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EFFECT OF AZOLLA AS GREEN MANURE ON SOIL PROPERTIES AND GRAIN YIELD OF RICE IN ACID SOIL OF JHARKHAND

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ABSTRACT

Rice (Oryza sativa) was grown during Kharif season as a test crop to study the effect of Azolla sp. Azolla caroliniana on the grain yield, nutrient uptake and some soil properties at experimental plot of Birsa Agricultural University, Ranchi having nine treatments namely control, Azolla as green manure, Azolla green manure (GM) + intercrops of Azolla (I), Azolla (GM)+50% NPK, Azolla (GM)+75% NPK, Azolla (GM) +100% NPK; 50% NPK; 75% NPK and 100% NPK. Initial soil pH was 5.7 where as OC was 3.8 g kg^{-1} with sandyloam textured soil. The results revealed that incorporation of Azolla into the soil increased grain yield of rice (7-31%) when either alone or with fertilizer. By the conjunctive use of Azolla as green manuring before transplanting and as intercrop increased grain yield of rice up to 16.3 per cent. The maximum grain yield (50.6 q ha^{-1}) was obtained with Azilla + 100% NPK that was statistically significantly superior to all the treaments. Bulk density and water holding capacity significantly improved by the application of Azolla eithe as green manuring or intercropping. Organic carbon, available N, P_2O_5, K_2O and NPK uptake were increased significantly by control. Incorporation of Azolla as green manure or as intercropping saved 50% inorganic fetilizer N in rice cultivation.

Key words: *Rice, Azolla caroliniana, green manure and intercropping.*

INTRODUCTION

Intensive crop production is the demand of time to feed the vast growing population of the country. This has created a pressure to use more chemical fertilizer. Use of chemical fertilizer injudiciously without organic manure create many soil health problems like low fertilizer use efficiency, poor soil physical condition, reduced water holding capacity, degraded rhizospharic properties, and low fertility as reported by (Awodun, 2008). Many other environmental problems are also being created. Farmers are using no or insufficient organic manures with the chemical fertilizers because they are habituated to use chemical fertilizers alone becuse they were getting higher yield. But by the continuous use of fertilizers they are not getting increasing trend of yield because of low fertilizer use efficiency. Imbalanced fertilizer use is also a problem as majority of farmers of the state use only urea or DAP without potassic fertilizer. All these factor resulting in the gradual declining in yield, multi-nutritional deficiency, deggradation of soil health and properties. The use of quality organic compost along with chemical fertilizer is must for the sustainability of soil productivity, fertility, health and quality of the natural resources as well as environment. The nutrient content however is low in compost but it help in may ways as acts like sponge to hold nutrients, water and air for the growth of plants (Swarup, 2010). It also works as an ameliorating agent for the soils chemical problems (Swarup and Gaunt 1998). Organic matter also affects the allelopathy of the soil and so controls the thermal effect also. Better aeration and proliferation of the roots are the other advantages. Now the question is how quality compost can be achieved in a sufficient quantity in time to meet the requirement. Use of fast growing and easily compostable organic substrates are needed in addition to the other organic sources of composts. Phytoplankton like Azolla might be useful to meet the need to some extent, because, it takes very less time for its growth and multiplication and it is easily compostable too. Azolla takes 2 to 3 days for doubling its mass trough multiplication and growth. There is a huge mass of surface water in the form of lake, ponds, ditches, dams, sewage, etc which can be utilize to grow it from where it can be harvested and utilized in crop production as the source of plant nutrients. Azolla grow and survive on the surface without disturbing flow of the water. It also kills the weeds by checking their

growth by preventing penetration of sun light below. It contains macro, secondary and micronutrients that is important for quality rice production. The present investigation was, therefore conducted to study the response of rice to Azolla as green manure in acid soil.

MATERIALS AND METHODS

The experiment was conducted in *Kharif* season at the Research farm of Birsa Agricultural University, Ranchi. The test crop was medium land rice and variety - *Lalat*. There were nine treatments namely : T_1-Control; T_2- 20 t Azolla ha^{-1} as green manure (GM); T_3-Azolla (GM) + Intercrops of Azolla (I); T_4-50% NPK+ Azolla (GM); T_5-75% NPK + Azolla (GM); T_6-100% NPK+ Azolla (GM); T_7-50% NPK; T_8-75% NPK and T_9-100% NPK :: 80:40:20. Fertilizer N was applied in three splits, 50% at the time of transplanting as basal with full dose of phosphorus and potassium whereas the rest 50% nitrogen was applied at two different crop growth stages (25 and 50 days after transplanting of rice crop). Experiment was conducted with three replications in ranomised block design. Azolla containing 3.2% N, 0.9% P, 2.2% K, 0.4% Ca, 0.7% Mg, 0.1% Mn and 0.2% Fe was incorporated in the plot as green manure as per treatment. Collected post harvest soils were analyzed for bulk density, water holding capacity, pH (1:2.5 soil and water ratio) and organic carbon by adopting standard procedures (Jackson, 1973). Soil samples were analyzed for vailable nitrogen (Subbiah and Asija, 1956), phosphorus (Watanable and Olsen, 1965) and available K in 1N NH_4 OAc using flame photometer, Nitrogen in grain was analyzed by Kjeldahl method, potassium by flame photometer and phosphorus using vanado molybdate (Jackson, 1973) in diacid extracts.Initial soil sample of the experimental plot was analyzed properly after well processing, using standard methods. The soil of the experimental plot was sandy clay loam (sand 42.0 %, silt 26.0 % and clay 30.0 %), having pH 5.7, organic carbon 3.6 g kg^{-1} and bulk density 1.53 g/cc, available nitroge 218.5 kg ha^{-1}, phosphorus 19.1 kg ha^{-1} and potash 295.4 kg ha^{-1}.

RESULTS AND DISCUSSION

Grain yield

The maximum grain yield (50.6 q ha^{-1}) was observed with 100% NPK + Azolla (GM) which increased by 31.6% over control. Application of 75% NPK + Azolla (GM) also contributed significant increase in grain yield (47.0 q ha^{-1}) compared to 100% NPK alone (46.0 q ha^{-1}). It is observed that the 75% NPK+ Azolla (GM) gave the at par result with 100% NPK whereas, 50% NPK alone gave at par rasults with Azolla green manure + intercrop.

Table 1: Effect of Azolla as green manure on grain yield and nutrient uptake in rice

Treatments	Grain yield (q ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 - Control	38.5	36.9	11.7	14.33
T_2 – Azolla (GM)	41.2	40.5	13.2	16.9
	(7.0)	(9.7)	(12.6)	(12.7)
T_3 – Azolla (GM) + Azolla (I)	44.7	43.3	13.6	17.2
	(16.3)	(17.3)	(15.9)	(15.0)
T_4 - Azolla (GM) + 50% NPK	44.8	43.8	13.9	17.3
	(16.4)	(18.8)	(18.9)	(15.4)
T_5 - Azolla (GM) + 75% NPK	47.0	44.2	14.9	18.6
	(22.2)	(19.7)	(27.8)	(23.7)
T_6 - Azolla (GM) + 100% NPK	50.6	47.8	15.4	19.4
	(31.6)	(29.6)	(31.7)	(29.6)
T_7 - 50% NPK	43.5	42.1	13.5	17.3
	(13.1)	(14.0)	(15.7)	(15.3)
T_8 - 75% NPK	45.4	44.5	14.5	17.7
	(18.1)	(20.6)	(24.3)	(17.8)
T_9 - 100% NPK	46.0	45.3	15.0	17.8
	(19.6)	(22.9)	(27.9)	(18.4)
CD (5%)	3.5	5.6	2.1	2.6
CV	10.1	7.5	8.7	8.6

* *Green manuring (GM), Intercropping (I)*
* *Value in parenthesis indicates percent over control*

Application of 50% NPK + Azolla was more beneficial in terms of grain yield copared to 50% NPK alone. The increase in grain yield might be due to build up of soil organic carbon and more nitrogen through the integrated use of NPK and green manuring with Azolla. Brian *et al.* (2013) also reported similar result on integrated plant nutrient management in rice - rice cropping system.

Nutrient uptake

All the treatments except Azolla alone as well as 50% NPK application showed significant increase in nitrogen uptake compared to the control. This may be due to continuous application of Azolla in rice field (Ram *et al.,* 1994). Application of Azolla proved beneficial for P upteke as compared to the control but there were no significant difference between the treatments T_5 and T_6 of different combination of NPK either alone or along with the Azolla green manuring whereas, 100% NPK showed the higher uptake (15.4 kg ha^{-1}) of P (Table 1). Increase in nutrient uptake might be due to the better supply of nutrient to the crop during the growth period through the integrated use of Azolla with chemical fertilizer. Lakshaminarayana and Patiram (2006) also reported similar effects of integrated plant nutrients management.

Table 2: Effect of Azolla as green manure on post-harvest nutrient status and physical properties of the soil

Treatments	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	OC (g kg^{-1})	WHC (%)	Bulk density (g /cc)
T_1 - Control	218.5	18.1	291.2	3.9	1.53	1.53
T_2 – Azolla (GM)	239.4	19.5	309.1	5.1	1.43	1.43
	(9.6)	(7.7)	(6.2)	(30.8)	(7.0)	(7.0)
T_3 – Azolla (GM) + Azolla (I)	253.0	21.5	313.6	6.3	1.39	1.39
	(15.8)	(19.0)	(7.7)	(61.2)	(8.7)	(8.7)
T_4 - Azolla (GM) + 50% NPK	248.8	23.2	318.1	5.5	1.41	1.41
	(13.9)	(28.5)	(9.2)	(41.0)	(7.2)	(7.9)
T_5 - Azolla (GM) + 75% N PK	253.0	27.6	340.5	5.5	1.42	1.42
	(15.8)	(52.5)	(16.9)	(41.0)	(7.9)	(7.2)
T_6 - Azolla (GM) + 100% N PK	274.0	29.6	358.2	5.6	1.42	1.42
	(25.4)	(64.0)	(23.0)	(43.6)	(6.8)	(6.8)
T_7 - 50% NPK	239.4	22.1	309.1	4.2	1.51	1.51
	(9.6)	(22.2)	6.2)	(7.7)	(0.9)	(0.9)
T_8 - 75% NPK	246.7	25.2	336.0	4.2	1.50	1.50
	(12.9)	(39.7)	(15.4)	(7.7)	(1.7)	(1.7)
T_9 - 100% NPK	255.1	27.4	345.0	4.4	1.50	1.50
	(16.7)	(51.6)	(18.5)	(12.8)	(1.7)	(1.7)
CD (5%)	34.6	3.8	NS	1.5	5.3	NS
CV %	8.1	9.1	9.9	16..9	12.0	9.0

Status of available nutrients in soil

Available nitrogen in the post harvest soil ranged from 218.5 to 274.0 kg ha^{-1}. The highest available nitrogen (274.0 kg ha^{-1}) was recorded with 100% NPK along with Azolla green manuring (T_6). Azolla application through the combination of two methods in rice as green manuring, before transplanting and intercrop within a week of transplanting (T_3) in the same plot was found similar to the treatment 100% NPK (T_9) in restoring post harvest available nitrogen into the soil (Table 2). However, Azolla application before rice transplanting only did not contributed better to the post harvest available nitrogen in the soil but in conjunction with intercropping of Azolla found significantly superior in increasing available nitrogen compared to the control plot, It might be due to the fixation of atmospharic nitrogen by azolla in addition to the fertilizer N (Awodun, 2008 and Ram *et al.,* 1994).Use of two methods as green manuring and as intercrop of using Azolla (T_3) proved beneficial and significant result over control in respect of P content (Table 2). The highest available phosphorus (29.6 kg ha^{-1}) was recorded with 100% NPK + green manuring of

Azolla. Treatment T_6 increased 42 percent of available P content compared to the control. Application of 75% NPK with Azolla was at par with 100% NPK alone. Available p increased may be due to the biochemical changes to release different forms of P present in the soil (Sudadi and Sumarno, 2014). Available K content was not affected significant by various treatments.

Physical properties of soil

The build up of organic carbon in the soil was significant with Azolla applied either alone or in combination with chemical fertilizers over control. Fertilizer application without Azolla was not beneficial. Significantly highest value (6.6 g kg^{-1}) of organic carbon was recorded with the Azolla as green manure and Azolla as intercropping (T_3). This may be due to the better growth and easy decomposition of the green biomass of the tinny fern of Azolla (Awodun, 2008). Azolla as green manure markedly affected the water holding capacity in both the situation either with fertilizer or without fertilizer. The treatment Azolla (GM) + Azolla (I) was found highly significant in increasing the water holding capacity of the soil (29.7%). Green manuring of Azolla along with fertilizer also found beneficial. It may be due to the increased organic carbon content in soil and better root biomass of crop. Bulk density was also improved by the incorporation of Azolla as green manuring. The bulk density increased by 8.7% with T_3 over control. Fertilizer application alone did not show any change in the bulk density as compared to the control. Change in physical properties was due to the contribution of organic carbon built into the soil by the decomposed mass of Azolla that was applied during the rice cultivation. The result corroborates with the earlier findings of Ram *et al.* (1994).

From the results it may be concluded that incorporation of Azolla increased the yield of paddy in an acid Alfisol up to 16% without addition of any fertilizer. For better and sustainable yield, addition of chemical fertilizer along with Azolla was also very beneficial. Addition of Azolla in any form in rice field not only increased the paddy yield but also maintained the soil health in terms of soil physical and chemical properties for sustainable yield.

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