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RESPONSE OF RICE TO AZOLLA INOCULATION AND FERTILIZER NITROGEN

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Abstract: Field experiments were conducted to study the effect of fertilizer nitrogen and azolla on yield of rice in Tamil Nadu Agricultural University wetland farm, Coimbatore. Experiments were laid out in a randomised block design with four replications during kharif and rabi, 1984-85. Azolla as dual crop, green manure, different forms of urea like prilled urea (PU), urea super-granules (USG) and neem coated urea (NCU) and their combinations were tried. Azolla biomass production was more in rabi season than kharif. All the forms of urea applied at 75 kg N/ha with and without azolla produced more yield than the control. Plots treated with 25 kg N each as PU, USG and NCU besides azolla as dual crop in kharif and 75 kg N as NCU and azolla as dual crop in rabi recorded the highest grain yield. Dry matter production had the maximum direct effect on grain yield in both the seasons.

INTRODUCTION

The shortage of chemical fertilizers and their high cost have focussed the attention in recent years to explore possibilities of utilizing nitrogen fixing organisms to augment the crop productivity. In wetland rice, azolla is considered to be a potential biological system (Kannaiyan, 1979). The utilization of azolla as biofertilizer for rice crop has been well established in recent years (Kannaiyan, 1985 and Watanabe, 1985) and the application of azolla as green manure or as dual culture has been shown to increase the grain yield of rice which was equivalent to the application of 30-40 kg N/ha (Lumpkin, 1984). *Azolla pinnata* R. Brown is the most common species prevalent in Tamil Nadu which is effectively used as dual culture with rice (Kannaiyan, 1979). The beneficial effects of azolla coupled with high cost of fertilizers necessitates the integrated use of organic and inorganic fertilizers to reduce the input cost. The present field investigation was undertaken to find out the combined effect of fertilizer nitrogen and azolla inoculation on rice yield.

MATERIALS AND METHODS

Field experiments were conducted in randomised block design with four replications during kharif (June-Sep) and rabi (Nov-March) seasons of 1984-85 in two different sites to study the effect of fertilizer nitrogen and azolla on rice. The soils of the experimental sites were clay loam. The available N, P and K of the two experimental sites were 274, 34, 707 and 442, 101 and 762 kg/ha respectively. *Azolla pinnata* R.Brown (A.pin-SK-CI strain) maintained at the Pady Breeding Station, Coimbatore was used in the nursery plot as per the method developed by Kannaiyan (1982). The treatments were

(T1) Control
(T2) Azolla as dual crop (DC) 200 g/m^2
(T3) Azolla as green manure, 10 t/ha
(T4) 75 kg N as prilled urea (PU)
(T5) 75 kg N as prilled urea + azolla (DC)
(T6) 75 kg N as urea super-granule (USG)
(T7) 75 kg N as urea super-granule + azolla (DC)
(T8) 75 kg N as neem-coated urea (NCU)
(T9) 75 kg N as neem coated urea + azolla (DC)
(T10) 25 kg N as PU + 25 kg N as USG + 25 kg N as NCU
(T11) 25 kg N as PU + 25 kg N as USG + 25 kg N as NCU + azolla (DC)

Wet nursery plots of 40 m^2 with channels all round in a puddled and levelled field were formed and rice was sown at the rate of 40 kg/ha. No fertilizer application was done for the nursery.

For all the treatments P and K were applied basally at the rate of 50 kg/ha. Azolla at 10t/ha was applied as green manure and incorporated before planting. For dual culturing, azolla at 200 g/m was inoculated one week after planting rice. Azolla was incorporated twice on 35th and 60th day after inoculation in kharif and 15th, 35th and 60th day after inoculation in rabi season. Prilled urea was applied in two splits, half as basal and the remaining half at 20 days after transplanting in kharif and 40 days after transplanting in rabi seasons. Neem-coated urea was prepared by mixing 20 per cent (w/w) neem cake powder with prilled urea and then shade drying for 3 hours.

In kharif, IR 50 sedlings were planted with a spacing of 15 x 10 cm and in rabi, Co.43 seedlings were planted with a spacing of 20 x 10 cm. Water level in the experimental plots was maintained at 3-5 cm throughout the period of experiment. Two hand weedings were done at 20th and 40th day after transplanting.

N, P and K contents of the plant samples of three stages were estimated. Preplanting and post-harvest soil samples were analysed for available N, P and K. The data were statistically analysed. The correlation coefficients were partitioned into direct and indirect effects of the above five plant characters on grain yield as per the method developed by Dawy and Lu (1959).

RESULTS AND DISCUSSION

Azolla inoculated plots as dual crop without any fertilizer nitrogen have recorded maximum azolla biomass production i.e., 15.6 and 27.6 t/ha in kharif and rabi seasons respectively. The other plots which have received different forms of N fertilizer along with azolla inoculation recorded almost similar trend. In general, more azolla biomass was produced in rabi than kharif season (Table 1). In kharif, the day and night temperatures were high and the crop duration was also less. The multiplication was less in kharif due to environmental conditions prevailed during that period. However, in rabi, the climate was conducive particularly due to the low temperature in both day and night times and thereby increasing the growth of azolla. The significant role of day/night temperatures on growth, multiplication and nitrogen fixing abilities of different azolla species has been earlier reported by Talley and Rains (1980) and Kannaiyan and Rains (1985). The high cost of chemical fertilizers and the beneficial biofertilizer value of azolla necessitated such study to identify the best combination of fertilizers which could increase the rice yield at comparatively low cost.

Highest grain yield was recorded in T11 during kharif, whereas T9 recorded highest grain yield during rabi (Table 2). The grain yield in kharif could be predicted by the equation $Y = 1446.17 - 17.09 X1 + 0.49 X2 - 0.33 X3 + 63.87 X4 + 174.82 X5$ and the yield in rabi could be predicted by the equation $Y = -873.47 - 9.97 X1 + 0.32 X2 - 3.77 X3 + 38.72 X4 + 78.17 X5$ where Y is the grain yield and X1, X2, X3, X4 and X5 are the number of tillers, dry matter production, panicle per m^2, panicle length and panicle weight respectively. It is evident from the results that azolla as dual crop along with three different forms of urea (PU, USG and NCU) has significantly increased the grain yield in

Table 1. Effect of azolla inoculation as dual crop with rice on biomass production

Treatments	Azolla biomass (g/m^2)						Total azolla biomass incorporation (t/ha)	
	I incorporation (15 days)		II incorporation (35 days)		III incorporation (60 days)			
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Azolla as dual crop(DC)	-	823	983	1278	573	655	15.56	27.56
75N as PU + azolla (DC)	-	748	555	950	518	718	10.73	24.16
75 N as USG + azolla (DC)	-	728	533	1135	560	430	10.93	22.93
75 N as NCU + azolla (DC)	-	730	448	803	570	490	10.18	20.23
25 N as PU + 25 N as USG + 25 N as NCU + azolla (DC)	-	664	513	1048	513	535	10.26	22.47
SEd		97.30	93.20	296.50	125.39	94.20		
CD (0.05)		NS	203.10	NS	NS	NS		

Table 2. Effect of fertilizer nitrogen and azolla on grain and straw yield of rice (1984-85)

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	
	Kharif	Rabi	Kharif	Rabi
T1	2269	3268	3140	5003
T2	2844	3694	3809	5301
T3	2800	3625	4092	5284
T4	3573	4679	4542	6150
T5	3912	4932	4704	6368
T6	3838	4621	4709	6423
T7	4347	4817	4812	6515
T8	3637	4875	4617	6402
T9	4232	5128	4724	6589
T10	4001	4822	4638	6522
T11	4358	5055	4679	6389
SEd	139.9	200.3	100.4	152.2
CD (0.05)	285.7	409.1	205.0	310.8

Table 3. Path coefficient analysis showing the direct and indirect effects of five characters of rice (kharif)

	Number of tillers	Dry matter production	Panicles per m^2	Panicle length	Panicle weight
Number of tillers	-0.034	0.607	-0.010	0.026	0.023
Dry matter production	-0.022	0.933	-0.013	0.043	0.032
Panicles/m^2	-0.018	0.678	-0.018	0.027	0.032
Panicle length	-0.008	0.374	-0.004	0.106	0.010
Panicle weight	-0.014	0.553	-0.011	0.019	0.054

Underlined figures denote the direct effect

both the seasons. This might be due to the nature of slow release fertilizer USG i.e., low dissolution rate, reduced denitrification of ammonia and leaching losses. The effect was further increased by the azolla N which was added at the later period of crop growth after decomposition and mineralisation of azolla fronds. Juang (1980) found that USG was more efficient by 40-50 per cent than conventional prilled urea. Neem cake which contains nimbin, nimbidol, nimbosterin, nimbicatin and azadiractin have been shown to have inhibitory action on nitrification process by inhibiting the nitrifying bacteria viz.,

Table 4. Path coefficient analysis showing the direct and indirect effects of five characters (rabi)

	Number of tillers	Dry matter production	Panicles per m^2	Panicle length	Panicle weight
Number of tillers	-0.026	0.253	0.072	0.019	0.004
Dry matter production	-0.008	0.787	0.143	0.029	0.017
Panicle/m^2	-0.010	0.603	0.186	0.029	0.013
Panicle length	-0.009	0.410	0.094	0.056	0.010
Panicle weight	-0.004	0.516	0.093	0.023	0.025

Underlined figures denote the direct effect

Table 5. Correlation coefficients for five characters in rice (kharif)

	Number of tillers	Dry matter production	Panicles per m^2	Panicle length	Panicle weight
Grain yield	0.6122"	0.9730"	0.7017"	0.4768"	0.6012"
Number of tillers		0.6500"	0.5309"	0.2436	0.4219"
Dry matter production			0.7263"	0.4003"	0.5923"
Panicle/m^2				0.2585	0.5968"
Panicle length					0.1797

* Significant at 5% level ** Significant at 1% level

Table 6. Correlation coefficients for five characters in rice (rabi)

	Number of tillers	Dry matter production	Panicles per m^2	Panicle length	Panicle weight
Grain yield	0.3232"	0.9675"	0.8207"	0.5628"	0.6531"
Number of tillers		0.3219"	0.3857"	0.3453"	0.1654
Dry matter production			0.7655"	0.5216"	0.6560"
Panicles/m^2				0.5064"	0.4971"
Panicle length					0.4126"

*Significant at 5% level ** Significant at 1% level nitrosomonas and nitrobacter (Khandelwal *et al.* (1977). Neem cake application was found to stimulate the growth of nitrogen fixation in *Azolla pinnata* (Kannaiyan *et al.*, 1984). In the present investigation azolla grown as dual crop provides azolla N at the later period of crop growth due to slow decomposition and mineralisation. The combination of urea with azolla enhanced the mineralization and the availability of N was found to be rapid (Nandabalan, 1985).

Straw yield was highest in T7 and T9 during kharif and rabi seasons respectively (Table 2). Slow release of N from USG, reduced loss of N from N fertilizer and also extra supply of azolla N at the later period of crop growth would have resulted in increased plant height and number of tillers which in turn increased the straw yield. However, in rabi, nitrification ihibiting property of NCU reduced the losses of N and regulated continuous supply of N along with additional supply of azolla N in later part of crop growth would have resulted in better growth which in turn might be increased the straw yield.

Grain yield exhibited positive and significant correlation with number of tilers, dry matter production, panicles per m^2, panicle length and panicle weight (Table 5 and 6). The R^2 value of 0.958 in kharif and 0.954 in rabi indicated that 95.8 per cent of yield in kharif and 95.4 per cent of yield in rabi could be explained by the five yield contributing characters studied. Dry matter production had the maximum direct effect in both the seasons followed by panicle weight in kharif and panicles per m^2 in rabi (Table 3 and 4). In the present study the dry matter production was found to be significantly contributed more to the yield. The expression of other characters towards yield was through dry matter only.

Grain yield in rabi was higher than in kharif season. The possible reasons attributed to this are (i) the soil contained more available N (2) the quantity of azolla N added was high. The temperature was also low in rabi season and hence the multiplication of azolla was rapid and they were incorporated thrice. It has been well established that azolla could supply biologically fixed nitrogen to rice crop more efficiently (Mian and Stewart, 1983). The transfer of N from azolla was documented by ^{15}N technique (David, 1985).

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