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Effects of *Azotobacter* Application on the Growth and Yield of Transplant *Aman* Rice and Nutrient Status of Post-harvest Soil

Kader, M. A., A. A. Mamun, S. M. A. Hossain and M. K. Hasna[1]
Department of Agronomy, BAU, Mymensingh-2202, Bangladesh
[1]Plant Pathology Division, BINA, Mymensingh, Bangladesh

Abstract: Effects of *Azotobacter* application either individually or in combination with the use of organic and chemical fertilizers on the growth and yield of transplant *amen* rice and nutrient status of post-harvest soil were evaluated. Increased growth in terms of leaf area index and tiller number/plant was recorded from Azotobacter application both individually and in combination with the use of organic and chemical fertilizers. Considering both grain and straw yields, *Azotobacter* exhibited significant influence along with all levels of organic and chemical fertilizers. But overall best performance regarding growth and yield was observed from *Azotobacter* application along with the use of three-fourths of the recommended dose of chemical fertilizers. Analysis of post-harvest soil showed that *Azototiacter* along with the use of three-fourths of the recommended dose of chemical fertilizers performed the best in maintaining organic matter and available P status in soil.

Key words: *Azotobacter*, leaf area index, yield, organic matter, transplantaman rice

Introduction

Depletion of soil organic matter is one of the most important factors of deterioration of crop productivity, as soil organic matter plays an important role in preserving the fertility and productivity of soils. Introduction of high yielding fertilizer responsive crop varieties coupled with intensive cropping in Bangladesh have thrusted tremendous pressure on the soil organic matter and soil nutrients. Moreover, farmers rarely add sufficient amount of organic manures to the soil against their removal. As a result, the natural nutrient reserve in soil has been steadily declining which is alarming for sustaining the crop productivity in Bangladesh. Karim *et al.* (1994) reported that soil organic matter in Bangladesh has been depleted by 945% during the period from 1969-70 to 1989-90. Under this situation, the integration of organic and inorganic fertilizers may facilitate the utilization of nutrients for crop growth and productivity and help replenish the organic matter status in soli. The long-term research at BRRI indicates that the addition of cowdung at 5 t/he/year can improve the rice productivity with no degradation of soil fertility (Bhuiyan, 1994). As the organic fertilizer is very limited in production, the feasibility of using bio-fertilizer in rice may be explored. A study was, therefore, undertaken to evaluate the effects of *Azotobacter* application on the growth and yield of transplant *amen* rice and nutrient status of post-harvest soil.

Materials and Methods

A field trial was conducted during *amen* season of 1996 at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh to see the effects of *Azotobecter* application on the growth and yield of rice and nutrient status of postharvest soil. The experiment included following treatments: two levels of *Azotobacter* application (*Arotobeeter* inoculation (A_1) and no inoculation (A_0)), three levels of cowdung (control, 5 Wet and 10 t/ha) and five levels of chemical fertilizers (control, one-fourth of the recommended dose, half of the recommended dose, three-fourths of the recommended dose and full of the recommended dose). Treatment combinations for chemical fertilizers and cowdung have been presented in Table 1. Recommended dose of chemical fertilizers used in the experiment was 80-60-40-30-5 kg of N-P_2O_5-K_1O-S-Zri, respectively (BRRI, 1995). Chemical fertilizers namely urea, TSP, MP, zinc sulphate and gypsum were applied as the source of N-P_2O_5-K_2O-S-Zrt, respectively. Split-plot design was followed in laying out the experiment with three replications assigning organic and chemical fertilizers in main plot and *Azotobacter* in sub-plot. Rice variety BR11 developed by Bangladesh Rice Research Institute was used as the planting material. Roots of rice seedlings were inoculated with *Azotobacter* by dipping them in *Azotobacter* solution (10 ml of *Azotobacter* inoculant with 1 L of water) for 20 minutes before transplanting. Full dose of cowdung was given at seven days before land preparation while full dose of TSP, MP, zinc sulphate and gypsum and one-third of urea were applied at the time of final land preparation. The rest of urea was top-dressed at maximum tillering stage and prior to panicle initiation stage. All the necessary intercultural practices were done as and when necessary.

Regarding the growth study of the crop data were collected on leaf area index (LAI) and number of tillers/m^2 measured at 15 days interval. Ten hills from each plot were selected randomly and tagged from which data on aforementioned growth parameters were recorded. LAI was calculated by using the leaf non-removing technique (IRRI, 1972). After harvesting of the crop plot-wise grain and straw yields were recorded at 12% moisture level. For soil nutrient analysis, initial soil sample before final land preparation and soil samples from each plot after harvesting of the crop were collected. Organic matter and total N were measured by wet oxidation method and micro kjeldahl method, respectively (Page *et al.,* 1982) and available P by the technique described by Black (1965).

Results and Discussion

Growth and yield: Leaf area index (LAO of transplant *amen* rice was significantly influenced by the inoculation of rice seedlings with *Azotobacter* (Fig. 1). The figure shows that LAI increased with the progress of the growth processes of the crop up to 80 days after transplanting (DAT) and declined afterwards. At the earlier stages of crop growth (up to 30 DAT) the rate of increment was slower, but it was rapid from 30 DAT and afterwards and reached the peak at 60 DAT. From this figure it is evident that in both the treatments LAI increased

Table 1: Treatment combinations far chemical fertilizers and cowdung

Treatment	Chemical fertilizers (kg/ha)					
	N	P_2O_5	K_2O	S	Zn	Cowdung l/ha
T_0	0	0	0	0	0	0
T_1	0	0	0	0	0	5
T_2	0	0	0	0	0	10
T_3	20	10	15	7.5	1.25	0
T_4	20	10	15	7.5	1.25	5
T_5	20	10	15	7.5	1.25	10
T_6	40	20	30	15.0	2.50	0
T_7	40	20	30	15.0	2.50	5
T_8	40	20	30	15.0	2.50	10
T_9	60	30	45	22.5	3.70	0
T_{10}	60	30	45	22.5	3.70	5
T_{11}	60	30	45	22.5	3.70	10
T_{12}	80	40	60	30.0	5.00	0
T_{13}	80	40	60	30.0	5.00	5
T_{14}	80	40	60	30.0	5.00	10

Table 2: Effects of *Azatobartar* application along with the use of organic and chemical fertilizers on leaf area index of transplant *amen* rice

Treatment	Lee area index					
	15 DAT	30 DAT	45 DAT	60 OAT	76 DAT	90 DAT
A_0T_0	O. 04hi	1.12l	2.46no	3.41f	3.08hi	2.15m
A_1T_0	0.04hi	1.18kl	2.86lm	3.76kl	3.17hi	2.53jkl
A_0T_1	0.40hi	1.16kl	3.02j-m	4.12ijk	3.67g	2.39klm
A_1T_1	0.51e-i	1.44ij	3.28i-1	4.75f-i	3.81fg	3.07f-i
A_0T_2	0.40hi	1.23jkl	3.05j-m	4.15ijk	3.61g	2.27lm
A_1T_2	0.62b-g	1.49hi	3.56ghi	4.60ghl	4.11ef	3.15e-h
A_0T_3	0.52e-i	1.16kl	2.57mno	3.66kl	3.2th	2.73ijk
A_1T_3	0.54d-i	1.40i-l	3.80d-h	5.40c-f	4.29e	3.15e-h
A_0T_4	0.44hi	1.15kl	2.18o	3.31f	3.10hi	2.20lm
A_1T_4	0.43hi	1.75efg	2.92k-n	3.94jkl	3.73g	3.20d-g
A_0T_5	0.55d-i	1.41ijk	3.37h-k	4.45hij	2.87l	2.51jkl
A_1T_5	0.57c-h	2.07bc	3.87d-g	4.70ghi	3.65g	2.87g-j
A_0T_6	0.48ghi	1.75efg	3.63f-i	4.77f-i	3.93fg	3.12e-h
A_1T_6	0.72bc	1.89c-f	4.13cde	5.75b-e	5.66a	4.63a
A_0T_7	0.50f-i	1.19jkl	2.88lmn	3.70kl	3.10hi	2.80hij
A_1T_7	0.61c-g	1.71fgh	3.76e-i	4.68ghi	3.72g	2.83hij
A_0T_8	0.44hi	1.39ijk	4.26bcd	5.24efg	4.34e	2.79hij
A_1T_8	0.613b-1	1.90def	4.27bod	6.43a	5.17bc	3.40def
A_0T_9	0.72bc	1.53ghi	3.72e-i	5.76b-e	4.70d	3.85c
A_1T_9	0.78ab	2.02bcd	4.05c-f	6.45a	5.86a	4.25b
A_0T_{10}	0.57c-h	1.17kl	3.48g-j	4.64ghi	3.68g	2.64jk
A_1T_{10}	0.57c-h	1.313c-f	5.04a	6.23ab	5.27b	3.15e-h
A_0T_{11}	0.62b-g	1.15kl	4.51bc	5.28d-g	4.29e	2.85g-j
A_1T_{11}	0.57c-h	1.99bcd	5.16a	5.94a-d	4.90cd	3.53d
A_0T_{12}	0.63b-g	1.29i-l	3.01j-m	4.92fgh	4.70b	3.89c
A_1T_{12}	0.61c-g	2.19ab	4.73ab	5.94a-d	5.07bc	4.74a
A_0T_{13}	0.64b-g	2.21ab	4.35bc	4.98fgh	3.81g	3.09f-i
A_1T_{13}	0.67b-e	2.39a	4.48bc	5.76b-e	4.87cd	3.32def
A_0T_{14}	0.69b-d	1.71fgh	4.15cde	5.20efg	4.35e	3.48de
A_1T_{14}	0.88a	1.78def	4.25bcd	5.97abc	5.07bc	4.57a
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

In a column, figures having similar letter(s) do not differ significantly whereas figures bearing dissimilar letters differ similarly (as per DMRT)

upto 60 DAT, but the rate of increment was much higher in *Azotobactor* inoculated treatment than that of uninoculated one. Almost a similar growth trend of LAI was also noticed in case of tiller number/m^2 due to *Azorobacrer* inoculation (Fig. 2). However, it is interesting to note that both LAI and tiller number/m^2 declined after 60 OAT much more sharply in uninoculated plot than those of inoculated one. Probably *Azorobactar* could supply N throughout the life cycle of the crop, especially at the later stages which was responsible for this slower declination of LAI and tiller number/m^2 after BO DAT in *Azotobanter* inoculated plot. Venkatararnan (1902) also stated that *Azorobacrer* accelerated the growth of crops by supplying nitrogen and growth stimulating substances. LAI was also influenced significantly when *Azorobacter* was applied along with organic and chemical fertilizers (Table 2). LA's were much lower at lower level of organic and chemical fertilizers while these were significantly higher with medium to high levels of chemical fertilizers. It can be seen from the table that LAI increased with the increasing levels of chemical fertilizers in combination with *A2atobacter.* But LAI declined when cowdung was added with *Azotobacter* and chemical fertilizers in most of the cases which indicated that application of *Azotobacter* along with chemical fertilizers was sufficient to achieve the best performance in producing Led. Purushothamon *et al.* (1977) also found increased growth of rice crop due to interaction of *Azorobacrer* with chemical

Table 3: Effects of *Azotabacter* application along with the use of organic and chemical fertilizers on grain and straw yields of transplant *aman* rice

Treatment	Grain yield		%increase of grain yield/control		Straw yield		%increase of grain yield/control	
	A_0	A_1	A_0	A_1	A_0	A_1	A_0	A_1
T_o	3.12	3.17	-	14.42	3.38	3.70	-	12.12
T_1	3.92	4.10	25.84	31.41	3.34	4.53	1.21	37.27
T_2	3.99	4.00	27.88	28.21	4.41	4.46	33.64	35.15
T_3	3.80	4.19	21.79	34.29	4.28	4.49	29.70	36.06
T_4	3.88	3.88	24.36	24.36	4.22	4.29	27.88	30.00
T_5	4.13	4.42	4.42	41.68	4.42	4.67	41.67	46.79
T_5	4.42	4.58	4.87	46.79	4.48	4.76	41.52	44.24
T_7	3.72	4.32	19.23	38.46	4.13	4.72	25.18	43.03
T_8	3.99	4.12	27.88	32.05	4.17	4.44	26.38	34.55
T_9	4.02	4.91	28.85	57.37	4.54	5.02	37.58	52.12
T_{10}	4.17	4.45	33.65	42.63	4.39	4.89	33.03	42.12
T_{11}	4.48	4.30	43.59	37.82	4.64	4.80	40.61	45.45
T_{12}	4.17	4.27	33.85	38.86	4.60	4.86	39.39	47.27
T_{13}	4.39	4.44	40.71	42.31	4.88	4.99	47.88	51.21
T_{14}	4.51	4.43	44.55	41.99	5.05	4.98	63.03	50.91

Table 4: Effects of *Azotobacter* application along with the use of organic and chemical fertilizers on nutrient status of post-harvest soil

Treatment	Organic matter (%)		Total N (%)		Available P (ppm)	
	A_0	A_1	A_0	A_1	A_0	A_1
T_0	0.87	0.95	0.063	0.065	13.33	19.93
T_1	1.02	1.05	0.052	0.052	13.00	19.00
T_2	1.05	1.13	0.057	0.058	15.33	21.37
T_3	0.89	1.05	0.052	0.061	15.33	18.83
T_4	1.03	1.14	0.063	0.062	16.07	16.87
T_5	0.08	1.07	0.060	0.056	15.27	18.33
T_6	0.96	1.08	0.060	0.057	19.60	19.03
T_7	1.06	1.05	0.058	0.053	12.03	15.00
T_8	1.10	1.10	0.053	0.068	19.27	21.37
T_9	0.98	1.13	0.053	0.051	18.67	19.33
T_{10}	0.99	1.11	0,054	0.051	19.53	19.50
T_{11}	1.12	1.09	0.053	0.059	17.33	18.23
T_{12}	0.97	1.08	0.067	0.063	19.60	19.93
T_{13}	1.03	1.11	0.062	0.069	18.47	20.07
7_{14}	1.14	1.14	0.053	0.083	20.07	19.80

In case of initial sell-organic matter content was 1.15; total N content wee 0.070 and available P content was 25pprn

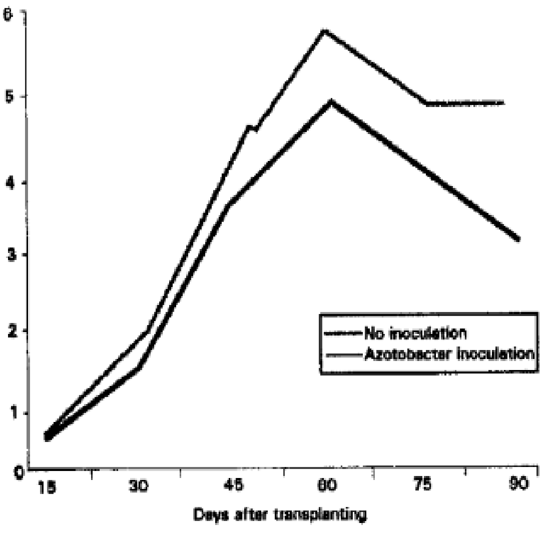

Fig. 1: Effects of *Azorobacter* application on leaf area

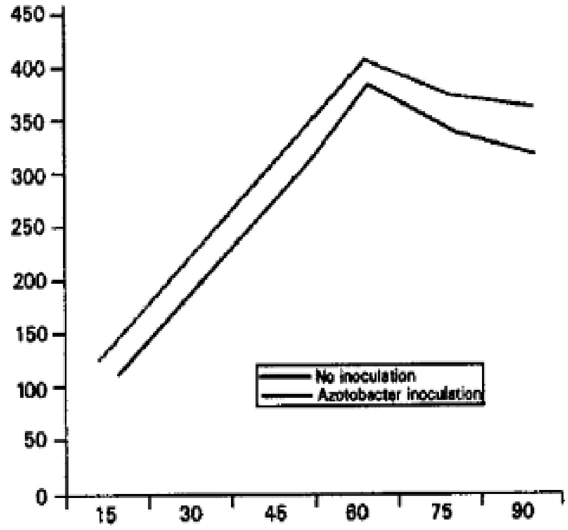

Fig. 2: Effects of *Azotobacter* application on tiger nurnberirn[2] index (LA1) of transplant *amen rice* of transplant *amen rice*

fertilizers NPK.

Table 3 represents the grain end straw yields of rice including their increment over control as influenced by Azotobsofer inoculation along with the application of organic and chemical fertilizers. *Azotobacter* application increased both grain end straw yields along with almost all levels of organic and chemical fertilizers. In case of grain yield, the highest 44.65% increment over control was recorded with the application of 10t cowdungtha and full dose of chemical fertilizers without *Azotobacter* application. On the other hand, *Azorobacrer* application along with the use of three-fourths of the recommended dose of chemical fertilizers produced the highest 57.31% increased grain yield over control. *Azotobecter* application also resulted notable increment overall In straw yield over control, though the highest straw yield increment (53.03%) was obtained from the application of 10t cowdung/ha and full dose of chemical fertilizers.

Nutrient status of post-harvest soil: Date in Table 4 presents the status of organic matter, total N and available P in the post-harvest soil as influenced by interaction of *Azotobacrer* with cowdung and chemical fertilizers. By *Azatobecter* inoculation total N remained unaffected while organic matter and available P showed significant changes. *Azotobacter* inoculation exerted significant effect in maintaining organic matter content and available P of the post-harvest soil. Although organic matter content and available P of postharvest soil declined from their respective initial, the rate of depletion on *Azotabacter* inoculated treatments was very minimum compared to those of uninoiulated treatments. However, *Azotobacter* inoculation along with three-fourths of the recommended dose of chemical fertilizers performed the best in maintaining organic matter and available P status of post-harvest soil probably because of increased enzymatic activities in soil resulting more availability of plant nutrients. The results of this study revealed that *Azotobacter applicatian* increased plant growth in terms of LAI and tiller number/m^2 and ultimately grain and straw yields of rice irrespective of levels of organic and chemical fertilizers. But the highest performance was achieved from *Azotobacter* application in combination with the use of three-fourths of the recommended dose of chemical fertilizers, On the other hand, *Azotobacter* application in combination with the use of same level of chemical fertilizer also helped in reducing nutrient depletion from soil.

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