation, dry matter production, nitrogen (N) uptake, yield and quality of the crop. Among the treatments, *Rhizobium* inoculant in combination with Barichola-5 in absence of nitrogen performed best in recording number and dry weight of nodules and nitrogenase activity of chickpea. Barichola-2 in presence of 100 kg N/ha performed best in recording dry weight of shoot and root, number of branches, chlorophyll a and b, nitrogen content in shoot, nitrogen uptake by shoot, protein content in seed, number of seeds per plant, number of pods per plant, 1000-seed weight and stover and seed yields. The performances of Barichola-5 and Barichola-3 in presence of *Rhizobium* inoculant and in the absence of mineral nitrogen were comparable to Barichola-2 in most of the parameters of the crop studied.

Keywords: *Rhizobium* inoculant, Nitrogen, Chickpea

Introduction

Chickpea (*Cicer arietinum* L) is the fifth most important legume in the world on the basis of total production after soybean, peanut, bean and pea[1]. Chickpea is protein rich crop grown in Bangladesh and has occupied sixth position both in production (10,380 metric tons) and as well as acreage (34,370 acres)[2]. It is also a staple food crop in many tropical and subtropical countries. It is mostly consumed as cooked, dehusked dhal and whole seeds. Several traditional food products are prepared from dhal and flour.

A good number of literature says that *Rhizobium* inoculation works favourably in respect to nodulation and biological nitrogen fixation in chickpea[3], pea[4], mungbean[5] and lentil[6] in Bangladesh. Chickpea, like most other legumes, is capable of fixing atmospheric nitrogen for its growth, enriching the nitrogen fertility of the soil if properly inoculated with the right strain of nodule bacteria. Proper *Rhizobium* strains and their adequate number are not normally present in soils of Bangladesh and hence inoculation with effective *Rhizobium* strain is essential for nodulation and nitrogen fixation of chickpea.

Mineral nitrogen increases the yield, protein content and nutrients uptake by chickpea but decreases nodulation and nitrogen fixation in grain legumes[7-8]. Information pertaining to the effect of *Rhizobium* inoculant and mineral nitrogen on chickpea is meagre, especially in the Salna Soil Series of Shallow Red Brown Terrace Soil. Keeping these facts in mind the present investigation was carried out to assess the effects of *Rhizobium* inoculant and mineral nitrogen on nodulation, nitrogen fixation, dry matter production, N uptake, yield and quality of chickpea.

Materials and Methods

The experiment was conducted at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh using five chickpea varieties, *viz*., V_1 = Barichola-2, V_2 = Barichola-3, V_3 = Barichola-4, V_4 = Barichola-5, and V_5 = Barichola-6. The soil of the farm was shallow-red brown terrace soil under Madhupur tract (agro-ecological zone, AEZ No. 28) and was classified as being Inceptisols. It was of silty clay loam texture and contained 0.94% organic carbon, 15.50 (meq/100g dry soil) cation exchange capacity (CEC), 0.069% total nitrogen, 12.50 ppm available phosphorus, 0.381 (meq/100g soil) exchangeable potassium (K) and had a pH 6.2. The number of *Rhizobium* was 4.1×10^6/g soil. Phosphorus @ 60 kg P_2O_5/ha in the form of triple super phosphate, potassium @ 40 kg K_2O/ha in the form of muriate of potash, sulphur @ 13.3 kg/ha in the form of gypsum, molybdenum @ 1 kg/ha in the form of ammonium molybdate were applied during final land preparation as basal dose. *Rhizobium* inoculant @ 20 g/kg seed was applied. The experiment was laid out in a split plot design with three replications. There were fifteen treatment combinations. *Rhizobium* strain was used as inoculant. Viable rhizobia present in the inoculant were counted by the drop plate method of Miles and Misra[9]. Seeds of

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chickpea were treated with mercuric chloride for surface sterilization. One g inoculant containing 1.6 x 10^8 cells/g was mixed with 50 g seeds with the help of gum Arabic. The seeds were sown in the experimental plot maintaining row to row 40 cm and seed to seed 5 cm spacing. Plots were irrigated up to saturation and inoculant to settle down in the soil. Plots were watered whenever necessary to maintain optimum field moisture condition. Intercultural operations such as weeding and mulching were done as and when necessary to ensure the normal growth of crop. The plots were carefully observed regularly to record any change of plant growth. The plants were free from insects and diseases. Therefore, no pesticide was used during the growth period.

Five plants were carefully uprooted with minimum disturbance of roots from each plot so that no nodules were left in soil both at vegetative (48 days after sowing, DAS) and flowering (72 DAS) stages of the crop. The roots were thoroughly washed with tap water and finally rinsed with distilled water. Nitrogenase activity of the plants was assessed by measuring acetylene reducing activity (ARA) in a gas chromatograph (Shimadzu, GC-8A) fitted with a flame ionization detector and a stainless steel column (3 mm diameter and 1.2 m length). After determination of nitrogenase activity, the nodules were separated from the roots and then nodule number and weight were recorded. The shoot, root and nodules were first air-dried and then oven-dried at 65°C for 72 h. The dry weights of the shoot, root and nodule were recorded. The oven-dried plant shoot material was ground in a grinding machine (Wiley Cutting Mill, Model 1029-B, Yoshida Seisakusho Co Ltd, Japan). Chlorophyll content of leaf was determined at vegetative stage using the method of Coombs *et al.*[10]. Total nitrogen (N) content in the shoot material was determined by ashing the plant material using salicylic acid modified Kjeldahl method following sulphuric acid digestion and then steam distillation and titration assay[11]. Nitrogen uptake by shoot was calculated from the data on dry matter yield and nitrogen content in the shoot material of chickpea. The crop was finally harvested at full physiological maturity. Data on number of seeds per plant, number of pods per plant and thousand seed weight were recorded from five randomly selected plants from each plot. The crude protein was determined by multiplying the %N in seeds, which was determined following the same method as described for N content in shoot, with a factor 6.25. All data were analyzed in the computer using MSTATC software program by Duncan's multiple range test (DMRT).

Results and Discussion

The number and dry weight of nodules were significantly influenced by *Rhizobium* inoculant and different levels of nitrogen (Table 1). The maximum number of nodules (25.00/plant) was observed by V_4 x N_0 at vegetative stage of chickpea, which was statistically superior to all other treatments except V_2 x N_{20}. At flowering stage, the same treatment also produced the highest number of nodules (27.60/plant) but its effect was similar to V_5 x N_0, V_2 x N_{20}, V_4 x N_{20} and V_5 x N_{20}. The lowest number of nodules (7.27 and 9.53/plant) was found by the treatment V_3 x N_{100} both at vegetative and flowering stages of chickpea. The highest number of nodules was recorded with V_4 x N_0 that might be attributed to greater fixation of atmospheric nitrogen in soil, which was essential for nodulation. More or less similar trend was observed in recording dry weight of nodules both at vegetative and

Table 1. *Interaction effect of nitrogen and variety on nodulation and nitrogenase activity of* chickpea

Treatment (N level)	Variety	Nodule (No./plant)		Nodule weight (mg/plant)		Nitrogenase activity (μmol C_2H_4/plant/h)	
		Vegetative	Flowering	Vegetative	Flowering	Vegetative	Flowering
N_0	V_1	12.40^{g}	10.33^{f}	20^{ef}	28^{de}	0.94^{de}	5.57^{c}
	V_2	19.67^{bcde}	19.47^{bcde}	39^{abcd}	58^{ab}	1.71^{cde}	15.13^{bc}
	V_3	12.47^{g}	10.40^{f}	22^{def}	28^{de}	1.06^{de}	5.60^{c}
	V_4	25.00^{a}	27.60^{a}	54^{a}	65^{a}	4.55^{a}	29.97^{a}
	V_5	21.33^{bc}	23.87^{abc}	44^{abc}	63^{a}	3.44^{ab}	29.10^{a}
N_{20}	V_1	15.80^{cfg}	13.80^{ef}	26^{cdef}	43^{bcd}	1.16^{de}	7.15^{c}
	V_2	21.80^{ab}	24.40^{ab}	49^{ab}	64^{a}	3.54^{ab}	29.32^{a}
	V_3	16.33^{cf}	16.87^{de}	28^{cdef}	48^{abc}	1.26^{de}	7.53^{c}
	V_4	20.67^{bcd}	21.60^{abcd}	43^{abc}	62^{ab}	2.87^{bc}	26.17^{ab}
	V_5	19.73^{bcde}	21.47^{abcd}	42^{abc}	60^{ab}	2.31^{bcd}	22.40^{ab}
N_{100}	V_1	14.93^{fg}	10.73^{f}	24^{cdef}	$36c^{de}$	1.09^{de}	5.53^{c}
	V_2	17.53^{cdef}	19.27^{bcde}	37^{abcd}	54^{abc}	1.70^{cde}	14.37^{bc}
	V_3	7.27^{h}	9.53^{f}	106^{f}	23^{e}	0.93^{de}	5.39^{c}
	V_4	19.67^{bcde}	20.33^{bcd}	41^{abcd}	59^{ab}	1.74^{cde}	17.54^{abc}
	V_5	17.17^{def}	17.73^{cde}	31^{bcdef}	48^{abc}	1.33^{de}	14.20^{bc}
CV(%)		3.48	5.62	6.50	6.50	3.55	4.38

Means in a column followed by same letter(s) are not significantly different at 5% level of Duncan's multiple range test (DMRT). V_1 = Barichola-2; V_2 = Barichola-3; V_3 = Barichola-4; V_4 = Barichola-5; V_5 = Barichola-6; N_0 = 0 kg N/ha; N_{20} = 20 kg N/ha; N_{100} = 100 kg N/ha.

flowering stages of the crop. These results are in good agreement with Solaiman[12], Solaiman and Hossain[8] who reported decreased nodulation in soybean due to the application of nitrogen fertilizer. Chamberland[13] reported that high N fertilizer depressed nodulation in cowpea. Solaiman and Rabbani[7] found that increasing the N level from 60-120 kg N/ha markedly decreased the number of nodules per plant in pea.

The interaction effect of varieties and nitrogen on nitrogenase activity of chickpea was found significant (Table 1). Among the treatments V_4 x N_0 scored the highest nitrogenase activity (4.55 μmol C_2H_4/plant/h), which was statistically similar to V_5 x N_0 and V_2 x N_{20} at vegetative stage of the crop. At flowering stage, the same treatment produced the maximum nitrogenase activity (29.97 μmol C_2H_4/plant/h) but its effect was similar to V_5 x N_0, V_2 x N_{20}, V_4 x N_{20}, V_5 x N_{20} and V_4 x N_{100}. Nitrogen, irrespective of level used, could not perform well in recording nitrogenase activity. The lowest nitrogenase activity (0.93 and 5.39 μmol C_2H_4/plant/h) was observed in the treatment V_3 x N_{100} both at vegetative and flowering stages of the crop. Solaiman and Rabbani[7] reported that nitrogen application depressed nitrogenase activity but encouraged vegetative growth in pea.

The highest dry weight of shoot (3.03 and 14.67 g/plant) was recorded with the treatment V_1 x N_{100} both at vegetative and flowering stages, respectively (Table 2). This might be due to adequate supply of nitrogen from chemical fertilizer, which enhanced vegetative growth and greater translocation of photosynthate and thereby increased shoot growth. The lowest dry weight of shoot (1.05 g/plant) was recorded by treatment V_5 x N_{20}. The increase in dry matter production of groundnut due to N fertilization was recorded by Jadhav and Narkhede[14] in groundnut and Jackson[15] in soybean.

There was a significant difference in dry weight of root per plant by the combination of variety and nitrogen (Table 2). The maximum dry weight of root (0.29 g/plant) was obtained with V_1 x N_{100}, which maintained significant difference with all other treatments at vegetative stage. More or less similar trend was found at flowering stage of the crop. The lowest values (0.09 g/plant and 0.35 g/plant) were observed in the treatment V_5 x N_{20} both at vegetative and flowering stages of crop. The positive effect of nitrogen with the combination of *Rhizobium* and arbuscular mycorrhiza on dry weight of root per plant in chickpea was also reported by Solaiman *et al*.[16]. Similar results in soybean were found by Solaiman *et al.*[17].

The maximum numbers of branches both at vegetative and flowering stages (5.20 and 6.43/plant) was observed in the treatment V_1 x N_{100} and its effect was superior to all other treatments (Table 2). The minimum number of branches per plant (2.46 and 2.86) was found in the treatment of N_{20} x V_5 both at vegetative and flowering stages of chickpea, respectively. Similar results were also reported by Solaiman *et al*.[16-17] in chickpea.

Treatment V_1 x N_{100} recorded the highest chlorophyll a (45.42 mg/100 g) in chickpea. Treatment V_1 x N_{100} was however, statistically at par with the treatments V_2 x N_0, V_4 x N_0, V_1 x N_{20}, V_3 x N_{100} and V_4 x N_{100} (Table 3) in recording chlorophyll a in chickpea. The lowest chlorophyll a (37.07 mg/100 g) was produced through the treatment V_5 x N_0.

Table 2. *Interaction effect of nitrogen and variety on dry weight of shoot, root and number of branches of chickpea*

Treatment	Variety	Dry weight of shoot(g/plant)		Dry weight of root(g/plant)		Branche(No./plant)	
(N level)		Vegetative	Flowering	Vegetative	Flowering	Vegetative	Flowering
N_0	V_1	1.60^{cde}	8.34^{de}	0.14^{bc}	0.59^{bcd}	2.80^{c}	3.33^{cdef}
	V_2	2.34^{abc}	10.28^{bc}	0.25^{a}	0.75^{bc}	4.33^{b}	4.40^{c}
	V_3	1.68^{cde}	8.46^{bcde}	0.15^{bc}	0.60^{bcd}	2.93^{c}	3.40^{cdef}
	V_4	2.64^{ab}	11.87^{ab}	0.27^{a}	0.94^{ab}	4.33^{b}	5.60^{b}
	V_5	1.32^{de}	5.26^{de}	0.10^{c}	0.36^{d}	2.60^{c}	3.06^{ef}
N_{20}	V_1	2.06^{bcd}	9.94^{bcd}	0.17^{b}	0.75^{bc}	3.13^{c}	4.10^{cd}
	V_2	1.48^{cde}	6.30^{cde}	0.13^{bc}	0.41^{cd}	2.73^{c}	3.06^{ef}
	V_3	1.50^{cde}	6.31^{cde}	0.14^{bc}	0.42^{cd}	2.80^{c}	3.20^{def}
	V_4	1.58^{cde}	7.43^{bcde}	0.14^{bc}	0.44^{cd}	2.80^{c}	3.20^{def}
	V_5	1.05^{e}	4.63^{e}	0.09^{c}	0.35^{d}	2.46^{c}	2.86^{f}
N_{100}	V_1	3.03^{a}	14.67^{a}	0.29^{a}	1.13^{a}	5.20^{a}	6.43^{a}
	V_2	1.82^{bcde}	8.50^{bcde}	0.15^{bc}	0.64^{bcd}	3.00^{c}	3.66^{cdef}
	V_3	2.03^{bcd}	8.90^{bcde}	0.15^{bc}	0.71^{bcd}	3.00^{c}	4.00^{cd}
	V_4	1.91^{bcde}	8.54^{bcde}	0.15^{bc}	0.70^{bcd}	3.00^{c}	3.80^{cde}
	V_5	1.38^{de}	5.64^{cde}	0.11^{c}	0.38^{cd}	2.73^{c}	3.06^{ef}
CV (%)		7.77	4.08	5.29	4.35	7.32	7.32

Means in a column followed by same letter(s) are not significantly different at 5% level of Duncan's multiple range test (DMRT). V_1 = Barichola-2; V_2 = Barichola-3; V_3 = Barichola-4; V_4 = Barichola-5; V_5 = Barichola-6; N_0 = 0 kg N/ha; N_{20} = 20 kg N/ha; N_{100} = 100 kg N/ha.

Table 3. *Interaction effect of nitrogen and variety on chlorophyll a, chlorophyll b, nitrogen content, nitrogen uptake by shoot and protein content in seed of chickpea*

Treatment (N level)	Variety	Chlorophyll a (mg/100 g fresh weight)	Chlorophyll b (mg/100 g fresh weight)	N content in shoot (%)		N uptake by shoot (mg/plant)		Protein content in seed (%)
				Vegetative stage	Flowering stage	Vegetative stage	Flowering stage	
N_0	V_1	43.86^{bc}	51.86^{i}	3.61^{bc}	3.13^{cde}	57.09^{fg}	261.04^{i}	22.90^{b}
	V_2	44.25^{ab}	75.04^{a}	4.29^{bc}	3.93^{bc}	87.79^{c}	484.00^{c}	27.81^{ab}
	V_3	43.89^{bc}	52.39^{h}	3.66^{bc}	3.16^{cde}	61.48^{ef}	267.33^{h}	23.25^{b}
	V_4	44.29^{ab}	57.72^{b}	5.08^{ab}	4.39^{b}	100.40^{b}	521.09^{b}	35.02^{a}
	V_5	42.48^{c}	45.14^{m}	3.30^{c}	2.28^{de}	43.56^{i}	119.92^{n}	20.85^{b}
N_{20}	V_1	44.16^{ab}	56.27^{d}	4.20^{bc}	3.99^{bcd}	86.52^{c}	376.60^{d}	27.44^{ab}
	V_2	43.77^{bc}	46.39^{l}	3.34^{c}	2.60^{de}	49.43^{hi}	163.80^{l}	22.08^{b}
	V_3	43.82^{bc}	48.74^{k}	3.54^{bc}	2.83^{cde}	53.10^{gh}	178.57^{k}	22.48^{b}
	V_4	43.84^{bc}	50.65^{j}	3.55^{bc}	3.13^{cde}	56.09^{fgh}	232.55^{j}	22.7^{b}
	V_5	37.07^{d}	42.27^{n}	2.94^{c}	2.07^{e}	30.87^{j}	95.84^{o}	17.15^{b}
N_{100}	V_1	45.42^{a}	75.25^{a}	6.22^{a}	5.39^{a}	134.10^{a}	790.71^{a}	35.08^{a}
	V_2	43.93^{bc}	53.63^{g}	3.71^{bc}	3.29^{bcd}	67.52^{e}	279.65^{g}	24.85^{ab}
	V_3	44.16^{ab}	56.00^{e}	4.19^{bc}	3.38^{bcd}	85.05^{c}	300.82^{e}	25.40^{ab}
	V_4	44.15^{ab}	54.22^{f}	3.93^{bc}	3.34^{bcd}	75.45^{d}	285.23^{f}	24.38^{b}
	V_5	42.67^{c}	45.29^{m}	3.32^{c}	2.31^{de}	48.57^{hi}	130.28^{m}	21.38^{b}
CV (%)		3.45	4.56	4.27	8.84	6.97	5.13	9.29

Means in a column followed by same letter(s) are not significantly different at 5% level of Duncan's multiple range test (DMRT). V_1 = Barichola-2; V_2 = Barichola-3; V_3 = Barichola-4; V_4 = Barichola-5; V_5 = Barichola-6; N_0 = 0 kg N/ha; N_{20} = 20 kg N/ha; N_{100} = 100 kg N/ha.

Chlorophyll b was significantly influenced by different levels of nitrogen with different varieties (Table 3). The maximum chlorophyll b (75.25 mg/100 g) was noted in treatment V_1 x N_{100} which was statistically superior to all other treatments except treatment V_2 x N_0. This might be attributed due to the higher level of nitrogen application. The lowest chlorophyll b (45.29 mg/100 g) was produced by the treatment V_5 x N_{100}.

At vegetative stage, nitrogen content in shoot, the major growth contributing character was likewise influenced by the varying levels of nitrogen fertilizer. The maximum nitrogen content (6.22%) was obtained in treatment V_1 x N_{100}, which was statistically similar to V_4 x N_0 but superior to the rest of the treatments (Table 3). The combined effect of *Rhizobium* inoculant and nitrogen might have led to better assimilation of N for the plants that might resulted the highest nitrogen content in shoots both at vegetative and flowering stages of the crop.

A significant interaction effect of variety and nitrogen in recording the nitrogen uptake by the crop was observed (Table 3). At vegetative stage, treatment V_1 x N_{100} recorded the maximum nitrogen uptake (134.10 mg/plant) which was statistically superior to the rest of the treatments. The same treatment combination also recorded the maximum nitrogen uptake (790.71 mg/plant) at flowering stage. *Rhizobium* inoculated plants in combination with 100 kg N/ha performed better than other treatments employed.

There was a significant interacting effect of variety and nitrogen in recording the protein content in seed of chickpea (Table 3). Treatment V_1 x N_{100} produced the maximum protein in seed (35.08%), which was statistically identical to V_2 x N_{100}, V_4 x N_0, V_1 x N_{20}, V_2 x N_{100} and V_3 x N_{100}. The lowest protein content in seed (17.15%) was noted in V_5 x N_{20}. Increase in crude protein content by increasing levels of N was also reported by Faldu[18], Jadhev and Narkhede[14] and Zade *et al*.[19] in groundnut.

The effects of different treatments on number of seeds per plant of chickpea were found significant (Table 4). The maximum number of seeds (52.07/plant) was observed with the treatment V_1 x N_{100}, which was statistically similar to V_2 x N_0, V_4 x N_0 and V_1 x N_{20}. This might be due to the optimum supply of nitrogen from chemical fertilizer as well as *Rhizobium* inoculant which enhanced vegetative growth and fruit bearing capacity of the crop. The lowest number of seeds (8.10/plant) of chickpea was recorded by V_5 x N_{20}.

There was a significant variation in the number of pods per plant of chickpea with different treatments (Table 4). The highest number of pods was obtained with the treatment V_1 x N_{100} and it was at par with V_2 x N_0 and V_4 x N_0 but higher over rest of the treatments. Solaiman *et al*.[16] conducted an experiment with chickpea and observed that *Rhizobium* inoculant in combination with arbuscular mycorrhiza and poultry litter produced the maximum number of pods per plant. The lowest number of pods per plant (16.77) was found with V_5 x N_{20}.

There was a significant interacting effect of variety and nitrogen in chickpea (Table 4). The maximum weight of 1,000-seed (192.70 g) was recorded with V_1 x N_{100}, which was statistically identical to V_3 x N_{100}, V_4 x N_{100}, V_1 x N_{20}, V_2 x N_0 and V_4 x N_0. Significantly higher 1,000-seed weight was obtained in edible-podded pea either with 100 kg N/ha or *Rhizobium* inoculant[20]. In this study the lowest 1,000-seed weight (124.80 g) was recorded by V_5 x N_{20}.

The trend of increase in stover yield was similar as that of seed yield per plant of chickpea. The maximum stover yield (2.57 t/ha) at harvest was recorded with treatment V_1 x N_{100} but it was similar to V_4 x N_0 and V_2 x N_0. Solaiman and Rabbani[20] obtained similar result in edible-podded pea with *Rhizobium* inoculant and mineral nitrogen. In this study the lowest stover yield (1.10 t/ha) of the present study was recorded with V_5 x N_{20}.

There was a significant effect of different treatments in increasing seed yield of the crop (Table 4). The highest seed yield

Table 4. *Interaction effect of nitrogen and variety on yield and yield contributing characters of chickpea*

Treatment (N level)	Variety	Seed (No./plant)	Pod (No./plant)	1,000-seed weight (g)	Stover yield (t/ha)	Seed yield (t/ha)
N_0	V_1	24.80^{cd}	23.70^{cde}	159.20^{cdef}	1.38^{bcde}	0.43^{cde}
	V_2	42.20^{ab}	36.80^{abc}	187.00^{ab}	2.27^{a}	0.72^{b}
	V_3	27.20^{bcd}	23.80^{cde}	161.70^{bcde}	1.45^{bcde}	0.52^{bcde}
	V_4	43.30^{ab}	42.80^{ab}	189.20^{a}	2.31^{a}	0.76^{b}
	V_5	18.80^{de}	16.97^{e}	126.60^{g}	1.16^{e}	0.24^{e}
N_{20}	V_1	41.27^{ab}	33.90^{bcd}	186.80^{ab}	1.82^{b}	0.66^{bc}
	V_2	19.93^{de}	18.27^{e}	141.50^{efg}	1.24^{de}	0.36^{de}
	V_3	21.10^{cde}	19.87^{de}	146.10^{defg}	1.34^{cde}	0.38^{cde}
	V_4	22.60^{cde}	20.60^{de}	146.30^{defg}	1.34^{cde}	0.42^{cde}
	V_5	8.10^{e}	16.77^{e}	124.80^{g}	1.10^{e}	0.27^{e}
N_{100}	V_1	52.07^{a}	50.17^{a}	192.70^{a}	2.57^{a}	1.12^{a}
	V_2	30.23^{bcd}	23.87^{cde}	160.59^{bcde}	1.45^{bcde}	0.52^{bcde}
	V_3	36.70^{abc}	29.20^{bcde}	184.90^{abc}	1.71^{bc}	0.60^{bcd}
	V_4	32.33^{bcd}	26.10^{cde}	177.90^{abc}	1.69^{bcd}	0.57^{bcd}
	V_5	19.27^{de}	18.10^{e}	133.70^{fg}	1.22^{e}	0.35^{de}
CV (%)		4.55	3.12	3.64	4.23	5.32

Means in a column followed by same letter(s) are not significantly different at 5% level of Duncan's multiple range test (DMRT). V_1 = Barichola-2; V_2 = Barichola-3; V_3 = Barichola-4; V_4 = Barichola-5; V_5 = Barichola-6; N_0 = 0 kg N/ha; N_{20} = 20 kg N/ha; N_{100} = 100 kg N/ha.

(1.12 t/ha) was observed with the treatment V_1 x N_{100}, which was statistically superior to all other treatments. The second highest seed yield was recorded with V_4 x N_0 but its effect was similar to V_2 x N_0, V_3 x N_0, V_1 x N_{20}, V_2 x N_{100}, V_3 x N_{100} and V_4 x N_{100}. Solaiman and Rabbani[20] obtained significantly higher seed yield in edible-podded pea with *Rhizobium* inoculant compared to uninoculated control. In the present study the lowest seed yield (0.24 t/ha) was found in V_5 x N_0.

References

1. Salunkhe DK & Kadam SS. 1989. *Handbook of World Food Legumes: Nutritional Chemistry, Processing, Technology, and Utilization*, Vol 1. CRC Press, Boca Raton, Florida.
2. Anonymous. 2004. *Yearbook of Agricultural Statistics of Bangladesh*. Bangladesh Bureau of Statistics (BBS), Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.
3. Eusuf Zai AK, Solaiman ARM, Karim AJMS & Ahmed JU. 1999. Performance of some chickpea varieties to *Rhizobium* inoculation in respect of growth, N uptake, yield and seed protein content. *Ann Bangladesh Agric*. **9**: 121-130.
4. Khondaker M, Solaiman ARM, Karim AJMS & Hossain MM. 2003. Response of pea varieties to *Rhizobium* inoculation: Nitrogenase activity, dry matter production and nitrogen uptake. *Korean J Crop Sci*. **48**: 361-368.
5. Solaiman ARM, Hossain D & Haque MM. 2003a. Response of mungbean varieties to *Rhizobium* inoculation in respect of nodulation, nitrogenase activity, dry matter yield and nitrogen uptake. *Korean J Crop Sci*. **48**: 355-360.
6. Solaiman ARM, Mahmud MS & Hoque MS. 2003. Response of lentil to *Rhizobium* inoculant and nitrogen: Yield and yield contributing characters. *Bangladesh J Life Sci*. **15**(2): 71-77.
7. Solaiman ARM & Rabbani MG. 2003. Performance of pea (*Pisum sativum*) as affected by *Rhizobium* inoculant, N, P and Mo application. *Bangladesh J Soil Sci*. **27-29**: 13-22.
8. Solaiman ARM & Hossain D. 2006. Effectiveness of *Bradyrhizobium japonicum* strains on soybean at field condition. *Bull Inst Trop Agric Kyushu University*. **29**: 11-20.
9. Miles AA & Misra SS. 1938. The estimation of the bactericidal power of blood. *J Hyg Cambridge*. **38**: 732-749.
10. Coombs J, Hall DO, Long SP & Scurlock JMO. 1985. *Techniques in Bio-productivity and Photosynthesis*, 2nd edn, pp 223-234. Paragamon International, Oxford.
11. Wide SA, Corney RB & Lyer JG. 1979. *Soil and Plant Analysis for Free Culture*, p 78. Soil Science, University of Wisconsin, GK Voigt, Yale School of Forestry, Wisconsin.
12. Solaiman ARM. 1999. Effects of *Bradyrhizobium japonicum* inoculation and molybdenum on soybean. *Bangladesh J Bot*. **28**: 181-183.
13. Chamberland E. 1982. Predicting the N, P and K requirement of legumes grown in mineral soil: Peas and Beans. *Can J Soil Sci*. **62**: 663-672.
14. Jadhav AS & Narkhede RN. 1983. Pattern of dry matter accumulation of groundnut as influenced by nitrogen and phosphorus fertilization. *Madras Agric J*. **69**: 756-759.
15. Jackson ML. 1973. *Soil Chemical Analysis*, pp 326-338. Prentice Hall of India (Pvt) Ltd, New Delhi.
16. Solaiman ARM, Rabbani. MG & Molla MN. 2005. Effects of inoculation of *Rhizobium* and arbuscular mycorrhiza, poultry litter, nitrogen and phosphorus on growth and yield in chickpea. *Korean J Crop Sci*. **50**(4): 256-261.
17. Solaiman ARM, Molla MN & Hossain MD. 2006. Response of chickpea to dual inoculation with *Rhizobium* and arbuscular mycorrhiza, nitrogen and phosphorus. *Korean J Crop Sci*. **51**(6): 527-533.19.
18. Faldu DG. 1978. Effect of nitrogen and phosphorus application on the yield and mineral composition of groundnut (*Arachis hypogaea* L) grown on calcareous soils low either in copper or molybdenum or both. *PhD Thesis*. Gujarat Agriculture University (GAU), Anand, India.
19. Zade KB, Deshmukh VA, Naphade PS, Mahulikar DS & Kharkhar PJ. 1985. Response of groundnut to foliar application of urea along with molybdenum. *Seed Farms*. **11**: 7-8.
20. Solaiman ARM & Rabbani MG. 2005. Effects of *Rhizobium* inoculant, compost and nitrogen on edible podded pea. *Bangladesh J Microbiol*. **22**(1): 5-9.