Temporal soil fertility with organic nitrogen sources in acidic soil of Meghalaya

SHUBHAM SINGH and SANJAY-SWAMI*

Central Agricultural University, Umiam, Meghalaya 793 103, India

Received: 24 April 2019; Accepted: 09 August 2019

Key words: Acidic soil, Azolla incorporation, Rice, Soil fertility build-up, Urea

Rice (Oryza sativa L.) constitutes 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 769.6 mt in 2017 with about 90% contribution from Asia. China was the leading global producer of rice with 212.7 mt followed by India (168.5 mt) in 2017 (FAOSTAT 2017), whereas in Meghalaya it is limited to 3.0 lakh tonnes (GoM 2016). The energy crisis and high fertilizer costs have already created considerable concern, and the use of organic materials as sources of plant nutrients has been viewed important option.

The use efficiency of N from fertilizer sources in lowland rice is low (30–50%), because of its losses 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 BGA and Azolla have been shown to be the most important in maintaining and improving the productivity of rice fields. Azolla is a free-floating water fern that floats in the water and fixes atmospheric N because of its association with the N fixing cyanobacterium Anabaena (Singh et al. 2018).

An Azolla-Anabaena system is ideal for the cultivation of rice under tropical conditions because of its ability to fix atmospheric N and capacity to multiply at faster rates (Asghar et al. 2018). An investigation was carried out at CAU, Umiam, Ri-Bhoi district of Meghalaya during kharif 2017 to study the temporal soil fertility build-up with N application through urea and Azolla under lowland rice cultivation in acidic soil. The experimental soil was having pH 5.1, SOC 1.75%, available N, P and K as 288.6, 17.2 and 201.5 kg/ha, respectively. The field trial was laid out in RBD with six treatments and four replications, viz. control (T1), Azolla incorporation on fresh weight basis @16000 kg/ha (T2), 30 kg N/ha through urea (T3), 60 kg N/ha through urea (T4), 30 kg N/ha through urea + Azolla incorporation @16000 kg/ha (T5) and 60 kg N/ha through urea with Azolla incorporation @16000 kg/ha (T6). The N, P and K content in Azolla on dry weight basis was 4.2, 0.6 and 1.9%, respectively.

The soil samples from each plot were collected by core sampling at 30, 60, 90 days after transplanting and at maturity of rice crop and analysed for available N P, K and organic C by standard methods. The results revealed a decreasing trend of available N with advancement of crop age (Table 1). The combined application of Azolla and urea in T5 and T6 exhibited significant effect on available N in the soil at 90 DAT and at maturity. The T6 treated plot had significantly greater available N at 30 DAT and at maturity i.e. 319.37 kg/ha and 290 kg/ha followed by T2 treated plot in comparison to control and other treatments plots. The T5 and T6 treatments registered 20.6 and 27.2% higher available N than the control in soil samples collected at maturity. Available N varied from 227.5 kg/ha under control (T1) in the soil samples collected at maturity to 319.4 kg/ha under T6 at 30 DAT. Available N in T6 was significantly higher over T4; T5 showed superiority over T2 with advancement in crop age. Also T2 was significantly better than T1. The values of available nitrogen obtained in T2 at all the crop age(s) i.e. 30, 60, 90 DAT and at maturity were statistically at par with the available nitrogen values of T4 whereas available nitrogen estimated in T1 was statistically at par with T2 at all the crop age(s). At 30 DAT available N was more in T2 (299.6 kg/ha) as compared to T4 (299.8 kg/ha). But at 60 and 90 DAT, available N was lower in T2 than in T4, however the trend reversed at maturity (T2> T4). The higher availability of N with combined use of N sources of Azolla and urea might be due to the enhanced microbial activities and higher rate of mineralization of soil organic N with advancement of crop age whereas, the higher soil available N in organic treatments might be due to a higher N fixation by micro-organisms that led to better soil condition and also due to the nutrient release pattern from Azolla. The higher soil available N in T4 as compared to T2 and T1 might be due to faster mineralization. The lower content in control plots is a result of mining of available N with continuous cropping without fertilization during the crop period. These results are in line with the findings of Asghar et al. (2018) who also observed that available N content

*Corresponding author e-mail: sanjayswamionline@gmail.com

https://doi.org/10.56093/ijas.v90i3.101519
in soil increased with the use of recommended dose of N fertilizer in combination with organic manures.

The combined application of Azolla and urea exhibited a significant effect on available P in the soil. The T6 treated plot had significantly greater available P (24.13 P2O5 kg/ha and 20.63 P2O5 kg/ha) at 30 DAT. The T5 and T6 treatments registered 24 and 29.4% higher available P than the control at maturity stage. Available P varied from 14.91 P2O5 kg/ha under control (T1) in the soil samples collected at maturity stage soil. The enhanced K availability could be attributed to the combined source of nutrients which activated the soil micro-organisms, thereby increased the mineralization of organic matter which helped in releasing the higher amounts of P to the soil. Addition of organic nutrient source might have resulted in the enhanced organic C content in the soil. The subsequent decomposition of Azolla into the soil. The combined application of Azolla along with urea in comparison to urea alone may be attributed to the inclusion of fresh Azolla biomass in large quantity (16000 kg/ha) which added humus to the soil and thus mass per unit volume decreased, resulting in increased organic C content (Bhuvaneshwari and Singh 2015). In combination treatments, urea enhanced root growth leading to accumulation of more organic residues in the soil. The increase in organic C content in the Azolla combination is also attributed to the direct incorporation of Azolla into the soil. The subsequent decomposition of Azolla over time might have resulted in the enhanced organic C content in the soil. Addition of organic nutrient source might have created environment conducive for formation of humic acid and stimulated the activity of soil micro-organisms, resulting increased organic C content of the soil (Srilatha et al. 2013).

### Table 1 Temporal availability of soil N, P and K (kg/ha) with nitrogen application through urea and Azolla under low land rice cultivation in acidic soil

| Treatment | 30 DAT | 60 DAT | 90 DAT | At maturity |
|-----------|--------|--------|--------|-------------|
|           | N      | P      | K      | N          | P      | K      | N      | P      | K      |
| T1        | 279.95 | 15.15  | 193.04 | 252.45     | 15.01  | 181.95 | 235.95 | 14.97  | 179.95 |
| T2        | 299.56 | 21.98  | 202.41 | 281.06     | 20.23  | 190.91 | 270.56 | 19.23  | 188.16 |
| T3        | 292.88 | 15.99  | 195.63 | 280.37     | 15.80  | 187.88 | 265.87 | 15.67  | 181.58 |
| T4        | 299.84 | 16.15  | 198.84 | 282.09     | 16.05  | 189.84 | 276.59 | 15.98  | 185.09 |
| T5        | 312.38 | 23.94  | 206.99 | 295.49     | 21.49  | 197.49 | 288.99 | 20.86  | 192.99 |
| T6        | 319.37 | 24.13  | 217.32 | 311.48     | 23.35  | 210.82 | 302.48 | 22.08  | 201.82 |
| SE(m)±    | 13.97  | 0.91   | 9.39   | 13.88      | 1.12   | 8.99   | 12.36  | 0.93   | 8.48   |
| CD (P=0.05) | NS    | 2.73   | NS     | NS         | 3.36   | NS     | 37.23  | 2.79   | NS     |

The combined application of Azolla with urea significantly increased the soil organic C as compared to urea alone at maturity (Table 2). The highest (22.2%) value was observed in T5 followed by 2.14% in T6 at 30 DAT whereas the lowest (1.55%) was observed in T1 (Control) at maturity. The T6 treated plot registered 29.7 and 35.5% higher soil organic C than the control in the maturity soil samples. The significant increase in soil organic C with the combined application of Azolla along with urea in comparison to urea alone may be attributed to the inclusion of fresh Azolla biomass in large quantity (16000 kg/ha) which added humus to the soil and thus mass per unit volume decreased, resulting in increased organic C content (Bhuvaneshwari and Singh 2015). In combination treatments, urea enhanced root growth leading to accumulation of more organic residues in the soil. The increase in organic C content in the Azolla combination is also attributed to the direct incorporation of Azolla into the soil. The subsequent decomposition of Azolla over time might have resulted in the enhanced organic C content in the soil. Addition of organic nutrient source might have created environment conducive for formation of humic acid and stimulated the activity of soil micro-organisms, resulting increased organic C content of the soil (Srilatha et al. 2013).

### Table 2 Temporal availability of SOC (%) with nitrogen application through urea and Azolla under low land rice cultivation in acidic soil

| Treatment | 30 DAT | 60 DAT | 90 DAT | At maturity |
|-----------|--------|--------|--------|-------------|
|           |        |        |        |             |
| T1        | 1.64   | 1.61   | 1.58   | 1.55        |
| T2        | 2.05   | 2.02   | 1.95   | 1.93        |
| T3        | 1.68   | 1.64   | 1.61   | 1.58        |
| T4        | 1.71   | 1.68   | 1.65   | 1.60        |
| T5        | 2.14   | 2.09   | 2.05   | 2.01        |
| T6        | 2.22   | 2.18   | 2.12   | 2.10        |
| SE(m)±    | 0.17   | 0.15   | 0.16   | 0.12        |
| CD (P=0.05) | NS    | 0.44   | NS     | 0.37        |

The combined application of Azolla with urea significantly increased the soil organic C as compared to urea alone at maturity (Table 2). The highest (22.2%) value was observed in T5 followed by 2.14% in T6 at 30 DAT whereas the lowest (1.55%) was observed in T1 (Control) at maturity. The T6 treated plot registered 29.7 and 35.5% higher soil organic C than the control in the maturity soil samples. The significant increase in soil organic C with the combined application of Azolla along with urea in comparison to urea alone may be attributed to the inclusion of fresh Azolla biomass in large quantity (16000 kg/ha) which added humus to the soil and thus mass per unit volume decreased, resulting in increased organic C content (Bhuvaneshwari and Singh 2015).
The investigation demonstrated that application of 60 kg N/ha through urea with *Azolla* incorporation @16000 kg/ha (T6) was found most effective in maintaining a steady pool of soil available N, P, K and organic C and also improving the temporal soil nutrient availability as compared to sole application of organic manure or chemical fertilizers. Therefore, this may be applied in Meghalaya and other similar regions for getting optimum production of rice in acidic soils.

**SUMMARY**

A field experiment was conducted at CAU, Umiam, Meghalaya during *kharif* 2017 to investigate the effect of nitrogen application through urea and *Azolla* on temporal soil fertility build-up under low land rice cultivation at 30, 60, 90 days after transplanting (DAT) and at maturity in acidic soil. The experiment consists of six treatments with and without *Azolla* incorporation laid out in RBD with four replications. The application of 60 kg N/ha through urea along with *Azolla* incorporation @16000 kg/ha (T6) recorded highest available N (289.98 kg/ha) after harvest which was significantly superior over control (227.45 kg/ha) with 9.1% increase. Similarly, this treatment recorded highest available P, K and OC i.e. 20.6, 192.3, 2.1 kg/ha after harvest followed by T5 and T2. Further, it was also observed that available P, K and OC in T6 were statistically significant over T4 whereas T5 was significant over T3 with respect to advancement in crop age.

**ACKNOWLEDGEMENT**

The laboratory facility provided by School of Natural Resource Management, CPGSAS, CAU, Umiam for present study is duly acknowledged.

**REFERENCES**

Asghar W, Iftikhar F, Latif A and Khan I A. 2018. *Azolla* bacteria promoting rice growth under saline condition. *Agricultural Research and Technology: Open Access Journal* 18(1): 556048. DOI: 10.19080/ARTOAJ.2018.18.556048.

Bhuvaneshwari K and Singh P K. 2015. Response of nitrogen-fixing water fern *Azolla* bio-fertilization to rice crop. *Biotechnology* 5(4): 523–29.

FAOSTAT. 2017. *FAO Global Statistical Yearbook*, Food and Agriculture Organization of the United Nations.

GoM. 2016. *State Level Crop Statistics Report on Total Rice and Food Grains, 2015-16*, Government of Meghalaya, Shillong.

Singh L N, Singh R K, Singh A H and Chhangte Z. 2005. Efficacy of urea in integration with *Azolla* and vermicompost in rain-fed rice production and their residual effect on soil properties. *Indian Journal of Agricultural Sciences* 75: 44–45.

Singh S, Sanjay-Swami and Gurjar G N. 2018. Effect of nitrogen application through urea and *Azolla* on growth and biological yield of rice (*Oryza sativa* L.) in acidic soil of Meghalaya. *International Journal of Current Microbiology and Applied Sciences* 7(7): 3135–40.

Srilatha M, Rao, P C, Sharma H K and Padmaja G. 2013. Physicochemical characterization of humic substances under long-term application of fertilizers and manures in rice-rice cropping sequence in an Inceptisol. *International Journal of Advance Research* 10: 343–48.

Urkurkar J S, Tiwari A, Chitale S and Bajpai R K. 2010. Influence of long-term use of inorganic and organic manures on soil fertility and sustainable productivity of rice and wheat in Inceptisols. *Indian Journal of Agricultural Sciences* 80: 208–12.