Biological Sciences Section

Pak. j. sci. ind.res., vol. 33, no. 4, April 1990

EFFECT OF AZOLLA AND UREA ON N, P,K, AND S CONTENT IN RICE

M.Z. SOLAIMAN, M. JAHIRUDDIN, M.S. HOQUE AND Z.H. BHUIYA

Department of Soil Science, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

(Received January 2, 1990; revised April 21, 1990)

A field experiment was carried out to investigate the impact of Azolla manuring and urea fertilization on N, P, K and S content in BR3 rice. There were six treatments of which four were Azolla treatments, one urea application and the other treatment without Azolla or urea (control). The Azolla treatments were: one, two and three incorporations of Azolla and dual culture. Urea was applied at a normal rate (80 kg N/ha). Both Azolla manuring and urea application produced significant effects on N concentration and uptake by rice. Urea supplement gave the best result. Among the Azolla treatments, thrice incorporation of Azolla showed the highest performance, and it appears to reduce as much as 60% use of costly urea fertilizer in rice cultivation. Concentration and uptake of other nutrients such as P, K and S were also significantly influenced by Azolla and urea applications.

Key words: Azolla, Urea, Nutrient content, Rice.

Introduction

Azolla can be a potential source of aquatic green manure for tropical rice production because of its high N_2 fixing capacity and the availability of its nitrogen to the current rice [1]. Azolla has unique ability to multiply rapidly and fix atmospheric nitrogen at a rate comparable to most tropical and subtropical legumes [2,3]. Mian and Stewart [4] reported that about 36% of the total Azolla-N added to the soil was released in 60 days and of that about 71% was assimilated by the rice plant and the remaining amount was mostly lost to the atmosphere as gas. Senapati and Behara [5] recorded 140 kg N/ha from 8 Azolla crops in a season at Bhubaneswar. There are several reports that N uptake by rice increases with increasing amount of Azolla application [6,7 and 8]. Azolla is reported to be extensively used in Vietnam [9] and Southern China [1]but it has received little attention in Bangladesh. The present study was undertaken to evaluate the comparative effect of Azolla manuring and urea application on the concentration and uptake of N, P, K and S by rice crop.

Materials and Methods

The experiment was carried out at BAU farm in the boro season of 1987-88 using BR3 rice (Biplab) as the test cultivar. The soil falls under the General Soil Type, Noncalcareous Dark Grey Floodplain Soils (order Inceptisol, suborder Aquept, and Subgroup Aeric Haplaquept). The general characteristics of the soil were : pH, 6.8; Organic matter, 1.8%; total nitrogen, 0.08%; available P, 13.5 ppm. available K, 0.31 me/100 g soil; available S, 11.0 ppm; and textural class, silt loam. There were six treatments stated as follows:

T_1: Control (No Azolla and urea used)

T_2: One incorporation of Azolla (7 days before transplantation)

T_3: Two incorporations of Azolla (7days before and 30 days after transplantation)

T_4: Three incorporations of Azolla (7 days before, and 30 and 60 days after transplantation)

T_5: Azolla dual culture (Azolla allowed to grow with rice throughout the season but not incorporated). Azolla was spread on the rice plots after 5 days of transplantation at the rate of 200 g fresh Azolla per m^2.

T_6: Urea-N (applied at the rate of 80 kg N/ha in three splits-50% at final land preparation and 25% at 35 days and 25% at 65 days of plant growth).

For the case of Azolla incorporation treatments, fresh Azolla were used at the rate of 10 kg per plot (6.7 t/ha) in each application. The Azolla species was *A. pinnata*.

The experiment was laid out in randomized block design with 4 replications of each treatment. Azolla was maintained and allowed to multiply in the nursery for use in the experimental plots. Azolla was analysed and it contained 3.6% N, 2.0% P, and 1.4% K on oven-dry basis. Fresh Azolla contained 5.6% dry matter. Each application of Azolla (6.7 t fresh Azolla per ha) provided 13.5 kg N/ha, 7.5 kg P/ha and 5.3 kg K/ha to soil. During land preparation all plots received 80 kg P_2O_5/ha as TSP, 60 kg K_2O/ha as MP and 20 kg S/ha as gypsum, as blankets. Intercultural operations such as weeding, irrigation and insecticide spraying were done whenever required. The mature crop was harvested after 125 days of transplantation. Grain and straw samples were analysed for N, P, K and S concentration. The uptake results were calculated from the yield and nutrient concentration data. The samples were digested with HNO_3-$HClO_4$ mixture (10:1) for P, K and S determination and with H_2SO_4 for N determination. Estimation of the elements in the digest was made using the standard methods [10].

Results and Discussion

Rice N content. Effect of Azolla manuring and urea application on concentration and uptake of nitrogen by BR3

TABLE 1. INFLUENCE OF AZOLLA AND UREA ON THE CONCENTRATION AND UPTAKE OF NITROGEN BY RICE.

Treatment	N Concentration(%)		N Uptake (kg/ha)		Total N Uptake		Apparent% recovery of N by grain
	Grain	Straw	Grain	Straw	kg/ha	% increase over control	
Control	0.90c	0.56b	22.7d	18.9b	41.6d	–	–
One incorporation of Azolla	1.09ab	0.59b	31.7c	20.6b	52.3c	26	66.7
Two incorporations of Azolla	1.09ab	0.64a	32.6bc	28.9a	61.5b	48	36.7
Three incorporations of Azolla	1.15ab	0.67a	37.1b	28.7a	65.8b	58	35.6
Dual culture of Azolla	1.04b	0.64a	28.5c	22.4b	50.9c	22	–
Urea-N application	1.18a	0.67a	47.2a	33.8a	81.0a	95	30.6
S.E. (±)	0.035	0.01	1.59	1.72	2.46	–	–

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

rice was highly significant. Nitrogen concentration in grain ranged from 0.9% to 1.18% while in straw it varied between 0.56% and 0.67% (Table 1). Both grain and straw N concentrations were highest due to urea treatment and lowest in control (no Azolla and urea). Although urea treatment produced the highest N concentrations in grain, statistically Azolla treatments irrespective of the number of incorporations gave the identical result. In the case of straw N concentration, the effect of urea application was comparable to that of all types of Azolla treatment except the one incorporation of Azolla which gave the lowest N content. Nitrogen uptake by grain, straw and the whole plant were significantly higher due to urea supplement than the control. Plants grown on urea treated plots showed higher N uptake with an increase of 39.4% kg/ha (95%) over the control. On the other hand, Azolla treatments gave 22-58% increased N uptake compared to control. Among the Azolla treatments, three incorporations produced the best effect on N content in rice. Total N uptake by crop due to various treatments follows the order: urea> Azolla three incorporations ≅ Azolla two incorporations > Azolla one incorporation ≅ Azolla dual culture> control. The data (Table 1) reveals that the one incorporation of Azolla and the Azolla dual culture were ineffective methods for supplementing soil nitrogen but three incorporations of Azolla can satisfy 60% of the N demand of rice. Highest recovery of N (66.7%) by grain was obtained in one incorporation of Azolla and the lowest recovery (30.6%) was noted in urea treatment. So, although the N uptake was highest from urea application, the loss of N was also maximum in this treatment. Mian and Stewart [11] observed 34% recovery of Azolla-N by 60 days old rice plants.

Rice P content. Like the N results, concentration and uptake of P by rice were significantly influenced by Azolla manuring and urea application. Azolla when incorporated into soil in three applications resulted in better P concentration in rice grain (Table 2). Although the variation in P concentration

TABLE 2. INFLUENCE OF AZOLLA AND UREA ON THE CONCENTRATION AND UPTAKE OF PHOSPHORUS BY RICE.

Treatment	P Concentration(%)		P Uptake (kg/ha)		Total P Uptake		Apparent% recovery of N by grain
	Grain	Straw	Grain	Straw	kg/ha	% increase over control	
Control	0.43c	0.20c	10.9c	6.8b	17.7c	–	–
One incorporation of Azolla	0.49b	0.30a	14.3b	10.5a	24.8ab	41	45.3
Two incorporations of Azolla	0.50ab	0.25abc	14.9b	11.4a	26.3a	49	26.7
Three incorporations of Azolla	0.55a	0.25abc	17.7a	10.7a	28.4a	61	30.2
Dual culture of Azolla	0.46bc	0.28ab	12.6bc	9.9a	22.5b	28	–
Urea-N application	0.44c	0.21c	17.6a	10.6a	28.2a	60	–
S.E. (±)	0.012	0.015	0.74	0.86	1.01	–	–

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

TABLE 3. INFLUENCE OF AZOLLA AND UREA ON THE CONCENTRATION AND UPTAKE OF POTASSIUM BY RICE.

Treatment	K Concentration(%)		K Uptake (kg/ha)		Total K Uptake		Apparent% recovery of K by grain
	Grain	Straw	Grain	Straw	kg/ha	% increase over control	
Control	0.19b	0.99b	4.8c	34.7c	39.5c	–	–
One incorporation of Azolla	0.21ab	1.52a	6.1b	53.0b	59.1b	50	24.5
Two incorporations of Azolla	0.23a	1.17b	6.9b	52.9b	59.8b	51	19.8
Three incorporations of Azolla	0.21ab	1.20ab	6.8b	51.4b	58.2b	47	12.6
Dual culture of Azolla	0.23a	1.09b	6.3b	36.9c	43.2c	9	–
Urea-N application	0.22a	1.34ab	8.8a	67.6a	76.4a	93	–
S.E. (±)	0.008	0.103	0.38	2.99	3.16	–	–

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

TABLE 4. INFLUENCE OF AZOLLA AND UREA ON THE CONCENTRATION AND UPTAKE OF SULPHUR BY RICE.

Treatment	S. Concentration (%)		S Uptake (kg/ha)		Total S Uptake	
	Grain	Straw	Grain	Straw	kg/ha	% increase over control
Control	0.09b	0.08	2.3c	2.7c	5.0d	–
One incorporation of Azolla	0.11a	0.09	3.2bc	3.1c	6.3c	26
Two incorporations of Azolla	0.11a	0.09	3.3bc	4.1ab	7.4bc	48
Three incorporations of Azolla	0.12a	0.10	3.9ab	4.3a	8.2ab	64
Dual culture of Azolla	0.11a	0.09	3.0bc	3.2bc	6.2c	24
Urea-N application	0.12a	0.09	4.8a	4.5a	9.3a	86
SE (±)	0.005	NS	0.32	0.28	0.38	–

NS= Not significant
In a column, the figures having common letter(s) do not differ significantly at 5% level of probability.

of both grain and straw due to various treatments was significant, there was no significant difference between urea and control treatments. Phosphorus concentration in grain varied from 0.43% to 0.55% and that in straw from 0.20% to 0.28%. Although the P concentration in control and urea treatment was similar, the P uptake in grain and straw was markedly higher in urea treatment than in control, due to the higher yield of dry matter. Phosphorus uptake in grain was significantly highest in the urea treated plots and those receiving three incorporations of Azolla. On the contrary, the straw P uptake was equally influenced by all the Azolla and urea treatments. The P uptake data indicate low results for the Azolla dual culture treatment. The recovery of P by grain varied from 26.7% in two incorporations of Azolla to 45.3% in one incorporation (Table 2). Singh [12] observed higher P uptake by rice plants in Azolla treatments than in N-fertilizer treatments . Sampaio *et. al.* [13] from an experiment with radio-active P (32p) reported that rice plants (shoot + root) received 61% of applied P as *Azolla pinnata.* Mian and Ajmal [14] noted 28% recovery of Azolla P by rice plants.

Rice K content. Both concentration and uptake of K by rice were significantly influenced by the treatments under study. Potassium concentration in rice grain changed slightly by various Azolla treatments. The K concentration in grain varied from 0.19% to 0.23% while that in straw from 0.99% to 1.52% (Table 3). Compared to the effect of Azolla manuring, influence of urea application on K uptake by plant was more dominant. Total uptake of K by rice was quite similar over the Azolla dual culture failed to give beneficial effect on K uptake by plant compared to no Azolla and urea application. The application of urea N resulted in 93% increase in K uptake by rice plant over control, while such increment for Azolla

incorporation was only about 50%. Similar to the N recovery pattern, the one incorporation of Azolla showed the highest K recovery by grain and the three incorporations did the lowest indicating that more K had been retained in soil from more Azolla incorporations.

Rice S content. The concentration of S in rice grain was significantly higher in both the Azolla and urea plots compared to the control. But the difference in grain S concentration due to various kinds of Azolla treatment and urea addition was not statistically significant. Sulphur concentration of rice straw was unaffected by any of the treatments imposed (Table 4). The highest S uptake by rice was noted in urea treatment and the lowest in control. Plants grown in urea treated plots showed 86 percent more S uptake in comparison to plants of

TABLE 5. FATE OF N/P, N/K AND N/S RATIOS IN RICE AS INFLUENCED BY AZOLLA AND UREA TREATMENTS.

Treatment	N/P Ratio		N/k Ratio		N/S Ratio	
	Grain	Straw	Grain	Straw	Grain	Straw
Control	2.1	2.8	4.7	0.57	10.0	7.0
One incorporation of Azolla	2.2	2.0	5.2	0.39	9.9	6.6
Two incorporations of Azolla	2.2	2.6	4.7	0.55	9.9	7.1
Three incorporations of Azolla	2.1	2.7	5.5	0.56	9.6	6.7
Azolla dual culture	2.3	2.3	4.5	0.59	9.5	7.1
Urea-N application	2.7	3.2	5.4	0.50	9.8	7.4

control plots while for Azolla treatments such uptake increment varied between 24 and 64 %. However, total S uptake by rice plant was statistically similar for urea, and Azolla when incorporated into soil three times.

N/P, N/K and N/S ratios. Ratios of N/P, N/K and N/S in both grain and straw were found to be fairly constant over the treaments under study (Table 5). This indicates that the plants tend to maintain a definite ratio of nutrients in its tissues. If the concentration of a nutrient is high, the concentration of other nutrients tends to increase proportionately. The probable reason is that application of N increases root growth and therefore, the plant explores a large volume of soil and can therefore, take up more of a range of elements. This is particularly true for P and K which generally do not diffuse through soil. This observation supports the importance of using balanced dose of fertilizers to soil. In general, the N/K and N/S ratios were higher in grain than in straw. But for the case of N/P ratio, results were the same for both grain and straw. It appears that N per cent in grain was about 5 times higher than K percent in grain and on the ocntrary straw N concentration was about 50% lower than straw K concentration (Tables 1 and 3). Generally the nutrient uptake in grain was higher than in straw, whereas the K concentration was about 6 times higher in straw than in grain.

References

1. FAO, Report on an FAO/UNDP Study Tour to the Peoples Republic of China, 21 May-11 June, 1978, FAO, Rome (1979).
2. I. Watanable, C.R. Espinas, N.S. Berja and B.V. Alimago, IRRI Res. Pap. Ser, **11,** 13 (1977).
3. FAO. Soils Bull., **41,** 81 (1978).
4. M.H. Mian and W.D.P. Stewart, *Practical Application of Azolla for Rice Production* (Martinus Nijnoff and Dr. W. Junk Publishers, Dordrecht, 1984), pp.168-175.
5. H.K. Senapati and B. Behara, IRRN, **11** (1), 30 (1986).
6. B.P.R. Subudhi and P.K. Singh, Biol. Plant, **21** (1), 66 (1979).
7. P.K. Singh, *Nitrogen and Rice* (IRRI, Los Banos, Laguna, Philippines, 1979), pp. 407-418.
8. B.D. Kaushik and G.S. Venkataraman , IRRN, **6** (6), 23 (1981).
9. T.Q. Thuyet and D.T. Tuan, Agril. Probl. , Vol. 4, Vietnamese Studies, **38,** 119 (1973).
10. C.A. Black, *Methods of Soil Analysis, Part 2*, (Am. Soc. Agron. Inc. Publisher, Madison, Wisconsin, USA, 1965).
11. M.H. Mian and W.D.P. Stewart, Plant and Soil, **83,** 371 (1985).
12. A.J.A.M. Sampaio, M.F. Fiore and A.P. Ruschel, *Practical Application of Azolla for Rice Production* (Mortinus Nijhoff and Dr. W. Junk Publishers, Dordrecht 1984), pp. 163-167.
13. P.K. Singh, *Review of Soil Research in India* (Division of Soil Science and Agricultural Chemistry, IARI, New Delhi, 1982), Vol.2, pp.236-242.
14. M.H. Mian and A.K.M. Ajmal, Plant and Soil, **119,** 211 (1989).