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ORIGINAL ARTICLE

Efficacy *of Azolla pinnata* in Rice (*Oriza sativa* L.) production in Nepal

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ABSTRACT
Because of the nitrogen (N) fixing ability and exponential growth rate Azolla has been considered as a natural N-factory which can be utilized as a bio-fertilizer or green manuring crop in rice cultivation. It is evident that Azolla could increase rice yield satisfactorily. To evaluate and verify the effects of Azolla pinnata in the production or rice variety (Sabitri), an experiment was conducted in Regional Agriculture Research Station (RARS), NARC, Parwanipur Bara in from 2015 A.D. to 2016 A.D. Three replications of six treatments (Azolla incorporation plus 40 and 30 kg ha^{-1} of P_2O_5 and K_2O, Azolla non-incorporation plus 40 and 30 kg ha^{-1} of P_2O_5 and K_2O, Azolla incorporation only, 100:40:30 kg ha^{-1} N, P_2O_5 and K_2O, 10 t ha^{-1} compost) were laidout in a randomized complete block design (RCBD). Rice growth and yield parameters were taken into the study and analysed statistically. The results revealed that plant height, tiller number and straw yield were significantly affected by the treatments. The highest grain yield (2.78 t ha^{-1}) was produced by the application of recommended dose of fertilizers (100:40:30 N, P_2O_5 and K_2O) which was almost 55 % higher than those produced by non-treated control crop followed by by the crop treated with Azolla incorporation applied along with 40 and 30 kg ha^{-1} of P_2O_5 and K_2O which was approximately 17 % higher than that of control crop. Application of compost alone at 10 t ha^{-1} increased the rice yield only by 15 percent. It seems that Azolla could be a good alternative source of chemical-N in areas where fertilizer is not available, expensive or is limited. In the other hand, it is more beneficial to the rice crop if applied in combination with other fertilizers.

Keywords: *Azolla pinnata*, *Oriza sativa* , nitrogen fixation, rice yield increase

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INTRODUCTION

Nitrogen (N) as a plant nutrient is generally considered a basic and vital nutrient for increased growth and grain production of rice (*Oriza sativa* L.) crop. Nepalese rice farmers generally use urea-N [$CO.(NH_2)_2$] or ammonium sulphate [$(NH4)_2.SO_4$)] to nourish and fertilize their crops. Nepal imports chemical fertilizers, including N-fertilizer every year from outside the country and pay millions of Dollars for purchasing them. These fertilizers more often difficulty to reach the farmers and sometimes not available in the cropping season and also, are very costlier. To overcome from such problems *Azolla* could be an alternative source of fertilizer-N which is also considered as Natural source of N-fertilizer which can help replace the fertilizer-N to some extent and if managed properly it can supplement a big amount of nitrogen (N) as high as 50 kg N ha^{-1} with a single crop of *Azolla* just within a month or two (Adhikary *et al.*1997 b). Research evidences have proved that it can increase rice yields by 50 % only by the use of *Azolla* alone.

METERIALS AND METHODS

Field experiments were conducted in the Regional Agricultural Research Station (RARS), Parwanipur during the year 2014/15 to study and evaluate the effects of *Azolla pinnata* and its application methods to the rice crops (*Oriza sativa* L). A total of six different combination treatments were taken into the study. The details of treatments have been shown in the Table 1. Randomized Complete Block Design (RCBD) with 3 replications was employed in the experiment. Plot size of 10 sq.m (2 m x 5 m) and spacing of 20 cm x 20 cm (PP x RR) was maintained. All amount of compost and PK fertilizers were applied basally in the

concerning plots but nitrogen fertilizer (N) was splitted 2 times, one as basal dose and the other as top-dress to the rice crop. *Azolla pinnata* @ 300 kg ha-1 was inoculated after transplanting of rice and was either incorporated at the weeding time (40 days of transplanting) or not incorporated depending upon the treatments used in the concerning plots. Sabitri variety of rice was used in the experiment. Plant growth parameters and yield components were taken into the study. All the studied parameters were analysed statistically following MSTAT package. *Azolla* plant samples, soil samples before crop planting and after crop harvest were analysed at Soil Science Division laboratory at Khumaltar, Lalitpur. Kjeldahl Distillation, Olsen's method and Flame Photometric methods were employed for nitrogen (N), phosphorus (P) and potash (K) analysis.

Table 1: Different treatment combination used in the field experiment

Treat-ments	*Azolla pinnata* use	Fertilizer and compost use	Remark
T_1	Control (no *Azolla*).	No fertilizers.	100:40:30 kg ha-1 is the recommended dose of fertilizer for rice.
T_2	*Azolla* applied @300 kgha-1 and incorporated after one month of inoculation. *Azoll*a @300 kgha-1 (non-incorporation).	40: 30 kgha-1 P_2O_5: K_2O.	
T_3	*Azolla* applied @300 kgha-1 and incorporated after one month .	40: 30 kgha-1 P_2O_5: K_2O.	
T_4	*Azolla* not applied.	No fertilizers applied.	
T_5	*Azolla* not applied.	100:40:30kgha1 N:P_2O_5: K_2O.	
T_6		Compost 10 tha-1	

RESULTS AND DISCUSSION

Effect of *Azolla pinnata* on rice grain production

The lowest grain yield of 1.79 t ha-1 was recorded in the non-treated control crop followed by the crop treated with *Azolla* incorporation only (1.84 t ha-1). These yield records are significantly different to those produced by the crop treated with recommended dose of fertilizers (N, P_2O_5 and K_2O at 100:40:30 kg ha-1) which produced an yield of 2.78 t ha-1 followed by the crop treated with Azolla incorporation plus P and K at 40 and 30 kg ha-1. The results indicated a sharp response of fertilizers than those produced by the application of *Azolla* or by compost. The yield was increased by 35 % with full dose of recommended doe of fertilizers over the control crop followed by the increase of 14.76 % with *Azolla* incorporation applied along with P and K fertilizers at 40 and 30 kg ha-1. Application of compost at 10 t ha-1 increased crop yield only by 13.1 % of the rice crop (Table 2).

Table 2: Response of treatments on the plant growth and grain yield of rice at Parwanipur, Bara during the year 2015/16.

Treatments	Grain yield, t ha-1	Yield increase, kg ha-1	Yield increase, %
T_1	1.79 b	0.00	00.00
T_2	2.10 b	310.0	17.31
T_3	1.98 b	190.0	10.61
T_4	1.84 b	50.0	02.79
T_5	2.78 a	990.0	55.30
T_6	2.06 b	270.0	15.08
Grand mean	1.09		
CV, %	12.39		
F-test	*		
LSD (0.05)	0.470		

Means in a column with a common letter(s) are not significantly different at 95 % level of confidence.

Table 3: Soil test results of the experimental plots before crop Planting and after crop harvest at Khumaltar and Parwanipur, Bara.

Treatments	Organic matter (SOM), %	Nitrogen (N) %	Phosphorus (P_2O_5), $kgha^{-1}$	Potassium (K_2O), $kgha^{-1}$
T_1	2.99 (1.42)	0.13 (0.07)	149.3 (115.3)	344.3 (142.3)
T_2	2.95 (0.82)	0.13 (0.06)	174.3 (112.6)	272.3 (137.6)
T_3	3.41 (1.21)	0.14 (0.07)	170.6 (111.6)	294.6 (169.6)
T_4	3.91 (0.76)	0.15 (0.07)	133.3 (98.0)	335.3 (169.3)
T_5	3.12 (1.02)	0.13 (0.07)	129.3 (132.6)	353.0 (209.6)
T_6	3.50 (0.91)	0.13 (0.07)	150.6 (111.3)	320.3 (160.3)
Composite sample	NA	0.125 (0.06)	146 (191)	358.0 (277.0)
Azolla plant	NA			

CONCLUSION

The results of this investigation revealed that *Azolla* could be an alternative supplementary source of fertilizer-N. Further, *Azolla* alone can increase rice yield at least by 12-14% without any additional fertilizer-N but recommended dose of P and K fertilizers are needed to meet the nutrient requirement of the crop. Results also indicated that applications of 10 tha^{-1} of compost alone on rice was comparable with *Azolla* applied rice crops either incorporated or non-incorporated at the recommended level of P and K fertilizers. Research from this experiment and other evidences indicated that farmers are advised to apply *Azolla* in their rice fields along with 50% of recommended dose of N and full dose of P and K fertilizers. *Azolla* could play a vital role as a natural -nitrogen source in organic rice farming which is better than other green manuring crops for paddy under adequate water management.Farmers are suggested to use *Azolla* in combination with P and K fertilizers in rice cultivation.

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