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EFFECT OF *BRADYRHIZOBIUM* INOCULANTS ON THE GROWTH AND YIELD OF SOYBEAN VARIETIES PB-1 AND G-2

A.H.M.N. ANWAR[1], A.K. PODDER[2], M.A. HASEM[3], P. BALA[4] AND M.A. ISLAM[5]

[1]Lecturer in Agricultural Science, Government Mujibur Rahman Women's College, Bogra, Bangladesh; [2]Chief Scientific Officer, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh; [3]Professor, Department of Soil Science, Bangladesh Agriculture University, Mymensingh, Bangladesh; [4]Lecturer in Agricultural Science, Lalmia City College, Gopalgonge, Bangladesh; [5]Scientific Officer, Soil Recourse Development Institute, Regional Laboratory, Rajshahi, Bangladesh.

Corresponding author & address: A.H.M.N. Anwar, Email: ahmn.anwar@gmail.com
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ABSTRACT

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The experiment was conducted at the Soil Science farm of Bangladesh Agricultural University (BAU) Mymensingh during the period from January to May 2000. The experimental soil was Sonatala silt loam, a member of hyperthermic aeric haplaquept. The experiment was laid out in a factorial experiment in Randomized Complete Block Design (RCBD) with three replications. Each replication was represented by a block which was divided into 7 plots. The total numbers of plots were 42 and the size of each plot was 4m × 2.5m. The crop used in this study was soybean (*Glycine max* L. Merr.). The varieties of the crop was PB-1 (Shohag) and G-2. The study comprised of the seven *Bradyrhizobium* inoculant treatments such as T_1: Uninoculated, T_2: BINA-SB-1906, T_3: BINA-SB-J43, T_4: BINA-SB-3407, T_5: BINA-SB-J11, T_6: BINA-SB-102 and T_7: BINA-SB-J2. Treatments were randomly distributed within the blocks. The overall results of the field experiment showed that *Bradyrhizobium* inoculation was beneficial in nodulation, plant fresh weight, dry matter production, plant height, seed yield and hay yield of soybean varieties PB-1 and G-2. The G-2 variety of soybean and bradyrhizobial inoculant BINA-SB-102 gave better results than other variety and other inoculants, respectively. Use of *Bradyrhizobium* inoculants appear to be an effective method for successful soybean production, which may also improve the soil health saving of costly synthetic chemical fertilizer and keep the soil and environment free from pollution.

Key words: *Bradyrhizobium*, growth, yield, soybean, variety-PB-1 and G-2

INTRODUCTION

Soybean (*Glycine max* L. Merr.) is considered to be the most import and well recognized grain legume, oil seed and protein crop in many countries of the world as it improves nitrogen fertility of soil. As a grain legume, it is gaining important position in the agriculture of tropical countries including Bangladesh Legumes have been building and conserving soil fertility since the beginning of agriculture. It has occupied the top position in terms of oil source in the world and has been placed second in Bangladesh as a good source of protein. Unsaturated fatty acids, minerals like Ca and P including vitamin A, B and D soybean can meet up different nutritional needs (Rahman 1982). The soybean seeds contain about 40-45% protein, 18-20% edible oil, hence it is referred as "the protein hope of future" as well as "the miracle golden bean". Although the other oil content in soybean is lower then oil seeds but the acreage production is higher than that of others. Further more, the soybean oil is cholesterol free and is easily acceptable diet. On an average, about 8-10 percent of protein intake in Bangladesh diet originates from animal sources, the rest can be meeting from plant sources by increasing the consumption of vegetables and pulses, especially of soybean.

Bradyrhizobium bacteria in symbiotic association with the leguminous plants are able to fix dinitrogen (N≡N) from the atmosphere. Atmospheric air contains about 78% nitrogen in the elemental form. This large amount of nitrogen can not be used by plants unless it is converted in available form. Fortunately, the bacteria *Bradyrhizobium japonicum* can fix atmospheric nitrogen (about 300 kg/ha/ya) in symbiosis with soybean (Kayser and Li, 1992). The effective bacteria in the nodules fix enough atmospheric nitrogen not only for the growth and development of the plant itself but also improve the soil fertility and productivity.

It is essential that suitable inoculant be provided for soybean crop on new land or in areas where effective nodulating bacteria are not present (Chomchalow 1980). Vincent (1974) reported that the inoculation is necessary in soils where the rhizobia are ineffective or absent. Increased nodulation, higher dry matter and grain yield production due to *Bradyrhizobium* inoculation have been documented by several workers. This crop can be easily cultivated throughout the year (Khaleque and Siddique, 1982). In Rabi season soybean can be successfully grown on the residual soil moisture. Though soybean is cultivated in some location of Bangladesh but its production is not satisfactory due to lack of native bradyrhizobia population.

The efficiency of the symbiont depends on many factors, important of which are genetic variability of the symbiont and the soil and environmental factors (Douka *et al.* 1986 and Somasegaran *et al.* 1990). The use of rhizobial inoculants in crop production can play a vital role in improving soil environment and agriculture sustainability. The objectives of present investigation were therefore, set as follows:

i) To evaluate the performance of different *Bradyrhizobium* inoculants in soybean variety viz. PB-1 and G-2.

ii) To investigate the interaction effect of *Bradyrhizobium* inoculants on the growth, yield, and nitrogen content of sovhean varieties PB-1 and G-2.

iii) To study the correlation among different parameters of soybean varieties as influenced by different *Bradyrhizobium* inoculants.

MATERIALS AND METHODS

The experiment was conducted at the Soil Science farm of Bangladesh Agricultural University (BAU) Mymensingh during the period from January to May 2000. The experimental soil was Sonatala silt loam, a member of hyperthermic aeric haplaquept.

The experiment was laid out in a factorial experiment in Randomized Complete Block Design (RCBD) with three replications. Each replication was represented by a block which was divided into 7 plots. The total numbers of plots were 42 and the size of each plot was 4m × 2.5m. The crop used in this study was soybean (*Glycine max* L. Merr.). The varieties of the crop was PB-1 (Shohag) and G-2. The study comprised of the seven Bradyrhizobium inoculant treatments such as T_1: Uninoculated, T_2: BINA-SB-1906, T_3: BINA-SB-J43, T_4: BINA-SB-3407, T_5: BINA-SB-J11, T_6: BINA-SB-102 and T_7: BINA-SB-J2. Treatments were randomly distributed within the blocks. Fertilizer such TSP and MP were used as sources for P and K respectively. No nitrogenous fertilizer was used during experimental period. The bradyrhizobial inoculant was prepared in the Soil Microbiology Laboratory, Soil Science Division, BINA,Mymensingh following the method of Vincent (1970). The amount of seed to be shown in each plot was weighed (65g/plot) on the basis of recommended rate of 65kg/ha. The seeds for each plot were then taken in a plastic bag. Bradyrhizobium inoculant (liquid) was then added at the rate 15 ml per kg seeds and mixed well with the seeds by shaking the bag thoroughly. For each inoculant, separate plastic bag was used and care was taken to avoid contamination of the inoculants. Seed inoculation was done on the 23 January, 2000 and the inoculated seeds were sown in the field on the same day in afternoon. The spacing between the line was 30 cm and between plants within a line was 5 cm. Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The crop was harvested at physiological maturity on May 13, 2000. The harvested plant materials of l sq.m. were allowed to dry in the sun for 3 days. After drying, threshing and processing were done plot wise carefully. Seed and straw yields were recorded plots wise, which were then converted into yield in kilogram per hectare. The data collected from the experiment at different stages of soybean growth and chemical analysis were statistically analyzed using PC MSTAT Software packages. The mean for all treatments were calculated and analysis of' variance of all characters were performed. When the ANOVA was significant ($p<0.05$) Duncan's Multiple Range Test (DMRT) was used to indicate treatment differences.

RESULTS AND DISCUSSION

Effect of Varieties on Yield and Yield Attributes of Soybean

Number of nodules per plant

The highest number of nodules was produced by the variety PB-1 (12.28/ plant) which were statistically significant to G-2 (11.32/plant) at 4 weeks of emergence. Variety PB-1 gave the highest number of nodules (29.21//plant) which was statistically significant to G-2 (23.48) at 50% flowering stage (Table 1.a).

The above results are in line with the findings of some investigators. Somasegaran *et al.* (1988) reported that inoculation with 3 strains of in desi and Kabuli types *Citer arietinum* L. resulted difference in nodulation for types and rhizobial strains.

Nodule dry weight

The results in Table 1.a showed that at 4 weeks emergence, variety PB-1 produced the highest nodule dry weight (53.56 mg/plant) which was statistically significant toG-2 variety.

At 50% flowering stage, variety PB-1 produced highest nodule dry weight (153.43 mg/plant) which was statistically different from and superior to variety G-2.

In two field experiments were conducted by scientist of BINA (1998) on PB-1 and G-2 varieties of soybean inoculation with 4 bradyrhizobia strains and observed that PB-1 variety produced maximum nodule dry weight over G-2.

Table 1.a. Effect of varieties on Number of nodules per plant (no./plant), Nodules dry weight (mg/plant), Plant fresh weight (g/plant), Plant dry weight (g/plant) of soybean at harvest

Varieties	Number of nodules per plant (no./plant)		Nodules dry weight (mg/plant)		Plant fresh weight (g/plant)		Plant dry weight (g/plant)	
	4 WE	50% FS	4WE	50% FS	4WE	50% FS	4WE	50% FS
PB-1	12.28 a	29.21 a	53.56 a	153.43 a	3.38 a	18.90 a	0.826 a	5.39 a
G-2	11.32 b	23.48 b	51.40 b	135.13 b	2.59 b	17.60 b	0.705 b	5.06 b
SE (m) ±	0.25	0.33	0.72	1.91	0.04	0.23	0.01	0.10

Table 1.b. Effect of varieties on root length, shoot length, of soybean at 4 weeks emergence (4WE) 50% flowering stage (50% FS), number of pods per plant, number of seeds per plant, 100-seed weight, seed yield and hay yield of soybean at harvest

Varieties	Root length (cm/plant)		Shoot length (cm/plant)		Number of pods per plant	Number of seeds per plant	100-seed weight	Seed yield	Hay yield
	4WE	50% FS	4WE	50% FS					
PB-1	8.53 a	13.19	15.89 b	46.16 b	38.71 b	60.49 b	14.56 a	2353 b	3417 b
G-2	8.10 b	13.46	16.72 a	61.43 a	43.25 a	87.20 a	10.94 b	2502 a	3990 a
SE (m) ±	0.12	NS	0.22	0.64	0.51	0.99	0.10	25.7	45.81

Plant fresh weight

Results in Table 1.a, showed that at 4 weeks emergence, variety PB-1 produced the highest plant fresh weight (3.38 g/plant) which was significantly different from and superior to variety G-2 (2.59 g/plant).

At 50% flowering stage, PB-1 variety produced higher plant fresh weight (18.90 g/plant) which was statistically different from variety G-2 (17.60 g/plant).

Plant dry weight

The better plant dry weight was produced in the variety of PB-1(0.826 g/plant) which was statistically significant than G-2 variety at 4 weeks emergence.

At 50% flowering stage, variety PB-l, produced the better plant dry weight (5.39 g/plant) which was statistically different from and superior to variety G-2.

Root length

The results presented in Table 1.b showed that variety PB-1 produced shorter root length (8.53 cm/plant) which was statistically different from G-2 variety at 4 weeks emergence. At 50% flowering stage, the variety was not significant effect on the root length.

Shoot length

At 4 weeks emergence, the higher shoot length was recorded in G-2 variety (16.72 cm/ plant) which was statistically and significantly different from and superior to PB-1 variety.

At 50% flowering stage the higher shoot length was recorded to the variety G-2 (61.43 cm/plant) which was significantly different to PB-I variety. Similar results were found by scientist of BINA (1998) in PB-1 and G-2 varieties of soybean.

Number of pods per plant

At harvesting, the higher number of pods per plant (43.25 g/plant) was recorded with G-2 variety of soybean which was significantly different to PB-1 variety (Table 1.b).

A field experiment was conducted by scientist of BINA (1998) on PB-1 and G-2 varieties of soybean and found that G-2 variety was produced higher number of pods over PB-I variety.

Number of seed per plant

The higher number of seeds (87.20/plant) was recorded with variety G-2 which was significantly different from and superior to PB-1 variety of soybean.

100 seed weight

The maximum 100 seed weight was obtained in the variety of PB-l. This treatment recorded 14.56 g/ 100 seed which was significantly different from and superior to G-2 variety of soybean.

Seed yield

Results showed that the higher seed yield (2502 kg/ha) was produced in G-2 variety of soybean was significantly different from and superior to PB-1 variety (Table 1.b).

A field experiment was conducted at BINA (1998) on PB-1 and G-2 varieties of soybean and it was found that G-2 variety produced higher seed yield than PB-l variety.

Hay yield

The higher hay yield (3990 kg/ha) was produced by the G-2 variety which was significantly different to PB-1 variety (Table 1.b).

Effect of *Bradyrhizobium* inoculation Yield and Yield Attributes of Soybean

Number of nodules per plant

There was highly significant effect of *Bradyrhizobium* inoculants on the number of nodules per plant, recorded at 4 weeks of emergence of crop growth (Table 2.a). Although all the inoculated treatments gave more nodules per plant than the control did, the inoculants themselves were not statistically different in nodule formation. Data on number of nodules per plant (Table 2.a) showed that the BINA-SB-102 inoculant produced the highest number of nodules and the lowest was in uninoculated control at 4 weeks of emergence. The number of nodules per plant ranged from 2.02 to 15.18. Inoculant 13INA-S13-3407 gave the second highest number of nodules (14.83/plant) followed by BINA-SB-1906 (14.05/plant), B1NA-SB-Jl1 (12.83/plant) and similar to BINA-SB-J43 and BINA-SB-J2 (11.85/plant).

Table 2.a. Effect of *Bradyrhizobium* inoculant on Number of nodules per plant (no./plant), Nodules dry weight (mg/plant), Plant fresh weight (g/plant), Plant dry weight (g/plant) of soybean at harvest

Treatments	Number of nodules per plant (no./plant)		Nodules dry weight (mg/plant)		Plant fresh weight (g/plant)		Plant dry weight (g/plant)	
	4 WE	50% FS	4 WE	50% FS	4 WE	50% FS	4 WE	50% FS
Uninoculated	2.02 d	4.69 d	6.89 d	19.25 d	1.72 d	10.66 e	0.673 c	3.78 d
BINA-SB-1906	14.05 ab	30.25 b	59.53 b	153.25 bc	3.20 b	21.20 b	0.748 b	5.57 b
BINA-SB-J43	11.85 c	33.20 a	54.68 c	187.03 a	3.66 a	20.26 b	0.833 a	6.12 ab
BINA-SB-3407	14.83 a	25.98 c	65.13 a	147.61 c	3.58 a	17.16 d	0.790 ab	4.76 c
BINA-SB-J11	12.83 bc	27.12 c	59.10 b	152.30 bc	3.07 b	18.90 c	0.760 ab	5.72 b
BINA-SB-102	15.18 a	33.82 a	67.38 a	189.05 a	3.60 a	23.67 a	0.820 a	6.51 a
BINA-SB-J2	11.85 c	29.43 b	54.66 c	161.48 b	2.26 c	15.95 d	0.720 bc	4.12 d
SE (m) ±	0.47	0.63	1.35	3.58	0.07	0.44	0.02	0.19

WE = Weeks emergence, FS = Flowering stage, NS = Not significant

In a column, figures having common letter (s) do not differ significantly at 5% and 1% level of probability.

Nodule dry weight

Results in Table 2.a showed that at 4 weeks emergence, BINA-SB-102 produced the highest nodule dry weight (67.38 mg/plant) which was statistically identical to BINA-SB-3407 (65.13mg/plant) but significantly superior to all other inoculant treatments (Table 2.a). The inoculant BINA-SB-1906 gave the second highest nodule dry weights (59.53 mg/plant) followed by the inoculant BINA-SB-J 1 1 (59. 10 mg/plant).

At 50% flowering stage, BINA-SB-102 inoculant gave the highest nodule dry weight (189.05 mg/plant) which was statistically similar to BINA-SB-J43 (187.03 mg/plant) but significantly different from all other inoculants.

The above results are in line with those of some investigators. Hoque *et al.* (1980) carried out two field experiments on Bragg soybean with 7 *Rhibium japonicum* strains in both peat and soil based inoculants and recorded 40% higher nodule dry weight over uninoculated control.

Plant fresh weight

The table 2.a showed that the maximum plant fresh weight (3.66 g/plant) was recorded with the application of strain BINA-SB-J43 which was statistically identical to BINA-SB-3407 and BINA-SB-102 and the minimum value was observed in control treatment, which was significantly different from all other inoculants at 4 weeks emergence.

At 50% flowering stage, the maximum plant fresh weight (23.67 g/plant) was recorded with the application of inoculant BINA-SB-102 and the minimum value was observed in control treatment (1.72 g/plant).

Plant dry weight

The maximum plant dry weight was produced (0.833 g/plant) by BINA-SB-J43 at 4 weeks emergence, which was statistically similar to BINA-SB-102, BINA-SB-3407 and BINA-SB-J11. The total plant dry weight ranged from 0.67 g/plant in control to 0.833 g/plant in BINA-SB-J43. The effect of all the inoculants on plant dry weight was significantly different and superior to uninoculated control.

At 50% flowering stage, the highest plant dry weight was produced (6.51g/plant) BINA-SB-102 which was statistically identical to BINA-SB-J43 but significantly different from and superior to all other inoculants. All these inoculants produced significantly higher total dry matter weights over control. Similar results were found by Hoque and Solaiman (1982), Rahman (1988) in soybean. Hoque and Hashem (1992, 1993 and 1994) in soybean and groundnut.

Root length

Results in the Table 2.b showed that at 4 weeks emergence, the shortest root length (7.68 cm/plant) was recorded from the uninoculated treatment. But the maximum root length (8.71 cm/plant) was recorded with the application of inoculum BINA-SB-J43, which was statistically identical to all other treatments over uninoculated control.

At 50% flowering stage, the shortest root length (11.70 cm/plant) was produced in the control treatment. The maximum root length (14.86 cm/plant) was produced by the application of inoculum BINA-SB-J43 which was statistically identical to BINA-SB-102 and BINA-SB-3407 but significant different and superior to all other treatments.

Table 2.b. Effect of *Bradyrhizobium* inoculant on plant dry weight, root length, shoot length of soybean at 4 weeks emergence (4WE), 50% flowering stage (50%FS), number of pods per plant, number of seeds per plant, 100-seed weight, seed yield and hay yield of soybean at harvest

Treatments	Root length (cm/plant)		Shoot length (cm/plant)		Number of pods per plant	Number of seeds per plant	100-seed weight	Seed yield	Hay yield
	4 WE	50% FS	4 WE	50% FS					
Uninoculated	7.68 b	11.70 d	14.78 c	49.42 c	27.25 c	48.07 c	10.07 b	1440 c	3054 d
BINA-SB-1906	8.68 a	13.51 b	16.53 ab	52.74 abc	42.92 b	78.08 b	13.04 a	2556 b	3813 bc
BINA-SB-J43	8.71 a	14.86 a	16.59 ab	55.83 ab	41.05 b	72.60 b	13.03 a	2495 b	3557 c
BINA-SB-3407	8.55 a	13.32 ab	16.09 ab	54.85 ab	43.17 b	78.55 b	13.16 a	2551 b	3902 ab
BINA-SB-J11	8.18 ab	12.48 cd	17.36 a	55.25 ab	41.10 b	74.48 b	13.08 a	2513 b	3702 bc
BINA-SB-102	8.30 ab	14.10 ab	16.88 ab	56.26 a	47.97 a	86.87 a	13.66 a	2834 a	4105 a
BINA-SB-J2	8.10 ab	13.33 bc	15.92 bc	52.23 bc	43.45 b	78.30 b	13.15 a	2608 b	3797 bc
SE (m) ±	0.23	0.28	0.42	1.20	0.97	1.86	3.87	4.85	85.7

WE = Weeks emergence, FS = Flowering stage, NS = Not significant

In a column, figures having common letter (s) do not differ significantly at 5% and 1% level of probability.

Shoot length

Shoot length of soybean was significantly influenced by the *Bradirhizobium* inoculation (Table 2.b). At 4 weeks emergence, the inoculant BINA-SB-J11 produced the highest shoot length (17.36 cm/plant) which was statistically similar with BINA-SB-102, BINA-SB-J43, BINA- SB-3407 and BINA-SB-1906 but significantly different to all other inoculants.

At 50% flowering stage, the inoculum BINA-SB-102 produced the highest shoot length (56.26 cm/plant) which was statistically identical with B1NA-SB-J43, BINA-SB-J11, BINA-SB-3407 and BINA-SB-1906 but significantly different from and superior to all other inoculants.

Podder *et al.* (1999) conducted field experiment on soybean inoculated with *Bradyrhizobium* strains and found that inoculation increased shoot length over uninoculated control. Similar results were found by BINA (1998), Essa and Dulaimi (1985) and Bhuiyan *et al.* (1998) in soybean.

Number of pods per plant

The highest number (47.97 no./plant) of pods per plant was recorded in the treatment of BINA-SB-102 followed by BINA-SB-J2 (43.45/plant) which was statistically identical with BINA SB 3407, BINA-SB-1906, BINA-SB-J43 and BINA-SB-J11.

The above results are in line with some workers. Podder (1999) reported that the effect of inoculations soybean caused highest number of pods per plant over uninoculated control. Similar type of results was found by Joshi *et al.* (1983), and Sattar and Podder (1994) in groundnut.

Number of seeds per plant

The highest number of seeds per plant was recorded by the application of inoculum BINA-SB-102. This inoculum produced on an average 86.87 seeds/plant which was statistically significant than other inoculauts. The lowest number of seeds/plant was observed from the uninoculated control (48.07 seeds/plant).

Podder *et al.* (1999) carried out a field experiment with soybean and found that *Bradyrhizobium* inoculation had favorable effect on seed number per plant and yield. Similar type of results found by Li Haixian (1993) in soybean.

100 seed weight

There was highly significant effect of different *Bradyrhizobium* inoculalts on 100-seed weight of soybean varieties PB-1 and G-2 (Table 2.b). The highest 100-seed weight of 13.66 g was recorded in BINA-SB-102 and the value of 10.70 g was observed in uninoculated control.

Podder *et al.* (1999) found that the increase in 100-seed weight of soybean was higher by inoculating the seeds with *Bradyrhizobium* inoculants. Hoque *et al.* (1988) showed that inoculation was the most effective method of increasing 100-seed weight.

Seed yield

The highest seed yield was recorded (2834 kg/ha) due to the application of innoculum BINA-SB-102 which was significantly different to all other inoculants, which increased 96% over uninoculated control. The inoculum BINA-SB-J2 produced the second highest seed yield (2608 kg/ha) followed by the inoculum BINA-SB-1906 (2556 kg/ha), BINA-SB-3407 (2551 kg/ha), BINA-SB-J11 (2513 kg/ha) and BINA-SB-J43 (2495 kg/ha) which increased 81.11%, 77.5%, 77.15, 74.51 % and 73.26% over uninoculated control, respectively.

The above results are in line with some investigators. Saxena and Tilak (1975) carried out a field experiment and found that in soybean both seed and soil inoculation produced 73 to 94% higher seed yield over uninoculated control. Podder *et al.* (1999) observed in a field experiment of seed inoculation with 8 *Bradyrhizobium* strains produced significantly higher yield over the uninoculated control. Similar results were found by Hoque and Hashem (1992, 1993 and 1994) in soybean and groundnut Dubey *et al.* (1995) soybean.

Hay yield

The highest hay yield due to application of inoculum BINA-SB-102 (4105 kg/ha) which was statistically identical with BINA-SB-3407 (3902 kg/ha) but significantly different from and superior to all other inoculants and uninoculated control. The second highest hay yield was recorded with inocula BINA-SB-1906 (3813 kg/ha) followed by BINA-SB-J2 (3797 kg/ha) and BINA-SB-J11 (3702 kg/ha).

The above results are in line with some investigators. Rao and Sharma (1980) reported that *Rhizobium* at different inoculum levels with seeds of soybean and blackgram recorded that inoculated seeds gave the highest dry matter yield over uninoculated control. Similar results were observed by Hoque and Jahiruddin (1988) and Daramola *et al*. (1994) in soybean, Hoque and Hashem (1992, 1994) in soybean and groundnut, BINA (1998) in soybean.

Interaction Effect (Variety x Bradyrhizobium)

Number of nodules per plant

At 4 weeks of emergence, the highest number of nodules (15.90/plant) was obtained due to the treatment PB-1 x BINA-SB-102, which was statistically not significant to all other interaction treatments (Table 3.a).

At 50% flowering stage, the highest number of nodules (36.03/plant) was produced by PB-1 x BINA-SB-J43, which was statistically identical to PB-1 x BINA-SB-102 and PB-1 x BINA-SB-1906 but significantly different from and superior to all other interaction treatments. The treatments PB-1 x BINA-SB-J2, G-2 x BINA-SB-102, PB-1 x BINA-SB-J11 and G-2 x BINA-SB-J43 were statistically identical but significantly different from and superior to all other treatments except PB-1 x BINA-SB-J43, PB-1 x BINA-SB-102 and PB-1 x BINASB-1906 (Table 3.a).

Table 3.a. Interaction effect Variety x Bradyrhizobium inoculant on number of nodules per plant (no./plant), nodules dry weight (mg/plant), plant fresh weight (g/plant), plant dry weight (g/plant) of soybean at harvest

Treatment	Number of nodules per plant (no./plant)		Nodules dry weight (mg/plant)		Plant fresh weight (g/plant)		Plant dry weight (g/plant)	
	4 WE	50% FS	4 WE	50% FS	4 WE	50% FS	4 WE	50% FS
PB-1 x uninoculated	2.03	4.71 f	6.65 g	19.63	1.62 f	10.72 h	0.680 cd	3.64 e
PB-1 x BINA-SB-1906	15.73	35.20 a	60.76 cd	163.50	3.37 b	24.94 a	0.780 bc	6.73 a
PB-1 x BINA-SB-J43	12.87	36.03 a	57.46 de	196.46	4.26 a	20.33 bcd	0.963 a	6.06 ab
PB-1 x BINA-SB-3407	15.03	29.10 c	67.83 ab	157.10	4.15 a	19.15 de	0.903 a	5.41 bc
PB-1 x BINA-SB-J11	13.07	31.03 bc	60.73 cd	163.16	3.59 b	15.59 fg	0.800 b	4.93 cd
PB-1 x BINA-SB-102	15.90	35.87 a	70.43 a	195.93	4.21 a	25.92 a	0.910 a	6.89 a
PB-1 x BINA-SB-J2	11.33	32.57 b	51.10 f	178.23	2.28 d	15.67 fg	0.746 bcd	4.08 de
G-2 x uninoculated	2.02	4.60 f	7.13 g	18.86	1.83 ef	10.60 h	0.666 d	3.91 e
G-2 x BINA-SB-1906	12.37	25.30 de	58.30 cd	143.00	2.67 d	17.46 ef	0.716 bcd	4.42 de
G-2 x BINA-SB-J43	10.83	30.37 bc	51.90 ef	177.60	3.06 c	20.19 cd	0.703 bcd	6.19 ab
G-2 x BINA-SB-3407	14.63	22.87 e	62.43 bcd	138.13	3.02 c	15.17 g	0.680 cd	4.12 de
G-2 x BINA-SB-J11	12.60	23.20 e	57.46 de	141.43	2.55 d	22.21 b	0.736 bcd	6.51 a
G-2 x BINA-SB-102	14.47	31.77 bc	64.33 bc	182.16	2.99 c	21.41 bc	0.730 bcd	6.13 ab
G-2 x BINA-SB-J2	12.37	26.30 d	58.23 cd	144.73	2.04 e	16.23 fg	0.700 bcd	4.17 de
SE (m) ±	NS	0.89	1.91	NS	0.10	0.62	0.03	0.27
CV (%)	9.91	5.91	6.30	6.09	6.20	5.90	7.28	9.25

WE = Weeks emergence, FS = Flowering stage, NS = Not significant
In a column, figures having common letter (s) do not differ significantly at 5% and 1% level of probability.

Nodule dry weight

At 4 weeks emergence, the highest nodule dry weight (70.43 mg/plant) was recorded with the interaction treatment PB-1 x BINA-SB-102 inoculant, which was statistically identical to PB-1 x BINA-SB-3407 (67.83 mg/plant) but significantly different from and superior to all other interaction treatments. The second highest nodule dry weight (64.33 mg/plant) was recorded with the interaction G-2 x BINA-SB-l02 which was followed by G-2 x BINA-SB-3407 (Table 3.a).

At 50% flowering stage, the highest nodule dry weight (195.93 mg/plant) was due to the interaction treatment PB-1 x BINA-SB-102 which was not significantly different to all the other interaction treatments.

The above results are in line with the findings of other investigators. Krishnamohan and Rao (1998) reported that the 4 soybean cultivars were seed inoculated with *Bradirhizobium japonicum* strains, ASB-10, ASB-13 and ASB 15. Inoculation with rhizobial strains significantly increased nodule dry weight production and the strain ASR-10 was the best. Hoque and Hashem (1992 & 1994) observed that inoculation with *Bradirhizobium inoculam* increased nodule dry weight of soybean and groundnut.

Plant fresh weight

At 4 weeks emergence, the maximum plant fresh weight (4.26 g/plant) was produced by the interaction treatment PB-1 x BINA-SB-J43 and the minimum value was observed in both control treatment interaction, which was statistically identical with PB-1 x BINA-SB-102 and PB-1 x BINA-SB-3407 but statistically different to other interaction treatments.

At 50% flowering stage, the maximum plant fresh weight (25.92 g/plant) was produced by the interaction treatment PB-1 x BINA-SB-102 which was statistically identical with PB-1 x BINA-SB-1906 and the minimum value was observed in both control treatment interaction. The second highest plant fresh weight (22.21 g/plant) was produced by the interaction G-2 x BINA-SB-J11, which was statistically similar to G-2 x BINA-SB-102 and PB-1 x BINA-SB-J43 belt significantly different and superior to all other interaction treatments (Table 3.a).

Plant dry weight

At 4 weeks emergence, the maximum plant dry weight (0.963 g/plant) was produced by the interaction treatment PB-1 x BINA-SB-J43 and the minimum value (0.666 g/plant) was observed in control treatment. This plant dry weight was statistically similar to PB-1 x BINA-SB-102 and PB-1 x BINA-SB-3407, but significantly different and superior to all other interaction treatments.

At 50% flowering stage, the maximum plant dry weight (6.89 g/plant) was produced by the interaction PB-1 x BINA-SB-102 and the minimum dry weight (3.65 g/plant) was observed by the interaction PB-1 variety x uninoculated. This plant dry weight was statistically similar to PB- 1 x BINA-SB-1906, PB-1 x BINA-SB-J43, G-2 x BINA-SB-J11, G-2 x BINA-SB-43 and G-2 x BINA-SB-102 but significantly different to all other interaction treatments.

Root length

At 4 weeks emergence and at 50% flowering stage, the variety and inoculant was not significant effect on root length in any interaction of the varieties PB-1 and G-2 of soybean and *Bradyrhizobium* inoculants.

Table 3.b. Interaction effect Variety x Bradyrhizobium inoculant on plant dry weight, root length, shoots length of soybean at 4 weeks emergence (4WE), 50% flowering stage (50% FS), number of pods per plant, number of seeds per plant, 100-seed weight, seed yield and hay yield of soybean at harvest

Treatment	Root length (cm/plant)		Shoot length (cm/plant)		Number of pods per plant	Number of seeds per plant	100-seed weight (g)	Seed yield (kg/ha)	Hay yield (kg N /ha)
	4 WE	50% FS	4 WE	50% FS					
PB-1 x uninoculated	8.03	11.04	14.00 d	40.00	25.53 c	41.17 f	12.02	1412 f	2938 f
PB-1 x BINA-SB-1906	8.60	13.40	16.50 bc	44.26	38.23 b	59.73 de	14.78	2327 e	3647 cd
PB-1 x BINA-SB-J43	8.66	14.81	17.37 ab	51.05	40.47 b	62.07 de	14.90	2472 de	3623 cd
PB-1 x BINA-SB-3407	8.70	13.20	16.11 bc	47.83	38.93 b	61.37 de	14.82	2390 de	3162 ef
PB-1 x BINA-SB-J11	8.70	12.18	16.00 bc	47.70	41.17 b	65.93 cd	15.07	2597 bcd	3418 de
PB-1 x BINA-SB-102	8.66	14.09	16.27 bc	48.74	46.23 a	71.27 c	15.36	2791 ab	3614 cd
PB-1 x BINA-SB-J2	8.36	13.62	15.05 cd	43.53	40.43 b	61.93 de	14.96	2485 de	3522 de
G-2 x uninoculated	7.33	12.36	15.27 bcd	58.83	28.97 c	54.97 e	8.11	1468 f	3170 ef
G-2 x BINA-SB-1906	8.76	13.62	16.57 bc	61.21	47.60 a	96.43 a	11.49	2785 ab	3938 bc
G-2 x BINA-SB-J43	8.76	14.90	15.81 bcd	60.61	41.63 b	83.13 b	11.15	2517 cde	3490 de
G-2 x BINA-SB-3407	8.40	13.43	16.07 bc	67.87	47.40 a	95.73 a	11.51	2712 abc	4641 a
G-2 x BINA-SB-J11	7.66	12.77	18.73 a	62.80	41.03 b	83.03 b	11.08	2428 de	3987 bc
G-2 x BINA-SB-102	7.93	14.10	17.50 ab	63.76	49.70 a	102.50 a	11.96	2877 a	4596 a
G-2 x BINA-SB-J2	7.83	13.03	16.80 bc	60.93	46.47 a	94.67 a	11.33	2731 abc	4071 b
SE (m) ±	NS	NS	0.60	NS	1.37	2.63	NS	68.01	121.22
CV (%)	7.68	5.16	6.40	5.47	5.80	6.18	3.87	4.85	5.67

WE = Weeks emergence, FS = Flowering stage, NS = Not significant

In a column, figures having common letter (s) do not differ significantly at 5% and 1% level of probability.

Shoot length

At 4 weeks emergence, the shortest shoot length has been recorded with the interaction treatment PB-1 x uninoculated (14.00 cm/plant). The highest shoot length (18.73 cm/plant) has been recorded with the interaction treatment G-2 x BINA-SB-J11 which was statistically identical with the interaction treatment G-2 x BINA-SB-102 and PB-1 x BINA-SB-J43) but significantly different from and superior to all other interaction treatments (Table 3.b).

At 50% flowering stage, the inoculants was not significant effect on the shoot length in any interaction with PB-1 and G-2 varieties of soybean. Similar type of results was found by Bhuiyan *et al.* (1998) and Podder *et al.* (1999) in soybean.

Number of pods per plant

Data showed that the highest number of pods per plant (49.7 no./plant) was recorded with the interaction G-2 x BINA-SB-102, which was statistically similar with the interaction G-2 x BINA-SB-1906. G-2 x BINA-SB-3407, G-2 x BINA-SB-102 and PB-2 x BINA-SB-102 but significantly different from and superior to all other interaction treatments.

The above results are in line with Polder *et al.* (1999) who reported that the inoculated seeds of PB-1 soybean produced more pods per plant than uninoculated control.

Number of seeds per plant

Data in the Table 3.b showed that the highest number of seeds per plant was recorded by the interaction treatment G-2 x BINA-SB-102. This interaction treatment produce on an average 102.5 seeds/plant which was statistically similar with the interaction treatment G-2 x BINA-SB-1906, G-2 x BINA-SB-3407 and G-2 x BINA-SB-J2 but significantly different from and superior to all other interaction. The lowest number of seeds/plant was observed by the interaction PB-1 x uninoculatcd control (41.17 seeds/plant).

100 seed weight

The variety inoculants was not significant on the 100 seed weight was in any interaction.

Seed yield

Results in Table 3.b showed that the highest seed yield (2877kg/ha) was recorded with the interaction G-2 x BINA-SB-102, which was statistically similar with the interaction PB-I x BINA-SB-102, G-2 x BINA-SB-1906, G-2 x BINA-SB-3407 but significantly different to all other interaction.

Similar type of results was also found by Podder and Habibullah (1982) in chickpea.

Hay yield

The highest hay yield (4641 kg/ha) was recorded with the interaction G-2 x BINA-SB-3407 which was statistically identical with the interaction G-2 x BINA-SB-102 (4596 kg/ha) and significantly different from and superior to all other interaction. The third highest hay yield (4071 kg/ha) was recorded by the interaction G-2 x BINA-SB-J2 followed by the interaction G-2 x BINA-SB-J11 and G-2 x BINA-SB-1906.

The above results are in line with many researchers. Islam *et al.* (1999) carried out a field experiment on soyabean inoculation with *Bradyrhizohium* inoculum and observed that inoculated seeds gave higher straw yield over uninoculated control. Similar results were found by Bhuiyan *et al.* (1998) in soybean.

CONCLUSION

Bradyrhizobium inoculation was beneficial in nodulation, plant fresh weight, dry matter production, plant height, seed yield and hay yield of soybean varieties PB-1 and G-2. The G-2 variety of soybean and bradyrhizobial inoculant BINA-SB-102 gave better results than other variety and other inoculants, respectively. Use of Bradyrhizobium inoculants appear to be an effective method for successful soybean production, which may also improve the soil health saving of costly synthetic chemical fertilizer and keep the soil and environment free from pollution.

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