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EFFECT OF *AZOLLA* AND NITROGENOUS FERTILIZER ON YIELD PERFORMANCE OF RICE*

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Abstract

The effect *Azolla pinnata* on rice yield was compared with the effect of nitrogenous fertilizer in the form of urea. Two commercial varieties of rice viz. IR6 and Basmati 370 were used when 15 t/ha of *Azolla* plus half recommended dose of nitrogen gave the highest grain yield, followed sequentially by full dose of nitrogen, 15 t/ha of *Azolla*, half dose of nitrogen, and the control. The treatment means over both varieties showed significant differences ($P < 0.01$) on grain yield in all treatments. The cost of at least half of the recommended dose of nitrogenous fertilizer for the rice crop could be saved by adopting *Azolla* culture.

Introduction

The significance of *Azolla* with its symbiont endophytic *Anabaena* is now well documented (Moore, 1969; Talley *et al.*, 1977; Watanabe *et al.*, 1977; Singh, 1979; Lumpkin & Plucknett, 1980). *Azolla pinnata* is a small floating aquatic fern that grows in standing water of channels, ponds, ditches and paddy fields under diverse ecological conditions. It harbours a symbiotic nitrogen fixing blue green alga *Anabaena azollae* in the cavities on the ventral side of its leaves. By this unique fern-alga symbiotic association, the delicate *Azolla* provides nutrients and protective cavities to *Anabaena colonies*, which in exchange, fix atomospheric nitrogen and make it readily available to *Azolla* and eventually to crop plants (Singh, 1977; Ashton & Walmsley 1976). It is estimated that *Azolla*, through its symbiotic process, fixes about 500 kg/ha of atmospheric nitrogen annualy (Watanabe *et al.*, 1981). Because of its high nitrogen fixation potential and rapid growth in wetland, *Azolla* has been used as a green manure for rice for centuries in Vietnam and China. The scientific interpretations of the beneficial effects of this practice is, however, a recent development (Singh, 1977; Watanabe, 1977). In Sri Lanka, *Azolla* inoculation in broadcast, transplanted, and avenue transplanted crop increased effectively the rice yield by 14, 22 and 48%, respectively (Kulasooriya, 1982). It has now become a traditional part of rice culture and rotation in some Asian countries, where it is known to increase rice production.

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Due to the increasing price of chemical fertilizers and the serious concern about their adverse effect on the environment, the potential of using *Azolla* as an alternate source of nitrogen has received considerable attention in recent years. The present studies were undertaken to evaluate the comparative effect of *Azolla* as a source of nitrogen alone and in combination with the chemical fertilizer urea on the grain yield, and the harvest index of the rice crop.

Materials and methods

The initial inoculum of *Azolla pinnata* was obtained from the stock maintained at PCSIR laboratories, Karachi, and was multiplied continuously throughout the year in tanks and rice fields at the Experimental Farm of Atomic Energy Agricultural Bank under the atmospheric and water temperatures ranging from 22°-39°C. Proper care of *Azolla* was taken during its multiplication by maintaining optimum pH of 7-8 of water through the application of phosphatic fertilizer and by using suitable granular pesticide padan.

Two most commonly cultivated commercial varieties of rice viz., the high yielding, semi-dwarf, medium fine-grain variety IR6 and the tall growing, fine-grain, aromatic variety Basmati 370 were used. The experimental design was randomized complete block with four replications, with plot size of 4 x 3m. One month old seedlings were transplanted at a distance of 20cm between rows and also between hills in each row with an average of three seedlings per hill. Five treatments used were (i) control with no nitrogen, no phosphorus and no *Azolla*, (ii) 15 t/ha of fresh *Azolla* (in three splits) plus phosphorus, in the form of single super-phosphate, (iii) half of the recommended dose of nitrogen in the form of urea plus phosphorus, (iv) half of the recommended dose of nitrogen plus phosphorus plus 15 t/ha of fresh *Azolla* and (v) the full recommended dose of nitrogen and phosphorus @ 120 kg N + 60 kg P/ha for variety IR6 and 80 kg N + 50 kg P/ha for variety Basmati 370. Phosphorous was in the form of single super-phosphate as basal dose 60 kg P/ha for IR6 and 50 kg P/ha for Basmati 370 in all treatments except control, where it was not applied. The half dose of nitrogen (urea) and full dose of phosphorus was applied as basal dose at transplanting and the remaining half dose of nitrogen was applied at panicle initiation. Chemical analysis of *Azolla* at the time of its incorporation in soil showed an average of 4.11% nitrogen, 0.40% phosphorus, 4.30% potassium, 0.38% calcium, and 1.60% sodium on dry weight basis.

The first inoculation of fresh *Azolla* was done @ 6 kg per treatment/plot, equivalent to 0.5 kg/m2, before transplanting where it multiplied and resulted in mat formation within 2 weeks. The *Azolla* mats were incorporated in the soil by stopping irrigation to lower the water level and then by trampling them under feet before transplanting rice. Subsequently, two more inoculations were made that resulted in the formation of *Azolla* mats. The first one of these mats was incorporated 2 weeks after transplanting, and the

second at the time of panicle initiation. The three applications resulted into a total quantity of about 15 t/ha of fresh *Azolla* per treatment, which was approximately equal to 100 kg N/ha. At maturity, the crop was harvested and observations on grain yield/plot, biological yield of $1m^2$, harvest index of $1m^2$ and grain/straw ratio of $1m^2$ recorded.

Results and discussion

Response of fertilizer application and *Azolla* culture was significantly positive in both varieties. Application of 15 t/ha of *Azolla* plus half dose of nitrogen gave highest grain yield followed by full recommended dose of nitrogen, and 15 t/ha of *Azolla*, half recommended dose of nitrogen and the control (Table 1). Rice where 60 kg N/ha plus 15 t/ha of *Azolla* was used in the rice CV IR6 gave the grain yield of 8.49 t/ha, which was 46.41% more than the control and was highest among all the treatments. The treatment with full dose of 120 kg N/ha recommended for semi-dwarf IRRI varieties gave the second highest grain yield of 8.19 t/ha, which was 41.23% more than the control. The sequence of grain yield for other treatments was 15 t/ha of *Azolla* (6.72 t/ha), 60 kg N/ha (6.42 t/ha) and the control treatment (5.80 t/ha).

In Basmati 370 also the result was similar to that of IR6. Treatment with 40 kg N/ha, which was half of the recommended dose of 80 kg N/ha for local tall growing varieties plus 15 t/ha of fresh *Azolla* gave the highest grain yield of 4.96 t/ha, which was 97.67% more than the control. The treatment with 80 kg N/ha gave the second highest grain yield of 4.48 t/ha which was 78.41% more than the control. The other treatments in order of their grain yield were 15 t/ha of *Azolla* (3.77 t/ha), 40 kg N/ha (3.08 t/ha) and the control (2.51 t/ha).

Application of *Azolla* alone proved better than half the recommended dose of nitrogen by giving significantly higher grain yield in both varieties of rice. The results also indicated that *Azolla* itself provided about 70 to 100 kg N/ha. These observations showed that incorporation of *Azolla* in the soil had positive effect on the grain yield of rice crop. Such increases in grain yield of rice through *Azolla* treatment alone as well as in combination with synthetic nitrogenous fertilizer have been reported (Moore, 1969; Kulasooriya & de Silva, 1977; Sawatdee *et al.*, 1978; Singh, 1979; Srinivasan, 1980; Watanabe 1984). Singh (1979) has reported that a thick layer of *Azolla* ensured about 30-40 kg N/ha because it contained 4-5% N on dry weight basis. The present studies lead to the conclusion that *Azolla* is a good source of nitrogen, which is efficiently utilized by the rice crop resulting in increased production. With proper use of *Azolla* culture, it is possible to reduce 50% the cost of nitrogenous fertilizer in rice cultivation.

Table 1. Effect of *Azolla* and nitrogenous fertilizer on grain yield and other characters of rice varieties IR6 and Basmati 370.

Varieties	Treatments		Biological yield* (kg/m^2)	Grain/ straw ratio	Harvest index	Grain yield* (tons/ha)	Percentage increase over control
IR6	Control	(T_1)	15.55 e	0.88	0.47	5.80 e	—
	60 kg P/ha + *Azolla*	(T_2)	17.55 c	0.91	0.47	6.72 c	15.80
	60 kg N + 60 P/ha	(T_3)	16.35 d	0.89	0.47	6.42 d	10.63
	60 kg N + 60 kg P/ha + *Azolla*	(T_4)	21.29 a	0.92	0.48	8.49 a	46.41
	120 kg N + 60 kg P/ha	(T_5)	20.43 b	0.93	0.47	8.19 b	41.23
Basmati 370	Control	(T_1)	9.32 e	0.48	0.32	2.51 e	—
	50 kg P/ha + *Azolla*	(T_2)	13.81 c	0.49	0.33	3.77 c	50.20
	40 kg N + 50 kg P/ha	(T_3)	11.37 d	0.48	0.33	3.08 d	22.71
	40 kg N + 50 kg /ha + *Azolla*	(T_4)	18.11 a	0.49	0.33	4.96 a	97.61
	80 kg N + 50 kg P/ha	(T_5)	16.38 b	0.49	0.33	4.48 b	78.49
Statistical estimates:							
IR6	L.S.D. (.05)		0.21			0.100	
	L.S.D. (.01)		0.29			0.142	
Basmati 370	L.S.D. (.05)		0.03			0.083	
	L.S.D. (.01)		0.05			0.117	

*Means followed by different letters in the same column are significantly different from each other at 1% level of significance.

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