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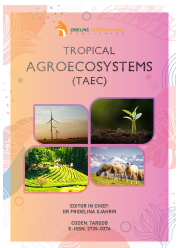

RESEARCH ARTICLE

EFFECT OF AZOLLA APPLICATION ON RICE PRODUCTION AT MID-HILLS CONDITION OF NEPAL

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ABSTRACT

Azolla pinnata, a floating water fern, is used as green manure (bio-fertilizer) for increasing rice yields. It can fix di-nitrogen (N_2) in association with Anabaena Azolla therefore helps to reduce the recommended dose of chemical-nitrogen when Azolla is applied to the paddy field. The species of Azolla has been collected from different parts of the country and maintained in the Soil Science Division, NARI, Khumaltar, Lalitpur. A field experiment was conducted at the Agronomy farm, Khumaltar to study and evaluate the effects of Azolla pinnata compared to other nutrient sources to the rice during 2015/16 and 2016/2017. The experimental design was a randomized complete block design (RCBD) comprising of 6 treatments and 3 replications. The rice variety used was Khumal-4. The results of the experiment revealed that incorporation of Azolla to rice field in combination with the recommended dose of Phosphorous and Potassium gave comparable yields to that of the recommended dose of Nitrogen, Phosphorous, and Potassium. Also, yields were comparable to that of the use of compost (10 ton/ha). The study indicates that Azolla could be a very good alternative supplementary source of fertilizer-N for rice production.

KEYWORDS

Azolla, chemical nitrogen, bio-fertilization, incorporation, rice, soil fertility.

1. INTRODUCTION

As a plant nutrient, nitrogen (N) is commonly considered an essential and critical nutrient for increasing rice growth and grain production. Nepalese rice farmers generally use urea or ammonium sulfate to nourish and fertilize their crops. Nepal imports chemical fertilizers, including N-fertilizer every year from outside the country and pays millions for purchasing them. To overcome such problems Azolla could be an alternative source of fertilizer-N which is also considered as a natural source of N-fertilizer. Azolla is an aquatic fern that is free-floating and rapidly raises its biomass over 3 to 5 days, fixing atmospheric nitrogen by establishing a symbiotic relationship with the blue-green algae Anabaena azolla. Azolla is grown before rice transplantation as green manure or as an intercrop with the rice. Both practices have been reported to increase rice growth and yield (Singh, 1989; Singh and Singh, 1995). About 80% of Nitrogen in Azolla comes from biological nitrogen fixation (BNF) (Bhattarai et al., 1987).

Azolla quickly breaks down in the soil at 3 and 8 weeks and releases 56% to 80% of its ammonia nitrogen (Khan, 1983). A group researcher described the slow mineralization in the soil of nitrogen in Azolla after its integration and that the rice crop has approximated 75 % of the total fixed nitrogen available in NH4+ form at 6 to 8 weeks (Bhattarai et al., 1987). Tuladhar has reported that combined use of Azolla and 60kg N/ha increased grain yield of rice by 17% over 60kg N/ha when used alone in the field (Tuladhar, 2003). The integrated utilization of organic and inorganic fertilizers promotes soil health and crop yields (Meelu and Singh, 1991; Prasanna et al., 2008). Phosphorus is Azolla 's single most essential nutrient. If Azolla is phosphorus-deficient, the leaves appear red or reddish-purple, the biomass is reduced, and Azolla's nitrogen content is eventually reduced (Maskey and Bhattarai, 1984). The current research was therefore undertaken to examine the possibility to use Azolla as a nutritional alternative for rice cultivation. Consequently, the main objective of this research was to study Azolla's effect on the growth and production of rice crops.

2. MATERIALS AND METHODS

The experiment was performed in Khumaltar, Lalitpur with three replications for two growing seasons (2015 and 2016) in a randomized complete block configuration. The rice variety Khumal-4 was used. A total of six different combination treatments were selected for the study (Table 1). An individual plot size of 10 m2 (2 m x 5 m) with a spacing of 20 cm x 20 cm (PP x RR) was maintained. A non-fertilized and no Azolla used treatment (T1) was used as control. All amounts of compost, Phosphatic, and Potassium fertilizers were applied basally in the concerning plots. Nitrogen fertilizer (urea) was applied in 2 splits, one as basal dose and the other as top-dressing. Azolla@ 300 kg ha-1 was inoculated after transplanting of rice and was either incorporated at the weeding time (40 days of transplanting) or used un-incorporated as per the treatments. Plant growth parameters and yield components were recorded for the study. The recommended dose of fertilizer used for rice was 100:40:30 kgha-1. All the studied parameters were analyzed using

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statistical package R. the data were subjected to a combined over year analysis of variance (ANOVA).

3. Results

Growth and grain production of rice was observed greatly affected under different treatments in Khumaltar condition during 2015/16 to 2016/17. An increase in plant height was observed in treatments associated with the Azolla application. Treatments T4, T5, and T6 where Azolla was used resulted in significantly higher plant heights (Figure 1) compared to the control (T1) treatment. However, the recommended dose of fertilizer (T2) also gave significantly higher plant heights in relation to control without showing significant differences from the Azolla applied treatments. Treatments T2, T3, T5, and T6 presented the greatest tiller numbers (Figure 2) without showing significant differences among them. The application of Azolla in combination with the chemical Phos-

Table 1: Different treatment combinations used in the field experiment.

SN	Azolla	Fertilizer			
		N (kg ha^{-1})	P_2O_5(kg ha^{-1}	K_2O (kg ha^{-1})	Compost (ton ha
T1	No Azolla	0	0	0	0
T2	No Azolla	0	0	0	10
T3	No Azolla	100	40	30	0
T4	Azolla incorporated	0	0	0	0
T5	Azolla incorporated	0	40	30	0
T6	Azolla unincorporated	0	40	30	0

Phorous and Potassium (T5 and T6) gave significantly higher tiller numbers compared to the control (T1) treatment. It was observed that compost application (T3) and RDF only (T2) treatments also showed significantly higher tiller numbers in relation to control, which recorded the poorest tiller numbers.

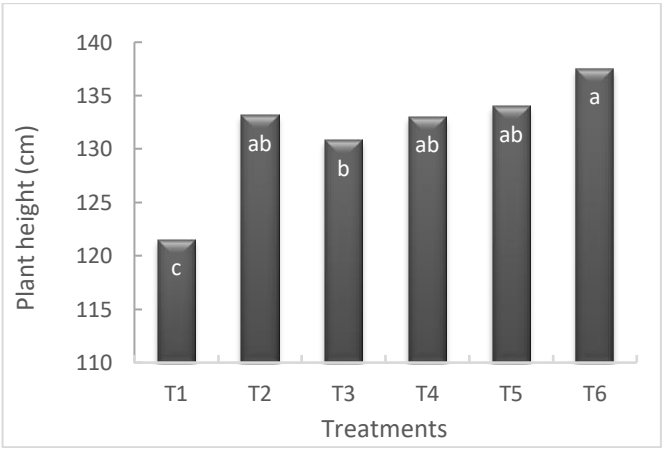

Figure 1: Effect of treatments on rice plant height(cm)

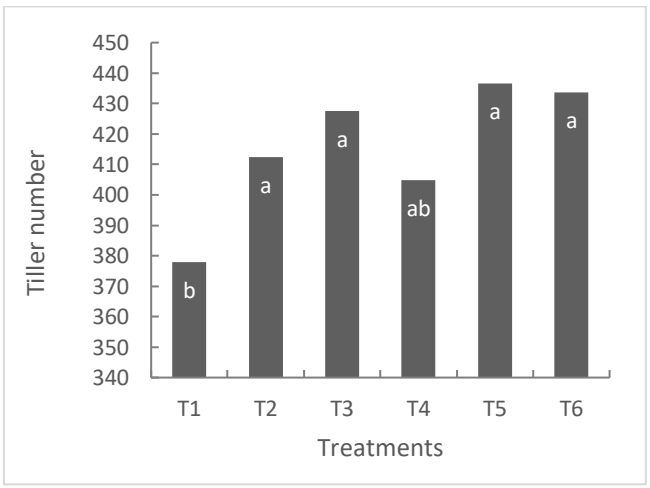

Figure 2: Effect of treatments on rice tiller number

The effect of the Azolla application was evident in the panicle length character. This trait was significantly affected by the Azolla association. T4, T5, and T6 presented significantly higher panicle lengths (Figure 3) in relation to control. Also, compost only application (T3) resulted in significantly higher panicle lengths compared to control. Regarding thousand seed weight (TSW), treatments T6, T5, T2, and T3 recorded significantly higher seed weights (Figure 4) compared to that of control. Treatments T2 and T3 resulted in greater thousand seed weight overall but were not significantly different from Azolla applied treatments.

In all the Azolla associated treatments, there was a significant increase in the grain yield over the control (Figure 5). However, the highest grain yield was obtained from the treatment T5. Application of recommended dose of fertilizer (T2) and compost (T3) each recorded grain yields comparable to that of the T5. Use of unincorporated Azolla (in T6) and incorporated Azolla only (T4) yielded significantly lower than T2, T5, and T3 but were still able to record significantly higher grain yields in relation to control.

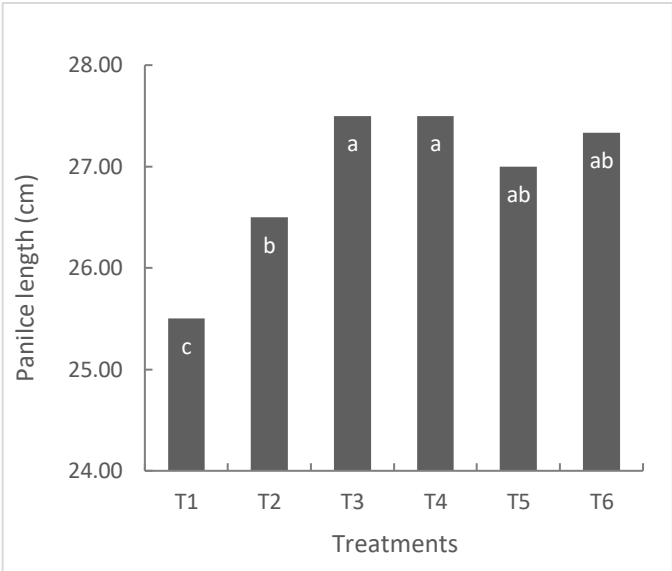

Figure 3: Effect of treatments on rice panicle length(cm)

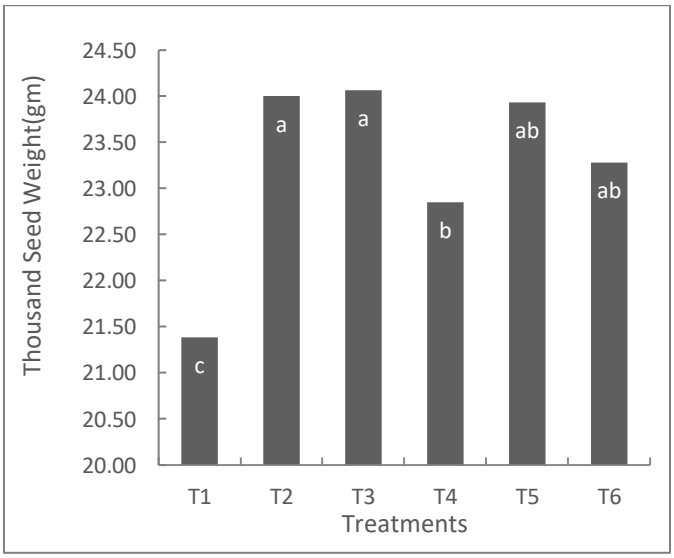

Figure 4: Effect of treatments on Thousand Seed Weight(gm)

4. Discussion

This study examined the effect of varied fertilization techniques on the growth and yield of rice. Using Azolla resulted in a higher number of tillers, panicles, and thousand seed weight compared to control (no Azolla application). A significant character may be the number of tillers, which will typically increase with the N rate (Prasertsak and Fukai, 2014; Pirmoradian et al., 2004). The high tillering ability can have a remarkable effect on rice production because tillers are closely

linked to the number of panicles per plant (Miller et al., 1991). Grain yields in different treatments have shown that using Azolla with the recommended amount of Phosphorous and Potassium will increase the yield of rice. Roy found that when inorganic nitrogen was applied, the mineralization of Azolla was more (Roy, 1984).

It can yield statistically similar levels to that of when using the recommended dose of chemical fertilizer for rice production. In this study, the increase in grain yield with Azolla could be attributed to the higher availability of Azolla nitrogen, efficient absorption of N, and possibly other nutrients. Azolla biofertilizer treatments improved rice N utilization efficiency, due to reduced N loss, and increased rice plant uptake of N (Yao et al., 2018).

The incorporation of Azolla has many advantages over raw, unrotted organic matter, and chemical fertilizers because its content materials are gradually delivered to the plants and it can maintain its reserves for a long time. A group researchers found that when Azolla was incorporated, the recovery of nitrogen was higher than when it was placed at surface water (Watanabe et al., 1981). It may help cope with the yield loss caused by the lack or deficiency of certain nutrients and micronutrients.

Azolla application desirably affects plant growth and biological yield, and increases OM, thereby enhancing nutrient quality (Gupta and Potalia, 1990). Earlier studies have demonstrated the positive impact of demand for Azolla on grain yield from rice (Arshad et al., 2004; Rizwan et al., 2007; Bi et al., 2009). Watanabe found that rice yield was increased up to 13% when Azolla was used as a biofertilizer in rice crop (Watanabe, 1977).

Overall, as indicated by the results of this report, the use of Azolla as green manure has great potential in rice, but constraining factors to its use are also important. The economics of using Azolla is very important because technology is very labor-intensive. Sometimes, therefore, farmers may have little to no economic benefit in choosing Azolla over chemical fertilizer because the possible additional labor costs, irrigation of land resources, application of phosphate fertilizer, and pesticides may make Azolla 's usage uneconomical.

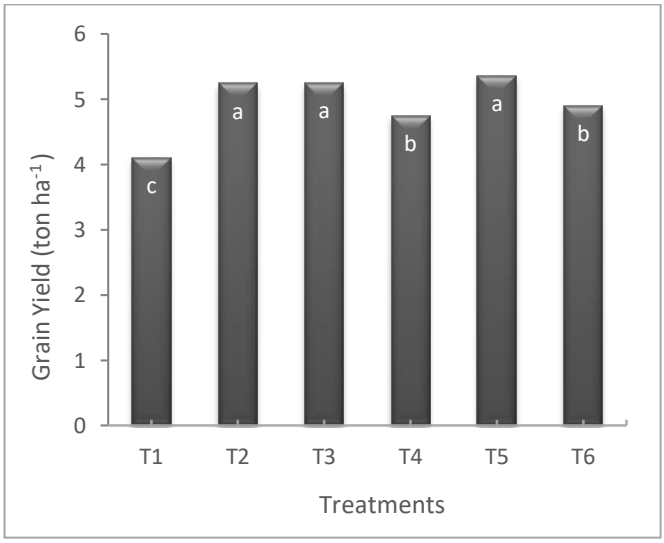

Figure 5: Effect of treatments on rice grain yield (ton ha-1)

5. Conclusion

Study findings showed that the incorporation of Azolla could contribute to the achievement of an environmentally friendly rice cropping system. The results showed that Azolla may be a supplementary alternative source of fertilizer-N. However, Azolla alone will increase the rice yield by at least 12-14 percent without any additional fertilizer-N but it needs a required dose of P and K fertilizers to meet the crop's nutrient requirements. Under proper water management, Azolla plays a vital role as a natural-nitrogen source in rice farming.

This suggests that Azolla application can be a viable option to the rice farmers for sustaining higher yields and protecting the environment as well. Further researches on ways to improve the efficacy and yield potential of Azolla is required. Studies are required on addressing the key issues of better exploitation and utilization of Azolla to improve its utility in agriculture and applied fields.

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Conflict of Interest

The authors declare no conflict of interest.

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