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Effect of Integrated Nutrient Management on Physico-Chemical Properties of Soil and Rice Yield

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Abstract: Effect of integrated nutrient management on physico-chemical properties of rice-grown on terraced land was studied in a two-year field experiment. There were twenty treatments consisting of different combinations of locally-available organic sources (FYM, vermicompost and goat manure), mineral fertilizers and lime. The different treatment combinations showed significant effect on yield of upland rice and soil properties *viz.* water holding capacity, hydraulic conductivity, bulk density, infiltration rate. Infiltration rate was highest in treatment comprising of 75% NPK +2.5 t ha^{-1} goat manure + lime and 75% NPK + 5t ha^{-1} FYM while water holding capacity was highest in 75%NPK+2.5 t ha^{-1} goat manure + lime. Application of 75% NPK + 5 t ha^{-1} FYM had maximum hydraulic conductivity (2.8 cm hr^{-1}). In general soil pH was higher in lime-amended soils. Treatment 75% NPK+ 5 t ha^{-1} FYM + lime produced highest grain yield (50.2 q ha^{-1}) followed by 50% NPK+5 t ha^{-1} FYM + lime (43.9 q ha^{-1}), and control had lowest yield (30.3 q ha^{-1}).

Keywords: *Terrace cultivation, acid soils, rice*

Introduction

For establishing a permanent farming system and for conserving soil and water resources, surface topography are often manipulated to get a terraced field on sloppy areas. Recently prepared terraces are rated as potentially low in production level because of the disturbance in the surface soil (Humtsoe and Chauhan 2005).To enhance fertility status of such soils on sustainable basis, appropriate fertility management practices must be adopted to enhance soil health in relation to nutrients supply and in-turn growth parameters.

Augmentation of nutrients' availability to a growing crop is achieved by addition of fertilizers, manures and lime, either alone or in combination. Application of N,P,K, and S, FYM and green manuring treatments, there was a build-up of N,P, and K in soils having INM practices including fertilizers alone over ther farmers practices (Singh *et al.* 2006). Factors like organic carbon content, pH, total acidity, buffering capacity, water holding capacity, infiltration rate, bulk density and nutrients availability can be taken as soil fertility indicators for any given acidic soils. This study was, therefore, carried out to evaluate the effect of different nutrient management practices on crop yield and soil physico-chemical properties of a soil on a recently terraced land of Nagaland.

Materials and Methods

Field experiments were conducted during *Kharif* 2008 and 2009 on recently developed terraces in experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, to investigate the effects of fertility management practices on soil physico-chemical properties and yield of local rice variety Likhimo (rainfed). The climate is sub-tropical with moderate temperature and medium to high humidity. The experiment was carried out for two consecutive years in randomized block design and replicated thrice.

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Four rows of contour terraces were constructed by making contour marks along contour lines. Preliminary ploughing was done along and then divided into individual plots of 3.6 m x 1.7 m sizes. This was followed by thorough ploughing manually with hand hoe. The treatments comprised of T_1 - control, T_2 – 5.0 t ha^{-1} FYM, -, T_3 – 5.0 t ha^{-1} FYM + lime, T_4 - 2.5 t ha^{-1} vermicompost, T_5 - 2.5 t ha^{-1} vermicompost + lime, T_6 - 2.5 t ha^{-1} goat manure, T_7 - 2.5 t ha^{-1} goat manure + lime, T_8 - 50% NPK + 5 t ha^{-1} FYM, T_9 - 50% NPK + 5 t ha^{-1} FYM + lime, T_{10} - 50% NPK + 2.5 t ha^{-1} vermicompost, T_{11} - 50% NPK + 2.5 t ha^{-1} vermicompost + lime LR, T_{12} - 50% NPK + 2.5 t ha^{-1} goat manure T_{13} - 50% NPK + 2.5 t ha^{-1} goat manure + lime, T_{14} - 75% NPK + 5 t ha^{-1} FYM, T_{15} - 75% NPK + 5 t ha^{-1} FYM + lime, T_{16} - 75% NPK + 2.5 t ha^{-1} vermicompost, T_{17} - 75% NPK + 2.5 t ha^{-1} vermicompost + lime, T_{18} - 75% NPK + 2.5 t ha^{-1} goat manure, T_{19} - 75% NPK + 2.5 t ha^{-1} goat manure + lime and T_{20} - 100% NPK. FYM and lime were applied 30 days before sowing while goat manure was applied 45 days prior to sowing. Vermicompost was applied along the furrows at the time of sowing. N, P and K fertilizers were applied @ 100%, 75% and 50% of recommended dose (RDF 120 kg N, 60 kg P_2O_5, 50 kg K_2O ha^{-1}).

Lime was added @ 1914.2 kg $CaCO_3$ ha^{-1} (25 % of lime requirement). Soil samples were analysed for water holding capacity, hydraulic conductivity, bulk density, infiltration rate, pH, organic carbon and cation exchange capacity as per the procedures described by Baruah and Barthakur (1997). Available N was determined by alkaline permanganate method as outlined by Subbaiah and Asija (1956) and available P was extracted by Bray's method as described by Jackson (1964). Neutral normal ammonium acetate was employed for available K extraction and was determined by flame photometric method.

Results and Discussion

Effect on soil physico - chemical properties

In general, there was a slight improvement in organic carbon content of soils due to the application organic manures for two years, and the improvements were nearly uniform across all the treatments having manures. The results are in conformity with the findings of Datta and Singh (2010) in acid soils of Tripura.

The water holding capacity was higher in all the treatments than the control (Table 1), being highest with 75% NPK + goat manure + lime application followed by 75% NPK + goat manure without lime barring total and pH-dependent acidity. It had positive correlation with all the parameters. The hydraulic conductivity was highest (2.8 cm hr^{-1}) in treatment having 75% NPK +5 t ha^{-1} FYM + lime in both the years, followed by 100% NPK and 75% NPK+ 5 t ha^{-1} FYM. Lime and 5 t ha^{-1} FYM showed the lowest value (2 cm hr^{-1}). Dutta and Chauhan (2010) also reported higher hydraulic conductivity in treatments having 75% NPK + 5 t ha^{-1}FYM + lime.

Treatment with lime + FYM recorded the highest bulk density, and 100% NPK, the lowest (Table 1). In general, there was slight variation in bulk density between years and also among the various fertility treatments. The infiltration rate was highest in 75% NPK +2.5t ha^{-1}goat manure + lime followed by 75% NPK + 5 t ha^{-1} FYM, owing to high humus content in soil due to addition of manure (Reghunath *et al.* 2006). All treatments showed higher infiltration rate than the control. The infiltration rate had strong correlation with water holding capacity, cation exchange capacity, organic carbon and N, P, K in 2008 (Table 3) and had positive correlation with cation exchange capacity, water holding capacity,P and K in 2009 (Table 4).

Effect on NPK availability

Available N content after two years cropping showed an increment in some of the treatments as compared to control. Maximum N availability was recorded in 75% NPK+2.5 t ha^{-1}goat manure + lime followed by 75% NPK + 5 t ha^{-1} FYM+ lime. The treatment having goat manure resulted in highest N availability followed by FYM in post-harvest soil samples. Bajpai *et al.* (2006) found 50 per cent N availability enhancement due to FYM application in an Inceptisols of Chhattisgarh. The sole 100% NPK treatment (Table 2) had higher N availability than control and it is in conformity with the findings of Laxminarayana (2006).

Table 1. Effect of integrated nutrient management on water holding capacity, hydraulic conductivity, bulk density and infiltration rate, pH, organic carbon, CEC and grain yield of rice

Treatments	Water holding capacity (%)		Hydraulic conductivity (cm hr^{-1})		Bulk density (mgm^{-3})		Infiltration rate (cm hr^{-1})		pH		Organic carbon (%)		CEC cmol (p^{+})kg^{-1}		Grain yield (q ha^{-1})	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
T_1 - Control	41.4	42.0	2.2	2.2	1.3	1.5	2.2	2.5	4.5	4.7	1.5	1.4	3.0	2.6	29.7	30.9
T_2- 5.0 t ha^{-1} FYM	42.9	43.6	2.6	2.5	1.3	1.4	3.1	3.3	4.5	4.7	1.7	1.3	5.8	5.9	30.7	31.2
T_3-5.0 t ha^{-1} FYM + lime	44.2	44.8	2.0	2.0	1.6	1.7	5.0	5.1	4.6	4.7	1.5	1.4	6.9	7.1	30.9	31.6
T_4 - 2.5 t ha^{-1} vermicompost	45.5	46.1	2.4	2.4	1.4	1.5	4.4	4.3	4.6	4.9	1.6	1.5	5.7	5.9	30.5	31.2
T_5 - 2.5 t ha^{-1} vermicompost + lime	45.8	46.1	2.5	2.3	1.5	1.4	6.5	6.3	4.7	5.5	1.5	1.7	6.8	7.1	30.6	30.9
T_6 - 2.5 t ha^{-1} goat manure	45.8	47.9	2.1	2.1	1.4	1.5	6.3	6.2	4.6	4.6	1.6	1.7	5.8	5.9	31.5	32.3
T_7 - 2.5 t ha^{-1} goat manure + lime	46.0	46.2	2.5	2.4	1.4	1.5	4.1	3.4	4.8	4.9	1.7	1.6	7.7	7.1	34.2	34.8
T_8 - 50% NPK + 5.0 t ha^{-1} FYM	47.0	47.2	2.3	2.2	1.4	1.5	6.5	6.9	4.7	4.6	1.5	1.6	10.5	6.6	40.8	41.4
T_9 - 50% NPK + 5.0 t ha^{-1} FYM + lime	47.2	47.0	2.8	2.7	1.5	1.6	4.1	4.2	4.7	4.8	1.7	1.7	11.6	7.6	43.5	44.4
T_{10} -50% NPK + 2.5 t ha^{-1} vermicompost	46.3	46.4	2.1	2.3	1.5	1.7	4.9	5.1	4.5	4.8	1.8	1.7	9.1	10.7	39.8	39.9
T_{11} -50% NPK + 2.5 t ha^{-1} vermicompost + lime	44.6	45.1	2.3	2.2	1.4	1.5	6.3	6.5	4.7	4.8	1.5	1.5	11.6	11.7	37.4	37.2
T_{12} -50% NPK + 2.5 t ha^{-1} goat manure	50.6	51.6	2.4	2.2	1.4	1.3	4.1	4.4	4.5	5.5	1.5	1.6	8.9	9.7	36.5	37.3
T_{13} -50% NPK + 2.5 t ha^{-1} goat manure + lime	52.0	52.8	2.7	2.4	1.4	1.6	5.0	5.3	4.7	4.6	1.6	1.6	9.1	11.6	38.3	39.7
T_{14} -75% NPK + 5.0 t ha^{-1} FYM	51.1	51.7	2.7	2.8	1.5	1.6	7.1	7.4	4.6	5.2	1.7	1.8	4.5	9.1	38.1	38.2
T_{15} -75% NPK + 5.0 t ha^{-1} FYM + lime	53.3	53.4	2.8	2.8	1.3	1.4	6.9	6.8	4.7	4.7	1.7	1.7	12.1	9.3	49.3	51.1
T_{16} -75% NPK + 2.5 t ha^{-1} vermicompost	55.7	56.2	2.4	2.5	1.6	1.5	6.0	6.4	4.6	4.7	1.5	1.6	10.7	11.5	37.4	38.3
T_{17} -75% NPK + 2.5 t t ha^{-1} vermicompost + lime	48.8	49.1	2.5	2.5	1.6	1.5	6.0	6.2	4.7	4.7	1.5	1.6	12.2	12.1	39.0	41.2
T_{18} -75% NPK + 2.5 t ha^{-1} goat manure	57.3	57.4	2.4	2.3	1.3	1.6	7.2	6.9	4.6	5.4	1.6	1.7	11.9	10.7	36.4	37.6
T_{19} -75% NPK + 2.5 t ha^{-1} goat manure + lime	58.4	58.6	2.4	2.2	1.5	1.6	7.3	7.6	4.5	5.0	1.7	1.9	12.5	12.3	40.0	39.4
T_{20} -100% NPK	48.1	48.4	2.7	2.7	1.2	1.3	4.1	4.4	4.8	5.9	1.5	1.5	9.7	9.9	35.7	35.6
SEM ±	0.31	0.32	0.10	0.10	0.2	0.10	0.18	0.18	0.09	0.08	0.13	0.11	0.23	0.20	0.11	0.41
CD at 5%	0.88	0.91	0.29	0.27	0.5	0.29	0.51	0.53	0.23	0.23	0.33	0.31	0.66	0.57	0.31	1.1

Table 2. Effect of integrated nutrient management on available N, P and K

Treatments	Available N kg ha^{-1}		Available P kg ha^{-1}		Available K kg ha^{-1}	
	2008	2009	2008	2009	2008	2009
T_1 Control	400.3	366.0	11.8	11.1	143.3	143.7
T_2 5.0 t ha^{-1} FYM	420.8	404.2	13.1	12.5	237.4	235.7
T_3 5.0 t ha^{-1} FYM + lime	454.4	444.1	15.1	15.4	251.1	251.2
T_4 2.5 t ha^{-1} vermicompost	437.6	423.6	19.9	19.3	236.5	234.1
T_5 2.5 t ha^{-1} vermicompost + lime	461.2	445.6	23.8	23.6	244.5	244.6
T_6 2.5 t ha^{-1} goat manure	499.8	469.9	18.8	19.1	246.7	246.6
T_7 2.5 t ha^{-1} goat manure + lime	498.4	473.1	19.5	20.2	254.5	254.4
T_8 50% NPK + 5.0 t ha^{-1} FYM	544.2	531.9	20.1	20.3	243.4	243.5
T_9 50% NPK + 5.0 t ha^{-1} FYM + lime	569.5	553.1	21.9	22.3	252.6	252.7
T_{10} 50% NPK + 2.5 t ha^{-1} vermicompost	403.2	420.0	25.5	25.4	237.3	235.7
T_{11} 50% NPK + 2.5 t ha^{-1} vermicompost + lime	443.6	414.2	25.8	26.0	246.1	246.2
T_{12} 50% NPK + 2.5 t ha^{-1} goat manure	537.5	515.5	20.6	21.2	250.7	250.6
T_{13} 50% NPK + 2.5 t ha^{-1} goat manure + lime	565.2	544.7	23.4	23.6	257.4	257.3
T_{14} 75% NPK + 5.0 t ha^{-1} FYM	560.7	523.5	21.5	21.8	232.4	278.3
T_{15} 75% NPK + 5.0 t ha^{-1} FYM + lime	570.3	520.3	25.8	25.6	292.9	292.8
T_{16} 75% NPK + 2.5 t ha^{-1} vermicompost	433.9	423.9	23.1	22.6	258.4	258.3
T_{17} 75% NPK + 2.5 t ha^{-1} vermicompost + lime	462.5	402.5	24.4	24.5	267.8	267.5
T_{18} 75% NPK + 2.5 t ha^{-1} goat manure	566.0	525.6	22.1	21.5	276.9	276.8
T_{19} 75% NPK + 2.5 t ha^{-1} goat manure + lime	577.5	545.9	26.0	26.3	306.1	306.0
T_{20} 100% NPK	506.7	415.5	24.1	24.0	315.8	315.9
SEM±	1.5	1.5	0.29	0.35	1.7	1.3
CD at 5%	4.3	4.4	0.82	1.0	4.9	3.8

Available P was higher in all the treatments than in control, being highest in 75%NPK+2.5 t goat manure ha^{-1} + lime treatment (Table 2) and lowest in sole FYM treatment. The available P increased remarkably in the treatment having NPK, organic manure and lime. Similar finding was also reported by Laxminarayana (2006) in Mizoram. P showed high positive correlation with K, water holding capacity and infiltration rate.

All the treatments brought significant increases in available K as compared to control. Highest available K was found in 100% NPK followed by 75% NPK+2.5 t ha^{-1} goat manure + lime. The treatment combinations with organic manures had higher available K, but sole treatments of goat manure, FYM and vermicompost had lower values. Available K was higher in the treatments of lime + manure than in sole and in organic sources with NPK. The data (Table 2) on available Kas affected by FYM + NPK is in consonance with the finding of Swarup and Yaduvanshi (2000), however goat manure + NPK, vermicompost + NPK and lime did not differ significantly (Humtsoe and Chauhan 2005).

Effect on crop yield

Among the treatments, 75% NPK+5 t ha^{-1} FYM + lime resulted in highest average grain yield (50.2 q ha^{-1}) followed by 50% NPK+5 t ha^{-1} FYM + lime (43.9 q ha^{-1}), which was 19.9 q ha^{-1} higher than control. The result is in conformity with the findings of Datta and Singh (2010) on rice grown on upland acid soils of Tripura. Application of 75% NPK + 2.5 t ha^{-1} goat manure + lime showed relatively higher yield to the tune of 39.7 q ha^{-1}. Out of the three organic treatments, goat manure performed better than the other two organic sources.

Table 3.Corelation among different soil parameters (2008)

	CEC	Av. N	Av. P	Av. K	LR	Org. C	WHC	Hydraulic Con	BD	Infil. rate	pH
CEC	1.00	0.29	0.72**	0.71**	-0.38NS	0.08	0.61**	0.25	0.13	0.48*	0.15
Available- N		1.00	0.19	0.44*	-0.06	0.02	0.58**	0.51*	-0.15	0.35NS	0.28
Available-P			1.00	0.78**	-0.29	0.16	0.56**	0.33NS	0.24	0.66**	0.31NS
Available- K				1.00	-0.28	0.04	0.62**	0.38NS	-0.02	0.50*	0.44*
Lime requirement					1.00	-0.60**	-0.06	-0.27	-0.16	0.11	0.05
Organic Carbon						1.00	0.02	0.01	0.02	0.05	-0.07
WHC							1.00	0.31NS	0.12	0.63**	0.14
Hydraulic conductivity								1.00	-0.26	0.03	0.35NS
Bulk density									1.00	0.31NS	-0.15
Infiltration Rate										1.00	0.28
pH											1.00

Critical r at 5%=0.4438 *, r at 1%=0.5614 **, NS – Non-significant

Table 4. Corelation among different soil parameters (2009)

	CEC	Av. N	Av. P	Av. K	LR	Org. C	WHC	Hydraulic Con.	BD	Infil. rate	pH
CEC	1.00	0.19	0.82**	0.68**	-0.30NS	0.48**	0.69**	0.18	0.14	0.58*	0.17
Av. N		1.00	0.21NS	0.53*	-0.04	-0.12	0.59*	0.21	0.00	0.40*	-0.14
Av. P			1.00	0.68**	-0.47*	0.23NS	0.55*	0.29	0.03	0.63**	0.11
Av. K				1.00	-0.44*	0.17	0.65**	0.42**	-0.10	0.57*	0.24
LR					1.00	-0.01	0.02	-0.30	0.06	-0.18	0.04
Org. C						1.00	0.57**	0.07	0.21	0.40*	0.06
WHC							1.00	0.20	0.09	0.65**	0.07
Hydraulic Con								1.00	-0.24	0.03	-0.06
BD									1.00	0.22	0.00
Infiltration rate										1.00	-0.12
pH											1.00

Conclusions

There was slight improvement in organic carbon content of soils due to the application of organic manures. The infiltration rate was highest in 75% NPK +2.5 t ha^{-1} goat manure + lime. Maximum availability of N and P was recorded in 75% NPK+2.5 t ha^{-1} goat manure + lime. The highest available K was found in 100% NPK. Treatment having 75% NPK+ 5 t ha^{-1} FYM + lime resulted in maximum grain yield (50.2 q ha^{-1}). It is concluded that FYM @ 5 t ha^{-1} combined with 75% RDF (NPK) along with lime is advisable for maximising the upland rice yield in terrace field of acidic soils of Nagaland.

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