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Effect of Nitrogen Application through Urea and Azolla on Growth and Biological Yield of Rice (*Oryza sativa* L.) in Acidic Soil of Meghalaya

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A B S T R A C T

A field experiment was conducted during *kharif* 2017-18 to investigate the effect of nitrogen application through urea and azolla on growth, yield of rice (*Oryza sativa* L.) and temporal soil phosphorus availability with six treatments *viz*., control (T_1), Azolla incorporation @ 16000 kg ha^{-1} (T_2), 30 kg N ha^{-1}through urea(T_3), 60 kg N ha^{-1}through urea(T_4), 30 kg N ha^{-1}through urea+ Azolla incorporation @ 16000 kg ha^{-1} (T_5) and 60 kg N ha^{-1}through urea with Azolla incorporation @ 16000 kg ha^{-1}(T_6) . The experiment was laid out in RBD and replicated four times. The experimental soil was having pH 5.1, SOC 1.75 per cent, available N, P and K as 288.62, 17.23and 201.46kg ha^{-1}, respectively. The experimental results revealed that the application of 60 kg N ha^{-1} through urea along with azolla incorporation @ 16000 kg ha^{-1} (T_6) recorded highest plant height (118.67 cm) at 90 DAT of rice which is significantly superior over control (98.17 cm) with 17.27 per cent increase. Similarly, 60 kg N ha^{-1} through urea with azolla incorporation @ 16000 kg ha^{-1} produced highest grain and straw yield i.e. 4.2 t ha^{-1} and 7.68 t ha^{-1} followed by T_5 and T_4. Further, it was observed that the grain yield obtained in T_2 was statistically at par with T_3. The grain and straw yield obtained in T_4 was also found statistically at par with the values obtained in T_5.

Introduction

Rice is the most widely consumed staple food for a large part of world's human population, especially in Asia. It is the agricultural commodity with the third highest worldwide production of 741.5 million tones in 2014 (FAOSTAT, 2014).In India, it has total production of 106.5 Mt whereas in Meghalaya it is limited to 2.8 lakh tones (DES, 2015). The food demand is on the increase, the factor productivity and rate of response of crops to applied fertilizers under intensive farming conditions are continuously declining with every passing year. The energy crisis and high fertilizer costs have created considerable concern and the use of organic materials as sources of plant nutrients for lowland rice.

The success of rice production depends mostly on an efficient and economic supply of N apart from irrigation. The use efficiency of N from fertiliser sources in lowland rice is notoriously low around 30 to 50 per cent, because of its loss from soils through various chemical and biochemical processes. It has, therefore, become necessary to look for alternative renewable resources to meet at least a part of the N demand of rice crops. N-fixing blue-green algae (BGA) or cyanobacteria and Azolla, have been shown to be the most important in maintaining and improving the productivity of rice fields (Raja *et al.*, 2012). Azolla is a free-floating water fern that floats in the water and fixes atmospheric nitrogen because of its association with the nitrogen fixing cyanobacterium Anabaena. It has also been reported in literature that an Azolla-Anabena system is ideal for the cultivation of rice under tropical conditions because of its ability to fix atmospheric nitrogen and capacity to multiply at faster rates. Keeping these facts in view, the present investigation was carried out to study the effect of nitrogen application through urea and azolla incorporation on growth and yield of rice (*Oryza sativa* L.) in acidic soil of Meghalaya.

Materials and Methods

The experiment was conducted at Research Farm of the College of Post-Graduate Studies (CPGS), Umiam, Ri-Bhoi district of Meghalaya located at $91^0$18’ to $92^0$18’ E longitude and $25^0$40’ to $26^0$20’ N latitude with an altitude of 950 m above the mean sea level during *kharif* season of 2017. The experimental soil was having pH 5.1, SOC 1.75 per cent, available N, P and K as 288.62, 17.23 and 201.46 kg ha^{-1}, respectively. The field experiment was conducted in Randomized Block Design (RBD) having six treatments and four replications *viz.*, control (T_1), Azolla incorporation @ 16000 kg ha^{-1} (T_2), 30 kg N ha^{-1} through urea (T_3), 60 kg N ha^{-1} through urea (T_4), 30 kg N ha^{-1} through urea + Azolla incorporation @ 16000 kg ha^{-1} (T_5) and 60 kg N ha^{-1} through urea with Azolla incorporation @ 16000 kg ha^{-1} (T_6). All the agronomic practices were followed for raising paddy crop. The nutrient content of N, P and K in azolla was 4.2, 0.6 and 1.9 per cent, respectively on dry weight basis.

Plant height was measured from ground level to the topmost node of the plant from five representative hills of each plot. The average height of plants was expressed in cm. The data recorded at 30, 60, 90 days after transplanting and at maturity. Grain, straw and biological yield of rice were recorded after the harvest of the crop when optimum moisture content was achieved and expressed in tha^{-1}. Harvest index was calculated by dividing the economic yield (grain) by biological yield (grain + straw) as suggested by Donald (1976). The data recorded for various parameters were analysed statistically by following procedure of Gomez and Gomez (1984).

Results and Discussion

Plant height (cm)

The plant height (cm) of rice under various treatments was recorded at four time intervals of crop growth i.e. 30, 60, 90 days after transplanting and at maturity (Table 1). The significant variations were recorded in plant height due to the treatment combinations at each time interval i.e. 30, 60, 90 DAT and at maturity. The application of 60 kg N ha^{-1}through urea along with azolla incorporation @ 16000 kg ha^{-1} (T_6) recorded highest plant height (118.67 cm) at 90 DAT of rice which is significantly superior over control (98.17 cm) with 17.27 per cent increase. The plant height also increased with 30 kg N ha^{-1}through urea + azolla incorporation @ 16000 kg ha^{-1}(T_5) over the sole application of 30 kg N ha^{-1} through urea (T_3) by 8.95 per cent. Similarly, the plant height also increased in T_6 (60 kg N ha^{-1} through urea with azolla incorporation @ 16000 kg ha^{-1} over T_4 with sole application of

60 kg N ha^{-1} through urea to the tune of 6.61 per cent at maturity. Similar results were also reported by Akhter *et al.,* (2002) in rice indicating that the combined application of azolla biomass plus urea-N significantly increased the plant height. However, the present findings are in partial agreement with the result of Paul *et al.,* (2016) who reported that the combined use of organic and chemical sources of plant nutrients in varying proportions resulted better growth of the plants compare to chemical fertilizers alone.

The increase in height with increasing levels of N be the reason for more plant height in T_4 (60 kg N ha^{-1}through urea) than T_3 (30 kg N ha^{-1} through urea). The result from the present study confirms the findings of Reddy *et al.,* (1987) and Akanda *et al.,* (1986). Availability of nitrogen throughout the growth stages might be responsible for the better performance of rice (Islam *et. al.,* 2009). Nitrogen in azolla becomes available after its decomposition in the soil. About half of nitrogen was mineralized within 3 weeks of water-logged incubation at 30^{o}C and two thirds of nitrogen was released after 6 or 8 weeks of incubation (Moro *et. al.,* 2015). This might be the reason for increased plant height in treatments with azolla incorporation.

Yield of rice (t ha^{-1})

Grain yield of rice was significantly increased with different level of urea and azola applications under different treatments (Table 2). It was found that T_6 with the application of 60 kg N ha^{-1} through urea + azolla incorporation @ 16000 kg ha^{-1} produced highest grain yield (4.2 t ha^{-1}) which was trailed by T_5 (30 kg N ha^{-1} through urea + azolla incorporation @ 16000 kg ha^{-1}) with 3.77 t ha^{-1}. The per cent increase in grain yield obtained in T_5 over T_3 (sole application of 30 kg N ha^{-1} through urea) was 17.81 per cent whereas, the per cent increase in T_6 over T_4 (sole application of 60 kg N ha^{-1} through urea) was recorded as 17.65. These results confirmed the earlier findings of Singh (1977) and Mahmud *et al.,* (2016) who reported that the incorporation of fresh or dry azolla biomass into the soil always increased grain and straw yield of rice. In the same way, Shanmugasundaram (1990) also found that azolla hybrid along with fertilizer nitrogen increased the grain yield of rice. Significant increase in grain yield of rice was also reported by Kannaiyan (1978) when azolla was used along with 100 kg N ha^{-1} as USG (Urea super granule).

Table.1 Effect of nitrogen application through urea and azolla on plant height (cm) of rice (*Oryza sativa* L.) at different time intervals

Treatments	30 DAT	60 DAT	90 DAT	At Maturity
T_1-Control	46.08	72.92	98.17	98.17
T_2-Azolla incorporation @ 16000 kg ha^{-1}	49.75	73.83	100.67	100.67
T_3- 30 kg N ha^{-1}through urea	50.75	75.50	104.33	104.33
T_4-60 kg N ha^{-1} through urea	54.50	77.83	110.83	110.83
T_5-30 kg N ha^{-1} through urea+ Azolla incorporation @ 16000 kg ha^{-1}	58.67	80.25	114.58	114.58
T_6-60 kg N ha^{-1} through urea+ Azolla incorporation @ 16000 kg ha^{-1}	60.17	82.58	118.67	118.67
SE(m)±	2.47	2.78	4.75	4.75
CD (P=0.05)	7.43	8.38	14.31	14.31

Table.2 Effect of nitrogen application through urea and azolla on grain, straw, biological yield (t ha^{-1}) of rice and harvest index (per cent)

Treatment	Grain (t ha^{-1})	Straw (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
T_1-Control	2.73	5.85	8.58	31.82
T_2-Azolla incorporation @ 16000 kg ha^{-1}	2.95	6.11	9.05	32.60
T_3- 30 kg N ha^{-1}through urea	3.20	6.51	9.71	32.96
T_4- 60 kg N ha^{-1} through urea	3.57	7.04	10.61	33.65
T_5- 30 kg N ha^{-1} through urea + Azolla incorporation @ 16000 kg ha^{-1}	3.77	7.42	11.19	33.69
T_6- 60 kg N ha^{-1} through urea + Azolla incorporation @ 16000 kg ha^{-1}	4.20	7.68	11.88	35.35
SE(m)±	0.21	0.39	0.50	2.00
CD(P=0.05)	0.62	1.19	1.47	6.02

In the present investigation also, the higher straw yield (7.68 t ha^{-1}) was recorded in T_6 (60 kg N ha^{-1} through urea + azolla incorporation @ 16000 kg ha^{-1}) while the minimum straw yield (5.85 t ha^{-1}) was recorded in T_1 (control). Again, the results obtained are in agreement with Kannaiyan and Rajeswari (1983) and Islaim *et al.,* (1984) that azolla application increased the yield components of rice. It has been established well that azolla is capable of increasing the grain yields of rice significantly (Lumpkin and Plucknett 1980). The reason for increased yield components and grain yield of rice with azolla incorporated treatments might be due to higher availability of azolla nitrogen to rice plants. When azolla is incorporated into the flooded soil, it undergoes active decomposition and the nitrogen released in ammonical form is readily absorbed by the rice plants. The low yield reported in azolla unincorporated treatments could be due to a lower rate of decomposition and possibly less availability of Azolla-N to rice plants. Moreover, Ito and Watanabe (1985) reported that rice plants absorbed more than 50 per cent of ^{15}N labelled Azolla-N incorporated at the time of transplanting and when azolla was kept on the surface of water, less than 10 per cent of its N was available to the rice plants. Hence, the efficiency of azolla bio-fertilizer could be increased by incorporating it into the rice soil, which avoids losses of nitrogen and higher yield response could be obtained from rice plants. Increased dry matter and grain yields observed in the present study with azolla application have been reported by several workers (Singh, 1977; Talley *et al.*, 1977; Shukla *et al.*, 2016; Rains & Talley, 1978).

The present investigation demonstrated that application of 60 kg N ha^{-1} through urea with azolla incorporation @ 16000 kg ha^{-1} (T_6) was found most effective in increasing grain and straw yield of rice as compared to sole application of azola or nitrogen application through urea. Therefore, the farmers of Meghalaya may be advised to use 60 kg N ha^{-1} through urea in combination with azolla incorporation @ 16000 kg ha^{-1} for getting optimum production of rice in acid soils.

Further, it indicates that farmers can manage around 30 kg N through incorporation of azolla @ 16000 kg ha^{-1} in rice crop instead of supplying through nitrogenous fertilizers keeping in view of sustainability of soil health.

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