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Full Length Research Paper

Influence of *Rhizobium* inoculants on the yield contributing characters and yield of soybean

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Influence of ***Rhizobium*** **inoculants on the yield contributing characters and yield of soybean was investigated. The experiment was conducted to observe the response of *Rhizobium* inoculants on the yield contributing characters and yield of soybean during the period from December 2012 to May 2013. The experiment consists of two factors: (i) three soybean varieties namely: V_1 = Soybean Sohag (PB-1), V_2 = Bari Soybean-5 and V_3 = Bari Soybean-6; and (ii) four *Rhizobium* inoculants namely: I_0 = control (no inoculant), I_1 = BINA 169, I_2 = BINA 301 and I_3 = BINA 441. The growth character shoot weights varied significantly due to both of varieties and *Rhizobium* inoculants; while plant height (cm) varied significantly due to only inoculants. The root weights (g) and number of branches plant^{-1} were non-significant due to both of varieties and *Rhizobium* inoculants. Three varieties were found to be statistically different in terms of number of pods plant^{-1}, number of seed plant^{-1}, seed weight plant^{-1} (g), 1000-seed weight (g), seed yield (Kg ha^{-1}), stover yield (Kg ha^{-1}) and harvest index (%); but in terms of biological yield (Kg/ha^{-1}), it was statistically non-significant. There was significant effect of inoculants on the entire yield contributing characters. There was also an interaction effect between varieties and inoculants in contrast to shoot weight plant^{-1} (g), number of pods plant^{-1}, seed yield (Kg/ha^{-1}) and stover yield (Kg/ha^{-1}); but the interaction effect in case of plant height (cm), root weight (g), number of branches, number of seed plant^{-1}, 1000-seed weight (g), seed weight plant^{-1} (g), biological yield (Kg/ha^{-1}) and harvest index (%) was statistically non-significant. Among three varieties, the highest seed yield of 2236.01 kg ha^{-1} was recorded with BARI soybean-6 variety which is followed by BARI soybean-5 (2152.77 kg ha^{-1}) and Sohag P B-1 (2091.36 kg ha^{-1}). On the other hand, the highest seed yield of 2418.00 kg ha^{-1} was recorded with the BINA 301 inoculant which is followed by BINA 441 (2317.94 kg ha^{-1}), BINA 169 (2196.37 kg ha^{-1}) and uninoculation (1708.60 kg ha^{-1}). The highest seed yield of 2507.08 kg ha^{-1} was obtained due to the interaction of BARI soybean-6 × BINA 301 inoculants. Out of 12 combinations, BARI soybean-6 × BINA 301 inoculant appeared to be the best combination for successful soybean production especially in the soil of AEZ-11.**

Key words: Influence, *Rhizobium* inoculants, yield contributing characters, yield, soybean.

INTRODUCTION

Soybean [*Glycine max* (L.) Merril] is an important widely used oil seed and protein crop in Bangladesh as well as the whole world. It is a good source of unsaturated fatty acids, minerals like Ca and P including vitamin A, B, C and D can meet up different nutritional needs (Rahman, 1982). It is referred to as “the protein hope of the future” as well as “the miracle golden bean” because of its high nutritive value containing about 42-45% protein and 20-25% edible oil. A variety of soya products as food like soya dal, soya chatni, soya-khichuri, soya-milk, soya-curd, soya-flour and roasted soybean snacks are becoming familiar to the people of Bangladesh (Smith, 1975). In Bangladesh, the consumption of edible oil is almost completely dependent on the oil-seed crop soybean. Till date, import is the only source to meet the demand of edible oil especially soybean. For this reason, soybean [*Glycine max* (L.) Merril] could be one of the widely grown oil-seed crops in Bangladesh. Some soybean varieties can be profitably used as green manure and fodder.

Biological nitrogen fixation (BNF) resulting from a symbiosis between legume crops and root nodule bacterium *Rhizobium* can ameliorate the use of costly and environmentally risky chemical fertilizers. Symbiotic

nitrogen fixation by *Rhizobium* met the N requirement of the crop and left 40-108 kg N ha^{-1} in the soil (Subba and Rao, 1977). Rhizobial inoculation to seeds is well studied and exploitation of this beneficial nitrogen fixing root nodule symbiosis represents a hallmark of successfully applied agricultural microbiology (Bruno et al., 2003). Soybeans, being leguminous crop, are capable of fixing atmospheric nitrogen in the soil and enrich soil fertility. Thus they are considered to be soil building crops. The successful growing of soybean is dependent on the availability of its micro-symbiont bacteria in soil. All effective *Rhizobium* strains are not present in all soils of Bangladesh. In this situation, inoculation can meet the challenge of providing superior strains in the soil, so that the most effective nodulation and nitrogen fixation are obtained. In Bangladesh, research and extension works on soybean have been started in 1972-1973 by Mennonite Central Committee (MCC) and subsequently by Bangladesh Agricultural Research Council (BARC). But very limited works have been carried out regarding the use of *Rhizobium* strains on soybean till date and the yield of soybean here is very discouraging compared to other soybean producing countries. This is mainly due to the use of low yield potential varieties and poor cultivation techniques, especially due to lack of knowledge about modern production technologies, that is, lack of judicious application of irrigation water, seed rate, fertilizer, bio-fertilizers, etc. Thus, it is thought that there is a scope for utilizing the effective *Rhizobium* strains for obtaining more yield of soybean under field condition, which may also play a vital role in improving soil environment, agricultural sustainability as well as the economy of our country. Therefore, this experiment was designed:

(i) To evaluate the influences of *Rhizobium* inoculants on the growth and yield of soybean.
(ii) To carry out the better combination of *Rhizobium* inoculant and soybean variety for successful soybean production in the soil of Bangladesh to meet the edible oil demand for our ever growing people.

MATERIALS AND METHODS

The experiment was conducted at the Field Laboratory of the Department of Agronomy and Agricultural Extension, Rajshahi University, Rajshahi during the period from December 2012 to May 2013 to observe the influence of *Rhizobium* inoculants on the yield contributing characters and yield of soybean. Three soybean varieties were used in this study namely: V_1 = Soybean Sohag (PB-1), V_2 = Bari Soybean-5 and V_3 = Bari Soybean-6. The inoculants were I_0 = Control (no inoculants), I_1 = BINA169, I_2 = BINA301 and I_3 = BINA441. The land of the experimental site was ploughed and cross-ploughed three times followed by laddering. Then all the stubbles and uprooted weeds were removed and the land was made ready. Urea, triple super phosphate (TSP), murate of potash (MP) and well decomposed cow dung (CD) were applied as basal dose during land preparation to the plots at 50, 175, 120 kg ha^{-1} and 6.5 t ha^{-1}, respectively. The experiment was laid out in split plot design with three replications by assigning varieties to the main plot and inoculants to the sub-plot. Each replication had three main plots and each main plot is divided into 4 sub-plots (unit plot). The size of the sub plot was 1 × 1 m^2 and the distances between replications, main plots and sub-plots were 1 m., 0.5 m. and 0.25 m., respectively. Total numbers of main plots and sub-plots were 9 and 36, respectively in this experiment. For coating the seeds of soybean varieties by inoculants, it was taken in small polythene bag equal in each for 36. Out of 36 polythene packets, 27 packets were made ready and mixed with 40% gum acacia per 1 kg seed. Then the selected inoculums were mixed with the seeds (at 50 g inoculums/kg seed) for each treatment and mixed well with the seeds by shaking the bag thoroughly. For each inoculant, separate polythene bag was used and care was taken to avoid contamination of the inoculants. After completing the coating by inoculants, the seeds were instantly sown in rows made by hand plough. The distances between rows and seeds were 25 and 10 cm, respectively and two seeds were placed in each point at 2-3 cm depth from the soil surface. The gaps where seeds failed to germinate were filled up within two weeks after germination of seeds. Irrigation was done as per necessity by watering cans to the young plants and by flow irrigation afterwards to maintain soil moisture at field capacity.

At the time of sampling, five plants were selected randomly from each sub-plot. Data for certain morphological characteristics, that is, plant height (cm), number of branches $plant^{-1}$, shoot weight (g) and root weight (g) were recorded at 65 days after sowing. On the other hand, data for yield contributing characters namely: number of pods $plant^{-1}$, number of seed $plant^{-1}$, seed yield $plant^{-1}$ (g), 1000-seed weight (g), seed yield (Kg ha^{-1}), stover yield (Kg ha^{-1}), biological yield (Kg ha^{-1}) and harvest index (%) were recorded at the time of plant maturity.

The recorded data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following the split-plot design with the help of computer package MSTAT program developed by Russell (1986). The mean differences among the treatments were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of *Rhizobium* inoculants on certain morphological characters of soybean

Plant height

There was no significant variation among the three varieties

Table 1. Effect of variety and *Rhizobium* inoculant on the plant height, number of branches, dry weight of shoot and dry weight of root of soybean at 65 days after sowing (DAS).

Factor	Plant height (cm)	Number of branches plant^{-1}	Shoot weight (g/plant^{-1})	Root weight (g/plant^{-1})
Variety				
Sohag P B-1	54.39	5.76	11.53^{b}	1.17
Bari Soybean-5	52.69	6.09	12.06^{a}	1.05
Bari Soybean-6	53.55	6.40	11.17^{c}	1.02
S. E. (m) ±	-	-	0.0830	-
LSD	-	-	0.3315	-
Level of significance	NS	NS	**	NS
CV (%)	6.21	3.18	2.49	16.63
Inoculants				
Control	47.54^{b}	4.62	9.55^{c}	0.97
BINA 169	54.26^{a}	6.19	11.98^{b}	1.15
BINA 301	56.73^{a}	6.82	12.59^{a}	1.10
BINA 441	55.63^{a}	6.71	12.23^{ab}	1.09
S. E. (m) ±	11.05	-	0.0830	-
LSD	4.418	-	0.3828	-
Level of significance	**	NS	**	NS
CV (%)	6.21	3.18	2.49	16.63

In columns, figures having same letter(s) do not differ significantly by DMRT at 5% level of probability. ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significant.

of soybean on plant height observed at 65 days after sowing. The tallest plant (54.39 cm) was found in Sohag PB-1 followed by Bari soybean-6 (53.55 cm) and the smallest plant (52.69 cm) was found in Bari soybean-5. There was a significant variation among the treatment of *Rhizobium* inoculations. BINA 301 inoculant produced the tallest plant (56.73 cm) and control treatment of inoculation produced the smallest plant (47.54 cm) (Table 1). The interaction effect was not statistically significant in receding plant height at 65 days after sowing. The plant height ranged from 44.33 cm recorded in BARI soyabean-5 without any *Rhizobium* inoculant to 57.17 cm in Sohag PB-1 variety due to inoculation with BINA 301 (Table 2).

Weight of shoot

Variation in shoot weight of the three varieties of soybean was statistically significant. The highest shoot weight (12.06 g plant^{-1}) was recorded for the BARI soybean-5 which was followed by Sohag PB-1 (11.53 g plant^{-1}) and BARI soybean-6 (11.17 g plant^{-1}). The effect of inoculant was statistically significant. The BINA 301 inoculant recorded the highest amount of shoot weight plant^{-1} (12.59 g), which was statistically superior to other inoculants. The lowest amount of shoot weight plant^{-1} (9.55 g) was found in the control treatment of inoculant (Table 1). The interaction of variety and *Rhizobium* inoculants on dry weight of shoot was significant at 65 days after sowing. Among the treatment combinations, the lowest shoot weight (9.47 g plant^{-1}) was recorded in the interaction of Sohag PB-1 and control treatment of *Rhizobium* inoculant and the highest shoot weight (13.17 g plant^{-1}) was recorded in BARI Soybean- 5 with BINA 301 *Rhizobium* inoculant (Table 2).

Weight of root

There was no significant variation in root weight among the three varieties of soybean. The highest root weight (1.17 g plant^{-1}) was recorded in Sohag PB-1, which was statistically superior to that of BARI soybean-5 (1.05 g plant^{-1}) and BARI soybean-6 (1.02 g plant^{-1}) (Table 1). At 65 days of sowing, the highest root weight (1.15 g plant^{-1}) was produced by BINA 169 *Rhizobium* inoculant, which was statistically superior to other uninoculated control and *Rhizobium* inoculant. The lowest root weight (0.97 g plant^{-1}) was produced by uninoculated control treatment. The interaction effect of soybean varieties and *Rhizobium* inoculants did not show any significant influence on root weight. The root weight ranged from 0.95 g plant^{-1} recorded in Sohag PB-1 without any *Rhizobium* inoculants (control) to 1.31 g plant^{-1} also in Sohag PB-1 variety due to inoculation with BINA 441 (Table 2).

Number of branches per plant

No significant variation was observed among the three

Table 2. Interaction effect of variety and *Rhizobium* inoculant on plant height, number of branches, dry weight of shoot and dry weight of root of soybean at 65 days after sowing (DAS).

Interaction	Plant height (cm)	Number of branches plant^{-1}	Shoot weight (g/plant^{-1})	Root weight (g/plant^{-1})
Sohag P B-1 × control	49.38	4.35	9.47^{g}	0.95
Sohag P B-1× BINA 169	54.50	5.65	11.96^{de}	1.25
Sohag P B-1× BINA 301	57.17	6.58	12.47^{bc}	1.18
Sohag P B-1× BINA 441	56.50	6.46	12.23^{cd}	1.31
Bari Soybean-5 × control	44.33	4.62	9.64^{g}	0.97
Bari Soybean-5 × BINA 169	55.00	6.24	12.57^{bc}	1.22
Bari Soybean-5 × BINA 301	56.20	6.74	13.17^{a}	1.01
Bari Soybean-5 × BINA 441	55.23	6.77	12.86^{ab}	0.98
Bari Soybean-6 × control	48.93	4.88	9.53^{g}	0.98
Bari Soybean-6 × BINA 169	53.28	6.69	11.41^{f}	0.99
Bari Soybean-6 × BINA 301	56.83	7.15	12.13^{cd}	1.12
Bari Soybean-6 × BINA 441	55.17	6.89	11.61^{ef}	1.00
S. E. (m) ±	-	-	0.0830	-
LSD	-	-	0.4878	-
Level of significance	NS	NS	*	NS
CV (%)	6.21	3.18	2.49	16.63

In columns, figures having same letter(s) do not differ significantly by DMRT at 5% level of probability. ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significant.

varieties of soybean in the case of number of branches plant^{-1}. The highest number of branches plant^{-1} (6.40) was recorded in BARI soybean-6 followed by BARI soybean-5 (6.09) and Sohag PB-1 (5.76) (Table 1). The effect of inoculants on the production of number of branches plant^{-1} was statistically non-significant. The data revealed that BINA 301 produced the maximum number of branches (6.82) among their respective treatments as was ascertained at 65 DAS. The results showed a clear superiority of the inoculants over the control in producing branches plant^{-1}. The lowest number of branches plant^{-1} (4.62) was produced by uninoculated control treatment (Table 1). The interaction effect between soybean varieties and *Rhizobium* inoculant on the number of branches plant^{-1} was non-significant. Among the treatment combinations, the lowest number of branches plant^{-1} (4.35) was recorded in the interaction of Sohag PB-1 and control treatment of *Rhizobium* inoculant and the highest number of branches plant^{-1} (7.15) was recorded in BARI Soybean-6 with BINA 301 *Rhizobium* inoculant (Table 2).

Effect of *Rhizobium* inoculants on yield and yield contributing characters of soybean

The data showed that there was a significant varietals effect on number of pod plant^{-1}. The highest number of pod plant^{-1} (48.78) was recorded in BARI soybean-6 followed by BARI soybean-5 (29.03) and Sohag PB-1 (28.50). In the case of inoculant effect, the number of pod plant^{-1} influenced significantly. The highest number of pod plant^{-1} (38.49) was recorded due to BINA 301, while the lowest number of pod plant^{-1} (30.05) was recorded in the case of uninoculated control treatment (Table 3). The interaction effect between soybean varieties and *Rhizobium* inoculants on the number of pod plant^{-1} was also statistically significant. Among the treatment combinations, the lowest number of pod plant^{-1} (24.30) was recorded in the interaction of Sohag PB-1 and control treatment of *Rhizobium* inoculant and the highest number of pod plant^{-1} (52.57) was recorded in BARI Soybean-6 with the inoculant of BINA 301 (Table 4). A significant variation was observed among three varieties of soybean in terms of number of seeds plant^{-}; the highest number of seeds plant^{-1} (100.36) was recorded in BARI soybean-6 and the lowest number of seeds plant^{-1} (66.07) was recorded in Sohag PB-1. The effect of inoculants on the production of number of seeds plant^{-1} was statistically significant. The highest number of seeds plant^{-1} (85.23) was produced by the inoculant BINA 301 followed by 82.22, 78.87, and 65.90 due to BINA 441, BINA 169 and uninoculated control treatment, respectively (Table 3). The interaction effect between soybean varieties and *Rhizobium* inoculants on the number of seeds plant^{-1} was non-significant. Among the treatment combinations, the lowest number of seeds plant^{-1} (56.13) was recorded in the interaction of Sohag PB-1 and control treatment of *Rhizobium* inoculant and the highest number of seeds plant^{-1} (108.82) was recorded in the interaction of BARI Soybean-6 and BINA 301 *Rhizobium* inoculant (Table 4).

Significant varietals effect was observed both on 1000 seed weight and seed weight plant^{-1}. The highest value of 1000 seed weight (110.10 g) was recorded in BARI

Table 3. Effect of variety and *Rhizobium* inoculant on number of pods plant^{-1}, number of seeds plant^{-1}, 1000-seed weight, seed weight plant^{-1}, seed yield, stover yield, biological yield and harvest index of soybean.

Factors / Variety	Number of pods plant^{-1}	Number of seeds plant^{-1}	1000-seed weight (g)	Seed weight (g plant^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Sohag P B-1	28.50^{b}	66.07^{b}	109.65^{ab}	7.26^{b}	2091.90^{b}	3298.36^{a}	5390.26	38.72^{b}
Bari Soybean-5	29.03^{b}	67.73^{b}	110.10^{a}	7.48^{b}	2152.77^{ab}	3384.44^{a}	55.37.21	38.80^{b}
Bari Soybean-6	48.78^{a}	100.36^{a}	108.86^{b}	10.94^{a}	2238.01^{a}	3190.10^{b}	5426.11	41.08^{a}
S.E. (m)±	1.257	9.084	1.157	0.1330	9.246	6.726	---	0.6750
LSD	1.290	3.468	0.9107	0.4197	11.070	9.438	---	0.9454
Level of significance	**	**	**	**	**	**	NS	**
CV (%)	3.16	3.86	0.98	4.26	4.45	2.49	3.00	2.07
Inoculant								
Control	30.05^{c}	65.90^{c}	105.51^{b}	6.96^{c}	1708.60^{c}	2780.21^{c}	4488.81^{c}	38.04^{c}
BINA 169	35.90^{b}	78.87^{b}	110.42^{a}	8.70^{b}	2196.37^{b}	3374.33^{b}	5570.70^{b}	39.43^{b}
BINA 301	38.49^{a}	85.23^{a}	111.55^{a}	9.49^{a}	2418.00^{a}	3544.25^{a}	5962.25^{a}	40.55^{a}
BINA 441	37.30^{ab}	82.22^{ab}	110.67^{a}	9.09^{ab}	2317.94^{ab}	3465.07^{ab}	5783.01^{ab}	40.10^{ab}
S.E. (m)±	1.257	9.084	1.157	0.1330	9.246	6.726	16.690	0.6750
LSD	1.490	4.005	1.429	0.4846	12.780	10.900	21.710	1.092
Level of significance	**	**	**	**	**	**	**	**
CV (%)	3.16	3.86	0.98	4.26	4.45	2.49	3.00	2.07

In columns, figures having same letter(s) do not differ significantly by DMRT at 5% level of probability. ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significant.

Table 4. Interaction effect of variety and *Rhizobium* inoculant on pods plant^{-1}, number of seeds plant^{-1}, 1000-seeds weight, seed weight plant^{-1}, seed yield, stover yield, biological yield and harvest index of soybean.

Interaction	Number of pods plant^{-1}	Number of seeds plant^{-1}	1000-seed weight (g)	Seed weight (g plant^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Sohag P B-1 × control	24.30^{e}	56.13	105.30	5.91	1656.21^{f}	2745.33^{f}	4401.55	37.60
Sohag P B-1× BINA 169	28.00^{d}	64.68	110.53	7.15	2116.86^{d}	3408.60^{cd}	5525.46	38.30
Sohag P B-1× BINA 301	31.50^{c}	73.09	111.82	8.17	2353.85^{ab}	3553.95^{ab}	5907.80	39.83
Sohag P B-1× BINA 441	30.20^{cd}	70.37	110.95	7.80	2240.68^{c}	3485.55^{abc}	5726.23	39.13
Bari Soybean-5 × control	24.52^{e}	56.87	105.15	5.98	1704.34^{ef}	2795.60^{f}	4499.94	37.87
Bari Soybean-5 × BINA 169	29.50^{cd}	69.05	111.30	7.69	2198.07^{cd}	3519.60^{abc}	5717.67	38.41
Bari Soybean-5 × BINA 301	31.40^{c}	73.80	112.60	8.31	2393.07^{ab}	3621.75^{a}	6014.82	39.78
Bari Soybean-5 × BINA 441	30.70^{c}	71.22	111.35	7.93	2315.59^{b}	3600.80^{a}	5916.39	39.14
Bari Soybean-6 × control	41.33^{b}	84.69	106.07	8.98	1765.24^{e}	2799.70^{f}	4564.94	38.67
Bari Soybean-6 × BINA 169	50.20^{a}	102.87	109.43	11.26	2274.17^{bc}	3194.80^{e}	5468.97	41.57
Bari Soybean-6 × BINA 301	52.57^{a}	108.82	110.23	11.99	2507.08^{a}	3457.05^{bc}	5964.13	42.04
Bari Soybean-6 × BINA 441	51.00^{a}	105.07	109.70	11.53	2397.56^{ab}	3308.85^{de}	5706.41	42.03
S.E. (m)±	1.257	---	---	---	9.246-	6.726	---	---
LSD	2.580	---	---	---	13.162	13.890	---	---
Level of significance	**	NS	NS	NS	*	*	NS	NS
CV (%)	3.16	3.86	0.98	4.26	4.45	2.49	3.00	2.07

In columns, figures having same letter(s) do not differ significantly by DMRT at 5% level of probability. ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significant.

soybean-5; while the highest seed weight plant^{-1} (10.94 g) was recorded in BARI soybean-6. The lowest value of 1000 seed weight (109.65 g) and seed weight plant^{-1} (7.26 g) both were recorded in Sohag PB-1. In the case

of inoculant effect, 1000 seed weight and seed weight plant^{-1} influenced significantly. The highest value both of 1000 seed weight (111.55 g) and seed weight plant^{-1} (9.49 g) were recorded due to BINA 301; while the lowest value of 105.51 g and 6.96 g of the same were recorded due to uninoculated control treatment (Table 3). But there was no significant interaction effect between variety and inoculant over both the 1000-seed weight plant^{-1} and seed weight plant^{-1}. The highest 1000-seed weight plant^{-1} (112.60 g) and seed weight plant^{-1} (11.99 g) was obtained due to the interaction of BARI soybean-5 × BINA 301 and BARI soybean-6 × BINA 301, respectively; while the lowest 1000-seed weight plant^{-1} (105.15 g) and seed weight plant^{-1} (5.91 g) was obtained due to the interaction of BARI soybean-5 × control and Sohag PB-1 × control treatment, respectively (Table 4).

The seed and stover yield of the crop had significant varietals effect. The highest seed yield (2236.01 kg ha^{-1}) and stover yield (3384.44 kg ha^{-1}) was recorded with BARI soybean-6 and BARI soybean-5 variety, respectively (Table 3). In terms of inoculant effect, seed yield and stover yield influenced significantly. The highest seed yield (2418.00 kg ha^{-1}) and stover yield (3544.25 kg ha^{-1}) was recorded with the BINA 301 inoculant; while the lowest seed yield (1708.60 kg ha^{-1}) and stover yield (2780.21 kg ha^{-1}) was recorded with the uninoculated control treatment. In the case of interaction effect between variety and inoculant on seed yield and stover yield, it was also statistically significant. The highest grain yield (2507.08 kg ha^{-1}) and stover yield (36.21.75 kg ha^{-1}) was obtained due to the interaction of BARI soybean-6 × BINA 301 and BARI soybean-5 × BINA 301 inoculant, respectively. On the other hand, the lowest grain yield (1656.21 kg ha^{-1}) and stover yield (2745.33 kg ha^{-1}) was obtained due to the interaction of Sohag PB-1 × control (Table 4).

The varietals effect of three varieties of soybean on biological yield was significant. The highest biological yield was obtained from BARI soybean-5 (5537.21 kg ha^{-1}) which was followed by BARI soybean-6 (5426.11 kg ha^{-1}) and Sohag PB-1 (5390.26 kg ha^{-1}). The *Rhizobium* inoculants effect was also significant on biological yield. The maximum biological yield was produced by BINA301 inoculant (5962.25 kg ha^{-1}), which was followed by BINA 441 (5783.01 kg ha^{-1}), BINA 169 (5570.70 kg ha^{-1}) and uninoculation (4488.81 kg ha^{-1}) (Table 3). The interaction effect between *Rhizobium* inoculants and soybean varieties showed non-significant effect. The highest amount of biological yield (6014.82 kg ha^{-1}) was produced by the interaction of BARI soybean-5 with mixed BINA 301 inoculants and the lowest biological yield (4401.55 kg ha^{-1}) is produced by the interaction of Sohag PB-1 variety with the control treatment of *Rhizobium* inoculation (Table 4). The three varieties of soybean showed significant effect on harvest index. However, the numerically highest harvest index was produced by BARI Soybean-6 (41.08 %), which is followed by BARI Soybean-5 (38.80%) and Sohag PB-1 variety (38.72 %). The *Rhizobium* inoculants also showed significant effect on harvest index. The highest and lowest harvest index was produced by BINA 301 (40.55%) and control treatment of *Rhizobium* (38.04%), respectively (Table 3). In terms of interaction effect between *Rhizobium* inoculants and soybean varieties, there was no significant effect on harvest index. The highest harvest index (42.04 %) was produced by BARI soybean-6 with the interaction of BINA 301 inoculant and the lowest harvest index (37.60%) was recorded due to the interaction of Sohag PB-1 × control (Table 4).

Conclusion

The overall results of the field experiment mentioned above revealed that the *Rhizobium* inoculation was beneficial on yield and yield contributing characters of soybean. All the *Rhizobium* treatments showed better performance in recording number of pod plant^{-1}, number of seed plant^{-1}, seed weight plant^{-1}, seed yield and stover yield over uninoculated control treatment. Similar results were made by Podder et al. (1999). From the view point of yield production among the three soybean varieties, tested BARI soybean-6 appeared to be the best. Among the inoculants (BINA 169, BINA 301 and BINA 441), BINA 301 inoculant was comparatively more effective for all of the three soybean varieties especially for BARI soybean-6 variety. Out of 12 combinations, BARI soybean-6 × BINA 301 inoculant appeared to be the best combination for successful soybean production especially in the soil of AEZ-11.

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