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ESTIMATING THE EFFECT OF COMBINE USE OF *RHIZOBIUM* INOCULATION AND PHOSPHORUS FERTILIZER ON GROWTH, NODULATION AND YIELD OF Binasoybean-1

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ABSTRACT

Akter S, Hoshain S, Das RC, Chakma P, Rabbani MG, Islam MR (2021) Estimating the effect of combine use of *Rhizobium* inoculation and phosphorus fertilizer on growth, nodulation and yield of Binasoybean-1. *Int. J. Sustain. Crop Prod.* 16(2), 4-10.

Application of the optimum dose of the combination of *Rhizobium* inoculation (RI) and phosphorus (P) fertilizer could be an important factor to get maximum yield in soybean. The experiment was conducted at Noakhali Science and Technology University Field Laboratory to examine the effect of different combine doses of RI and P on nodulation, growth, and yield of Binasoybean-1. Four levels of RI (0, 25, 50, 75 g kg^{-1} seed i.e. I_0, I_1, I_2, I_3) and P (0, 18, 36, and 54 kg P ha^{-1} i.e. P_0, P_1, P_2, P_3) were applied. Plant height and no. of nodule $plant^{-1}$ showed significant interaction effect between different levels of RI and P at all sampling dates. Dry weight $plant^{-1}$ showed significant at 60 and 75 days after sowing (DAS) whereas insignificant result showed at 45 DAS. The highest plant height, no. of nodule $plant^{-1}$ and dry weight $plant^{-1}$ were observed in 75 DAS with the combinations of RI and P rates at I_1P_0 (25 g kg^{-1} seed and 0 kg P ha^{-1}), I_1P_1 (25 g kg^{-1} seed and 18 kg P ha^{-1}) and I_3P_1 (75 g kg^{-1} seed and 25 kg P ha^{-1}) respectively. The interaction effect between the different levels of RI and P with the no. of pods $plant^{-1}$, no. of effective pods $plant^{-1}$, no. of seed pod^{-1} and 1000 seed weight were statistically significant, whereas insignificant relation with the no. of non-effective pods $plant^{-1}$ and pod length. Besides, total node number and plant dry weight without seed at harvest stage showed a highly significant positive correlation with seed yield, indicating higher vegetative growth increase seed yield of soybean. Among sixteen treatment combinations, the highest seed yield (2.297 t ha^{-1}) was obtained from the treatment combination of I_2P_3 (50 g kg^{-1} seed and 54 kg P ha^{-1}) and it may be suggested as a proper dose of RI and P for Binasoybean-1.

Key words: *Rhizobium inoculation, phosphorus, nodulation, growth, Binasoybean-1.*

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a highly nutritional crop; 100 grams of mature soybean seeds contain 36.49 g of protein, 19.94 g fat, 30.16 g carbohydrates, 7.33 g sugar, 9.3 g dietary fiber, 446 kcal energy (USDA 2016). However, total soybean production areas (0.04 million ha) and seed yield (1.64 ton ha^{-1}) are low in Bangladesh, alternately demand is very high (BBS 2013; FAO 2016). The United States, Brazil and Argentina are the world's largest soybean producers and represent more than 80% of global soybean production (FAO 2016). Therefore, it is necessary to increase production area and seed yield in Bangladesh to fulfill its demand.

RI plays an important role to increase yield in soybean. Gidden *et al.* (1982) reported that inoculation of *rhizobium* strains with seed is an essential production practice to increase yield in soybean. Wiersma and Orf (1992) also stated a similar result that inoculation of *rhizobium* enhances soybean quality and production. Nodule number, nodule dry weight and soybean shoot yield were increased when seeds were inoculated by *Bradyrhizobium* (Okereke *et al.* 2004; Egamberdiyeva *et al.* 2004a; 2004b). Ashraf *et al.* (2002) reported a specific combination of soybean genotype with *rhizobium* strains resulting in many folds increase in the amount of N_2 fixed and grain yield of soybean. Ghasem *et al.* (2015) reported RI inoculated treatment increased 23% seed in pod compared with non-inoculated treatment. Few reports also stated that RI increased the number of nodule and yield in soybean (RW and Frederick, 1974; Majid *et al.* 2009).

P is the yield limiting factor in soybean. Tsvetkova and Georgiev (2003) reported that P deficiency in soybean decreased the whole plant's fresh and dry mass, nodule weight, and nodule number. Several scientists reported that soybean growth, 100-grain weight and seed yield is significantly increased by the adding of 90 and 100 kg P_2O_5 ha^{-1} (Hussain *et al.* 1981; Taj *et al.* 1986).

Matusso *et al.* (2015) reported that the combination of RI and P significantly increased seed yield in soybean. Abbasi *et al.* (2008) used the combination of RI and P and reported that there was a positive effect of RI and P on growth, nodulation and yield of soybean. From this background, there is a major impact of RI and P on the growth and development and yield of soybean. Thus, a systematic investigation is needed for better a understanding of the effect of RI and P on the growth and yield of the soybean plant. Therefore, the objectives of this study were to examine the combined effect of RI and P on nodulation, growth and yield of soybean.

MATERIALS AND METHODS

The study site

The experiment was carried out at Noakhali Science and Technology University field laboratory during the period from 15th January to 1st week of May 2018. The area lies between 10 m above sea level and latitude 22.79^0 with loamy soil, medium high land. The area was characterized by sub-tropical climate. And, average temperature and rainfall were 27.5ºC and 33.125 mm respectively during the experimental time (WMN 2018).

Experimental set up

The Binasoybean-1 seed was sown on 15 January 2018. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 48 plots having the size of each plot was 2.5 m × 4 m. Four levels of RI (0, 25, 50, 75 g kg^{-1} seed i.e. I_0, I_1, I_2, I_3) and P (0, 18, 36, and 54 kg P ha^{-1} i.e., P_0, P_1, P_2, P_3) were applied as a treatment. Chemical fertilizer was applied as basal at a rate of urea: M_OP: Gypsum: Boric acid = 55:110:100: 10 kg ha^{-1}. Weeding was done 20-25 days after emergence and pesticide and water were applied as when as necessary.

Measurement and data collection

Plant height (cm), number of nodules $plant^{-1}$ (the whole plant uprooted softly, then visible nodules were counted), dry weight (gm) were measured at 45, 60 and 75 days after sowing for 5 plants which was randomly selected from each plot. Besides, number of pods $plant^{-1}$, number of effective pods $plant^{-1}$, number of non-effective pods plant, pod length (cm), number of seeds pod^{-1}, weight of 1000 seeds (gm), total node number at harvest stage, plant dry weight without seed at harvest stage (gm), yield (t ha^{-1}) for 5 plants which was randomly selected from each plot.

Statistical Analysis

Analysis of variance was done with the help of the MSTAT-C computer package programme, developed by Russel (1986). The mean differences among the treatments were adjudged by the DMRT test (Gomez and Gomez, 1984). Additionally, the Pearson correlation coefficients with significant level were measured by using data analysis tool of Microsoft Excel (Version 2016).

RESULT AND DISCUSSION

Effect of the combine use of RI and P on growth performance of Binasoybean-1

The analysis of variance of RI and P on plant height, number of nodules $plant^{-1}$, and dry weight depicted in Table 1. The interactive effect of RI and P on plant height was statistically significant at 45 DAS, 60 DAS, and 75 DAS at 1% level of probability (Table 1). The highest plant height observed with the treatment combination of I_1P_0 at 45, 60 and 75 DAS (Table 1) showing plant height may accelerate by 25g kg^{-1} RI without P. The opposite result reported by Robson and O'Hara (1981) that P nutrition increased symbiotic N_2 fixation and increased plant height. To clarify this fact, it is needed to examine the individual effect of RI and P on soybean plants.

Similar result like plant height showed increase of number of nodules $plant^{-1}$. The interactive effect of RI and P was statistically significant at 45 DAS, 60 DAS, and 75 DAS at 1% level of probability (Table 1). At 75 DAS higher number of nodules $plant^{-1}$ was recorded by the treatment combination of I_1P_1 and lowest number of nodules $plant^{-1}$ was recorded by I_1P_2, indicating that the nodules formation were more effective by the combination of RI 25 g Kg^{-1} with 18 Kg ha^{-1} P. Majid *et al.* (2009) observed that P with 25 kg N ha^{-1} with 25 g Kg^{-1} *Bradyrhizobium* strains produced the highest number of nodules $plant^{-1}$; this result is supported our result. The interactive effect of RI and P on dry weight was statistically significant at 60 DAS at 5% level of probability and the effect of RI and P was statistically significant at 75 DAS at 1% level of probability (Table 1). However, the interactive effect of RI and P at 45 date did not show significant effect. The highest dry weight of plant (13.87 g $plant^{-1}$) observed at 75 DAS with the treatment combination of I_0P_3, indicating larger vegetative growth (dry weight) was produced by the application of 36 kg ha^{-1} P. Begum *et al*. (2015) studied the effect of phosphorus on the performance of soybean and reported that soybean dry weight significantly increased with the application of 54 kg P ha^{-1}. Lamptey *et al*. (2014) investigated that the influence of phosphorus at different source on soybean and indicated that weight of the dry weight of plant increased significantly with the application of phosphorus from a different source.

Effect of the combine use of RI and P on some yield parameters and seed yield of Binasoybean-1

Analysis of variance is given (Table 2) to summarize statistical significances of the effect of RI and P on different yield characteristics and seed yield of Binasoybean-1. Results showed that pods $plant^{-1}$ was significantly affected by different combination of RI and P. The maximum number of pods $plant^{-1}$ (40.41) was observed by the treatment I_2P_2 which was statistically identical with I_1P_1 and minimum number of pods (27.53) was recorded with the treatment combination of I_0P_0. Few reports showed that application of RI and P significantly increased the number of pods $plant^{-1}$ (Matusso *et al*. 2015; Hoque *et al*. 1983).

The highest number of effective pods $plant^{-1}$ was observed by the combination of I_2P_2 which was statistically identical with I_1P_0. Begum *et al*. (2015) studied the effect of phosphorus on the performance of soybean and reported that application of P at 54 kg ha^{-1} showed the highest number of effective pods $plant^{-1}$. However, statistical analysis showed an insignificant difference by the interaction effect of RI and P on number of non-effective pods and pod length (Table 2). Different levels of RI and P significantly influenced the production of the number of seeds pod^{-1} at 1% level of probability (Table 2). Thousand seeds weight showed significant at 5% level of probability due application of RI and P. The maximum weight of thousand seeds was observed (147.0 g $plant^{-1}$) by the treatment of I_1P_2 which was statistically identical with I_0P_2 (Table 2).

Table 1. Effect of the combine use of RI and P on the growth performance of Binasoybean-1

Treatment	Plant height (cm)			No. of nodules plant^{-1}			Dry wt. (gm)		
	45DAS	60DAS	75DAS	45DAS	60DAS	75DAS	45DAS	60DAS	75DAS
I_0P_0	33.89 e	39.55 h	46.22 b	3.667 h	6.000 gh	13.15 c	4.46	4.850 d	8.283 g
I_0P_1	40.52 bc	44.44 bcd	45.40 b	2.667 h	4.667 h	9.440 e	5.68	6.543 cd	9.250 fg
I_0P_2	41.78 ab	45.80 abc	44.55 bc	4.000 h	8.110 fg	10.47 de	6.40	7.443 bcd	10.78 def
I_0P_3	41.67 ab	42.67 defg	40.58 d	6.000 g	8.810 f	8.427 ef	4.98	5.570 cd	13.87 ab
I_1P_0	42.59 ab	47.63 a	49.65 a	8.437 ef	11.51 de	4.837 g	6.19	6.530 cd	12.80 abcde
I_1P_1	41.59 ab	44.40 bcd	46.96 b	8.913 def	12.78 cde	24.50 a	9.25	10.48 a	12.45 abcde
I_1P_2	45.00 a	46.47 ab	42.52 cd	10.37 de	13.55 cd	6.193 fg	6.86	9.557 ab	12.70 abcde
I_1P_3	42.63 ab	44.27 bcde	44.18 bc	12.37 c	16.15 b	11.89 cd	7.10	6.527 cd	13.53 abc
I_2P_0	36.07 e	41.73 efgh	44.33 bc	15.48 b	22.44 a	9.707 de	7.64	7.527 bcd	12.90 abcd
I_2P_1	39.96 bcd	44.00 bcdef	46.89 b	12.39 c	16.36 b	17.07 b	5.41	6.090 cd	11.45 cde
I_2P_2	37.33 cde	41.62 fgh	41.44 d	8.887 def	10.66 ef	6.640 fg	5.94	6.393 cd	11.72 bcde
I_2P_3	36.52 de	40.18 gh	45.49 b	7.000 fg	10.67 ef	8.470 ef	7.16	7.840 abc	11.20 def
I_3P_0	40.71 bc	46.66 ab	40.49 d	9.517 de	13.44 cd	10.41 de	6.82	8.113 abc	10.61 ef
I_3P_1	35.15 e	43.22 cdef	46.44 b	19.63 a	21.44 a	10.55 de	7.73	9.450 ab	14.53 a
I_3P_2	34.64 e	40.55 gh	40.81 d	10.54 cd	11.44 de	13.46 c	6.49	7.647 bcd	12.44 abcde
I_3P_3	41.81 ab	46.22 ab	44.45 bc	10.29 de	15.00 bc	13.00 c	7.66	8.183 abc	11.88 bcde
SX	1.19	0.80	0.83	0.62	0.82	0.74	0.89	0.83	0.65
Level of Significance	**	**	**	**	**	**	NS	*	**
CV (%)	5.25	3.21	3.28	11.47	11.31	11.54	23.44	19.56	9.60

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)

**=Significant at 1% level of probability

*= Significant at 5% level of probability, NS = Not Significant, SX= the standard deviation of sample

Table 2. Effect of the combine use of RI and P on the yield of Binasoybean-1

Treatment	No. of pods plant^{-1}	No. of effective pods plant^{-1}	No. of non-effective pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Weight of 1000 seeds(gm)	Yield (t ha^{-1})
I_0P_0	34.64 bc	26.45 def	8.19	3.09	3.017 a	142.3 abcd	1.780 bc
I_0P_1	31.19 def	24.52 fg	8.79	3.34	2.497 bcd	141.0 abcd	1.927 b
I_0P_2	33.00 cde	26.56 def	6.44	3.58	2.850 ab	146.7 ab	2.187 a
I_0P_3	33.34 cd	29.00 bcd	4.34	3.60	2.520 bcd	138.7 abcd	2.220 a
I_1P_0	36.48 b	31.45 ab	5.03	3.49	2.807 ab	138.0 abcd	1.343 f
I_1P_1	39.85 a	30.22 abc	9.62	3.56	2.520 bcd	132.0 d	1.360 ef
I_1P_2	30.07 efg	25.55 ef	4.52	3.38	2.850 ab	147.0 a	2.233 a
I_1P_3	30.37 defg	27.30 de	3.07	3.26	2.497 bcd	135.7 bcd	1.690 bcd
I_2P_0	28.75 fg	22.48 g	6.26	3.29	2.500 bcd	137.3 abcd	1.460 def
I_2P_1	27.66 g	24.11 fg	3.54	3.43	2.547 bcd	137.7 abcd	1.580 cdef
I_2P_2	40.41 a	31.62 a	6.66	3.27	2.333 cd	142.7 abcd	1.877 b
I_2P_3	30.53 defg	27.70 cde	2.83	3.25	2.817 ab	144.3 abc	2.297 a
I_3P_0	33.08 cde	26.45 def	6.62	3.36	3.003 a	140.3 abcd	1.773 bc
I_3P_1	34.89 bc	25.48 ef	9.41	3.38	2.733 abc	142.3 abcd	1.607 cde
I_3P_2	33.29 cd	28.51 cd	4.78	3.49	2.673 abcd	135.0 cd	1.340 f
I_3P_3	27.53 g	24.00 fg	3.52	3.63	2.297 d	145.7 abc	2.200 a
SX	0.93	0.81	1.27	0.12	0.12	3.28	0.08
Level of Significance	**	**	NS	NS	**	*	**
CV (%)	4.94	5.23	37.73	6.29	8.17	4.06	7.76

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)
**=Significant at 1% level of probability, *= Significant at 5% level of probability, NS = Not Significant, SX= the standard deviation of sample

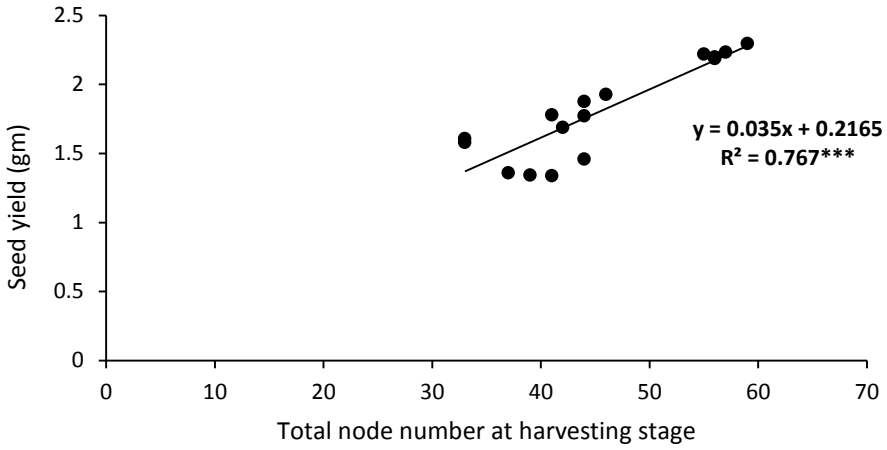

Fig. 1. Relationship between total node number by the sixteen combination of treatments at harvesting stage and seed yield. *** denotes significant at P<0.001

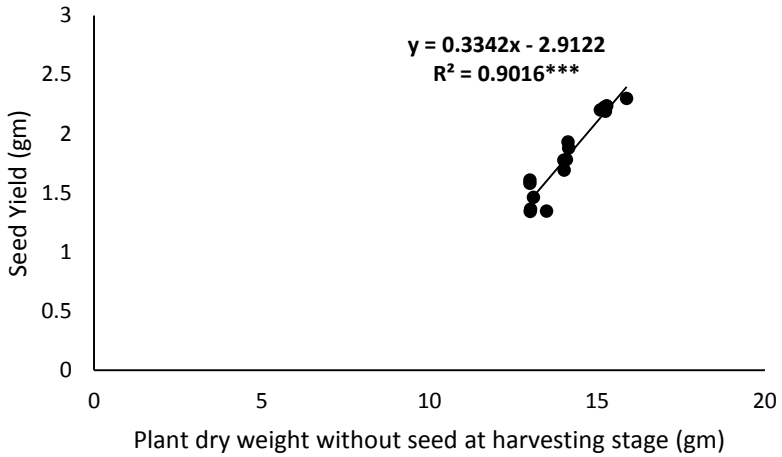

Fig. 2. Relationship between plant dry weight without seed by the sixteen combination of treatments at harvesting stage and seed yield. *** denotes significant at P<0.001

Statistical analysis for seed yield is depicted in Table 2. Statistical analysis of data showed that seed yield was significantly affected by the RI and P. The data revealed that the highest yield (2.297 t ha^{-1}) was produced by the treatment of I_2P_3 which was statistically identical with the treatment of I_1P_2. Therefore, 50 g kg^{-1} RI with 54 kg ha^{-1} would be proper estimated dose for higher yield for Binasoybean-1.

Fig.1. showed the relationship between total node number at harvest stage and seed yield. Total node number at harvest stage was positively correlated with seed yield. Similarly, Fig. 2 showed the relationship between plant dry weight without seed at harvest stage and seed yield. Plant dry weight without seed at harvest stage showed highly significant relationship with seed yield of soybean indicating vegetative growth (plant dry weight) increase seed yield. Islam *et al.* (2020) also reported a similar result in soybean plants.

CONCLUSION

Results revealed that use of RI at 50 g kg^{-1} seed in combination with 54 kg ha^{-1} P appeared as the best practice for producing the highest grain yield of Binasoybean-1. This conclusion has been made based on the place of the study, yield may vary in another place due to different fertility status of soil in Bangladeshi.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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