Chemical Science Review and Letters ISSN 2278-6783

Research Article

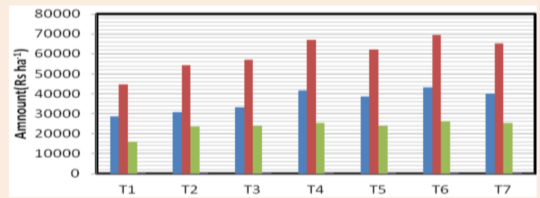
Changes in Soil Chemical Environment by Integrated Nutrient Management Practices and its Effect on Yield, Economics under Rice-fallow Cropping System

Tiryak Kumar Samant*

Krishi Vigyan Kendra, Angul, Orissa University of Agriculture and Technology, Odisha, India

Abstract

The current study investigated on changes in soil chemical environment by integrated nutrient management practices and its effect on yield, economics under rice-fallow cropping system. The results indicated application of 50% RDF + 10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each recorded higher organic carbon(0.446 %), N(211 kg ha^{-1}), P(25.50 kg ha^{-1}), K(198 kg ha^{-1}), S (25.7 kg ha^{-1}), Ca(0.22 %), Mg(0.09 %) , grain yield (51.43 q ha^{-1}), harvest index (49.81 %), gross return (Rs.69470 ha^{-1}) and influenced greatly on changes in soil chemical environment which enhances the yield, economics of rice and soil fertility.



*** Correspondence**

T. K. Samant

Email: tksamant_2003@yahoo.co.in

Keywords: Soil chemical environment, INM, Yield, Economics, Rice

Introduction

The soil chemical environment is dynamic and reactions that maintain dilute solution of nutrient elements and indispensable for continual plant growth. The nutrient transformation and its availability in soils depends on pH, clay minerals, cation and anion exchange capacity [1]. Soil health is one of the key factors, which decides the yield targets. Organic manures are indispensable factor for maintaining soil health and it has multiple effects in which the influence on plant growth can be grouped into indirect effect on physical, chemical and biological properties of soil and direct effect on physiological and biological processes of plants [2].

Chemical fertilizers are essential basic needs of the present day intensive agriculture. Continuous use of these chemical fertilizers leads to the deterioration in soil fertility. Organic manures are available indigenously which improve soil health which alone might not meet the plant requirements due to presence of relatively low levels of nutrients. It is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yield [3]. Per hectare average fertilizer consumption in Angul district of Odidha is 22.6 kg ha^{-1} which is very less as compared to average state consumption (65.50 kg ha^{-1}). Kharif paddy is predominant in the state contributing about 94% of the total rice area [4]. Therefore, this study focused on changes in soil chemical environment by integrated nutrient management practices and its effect on yield, economics under rice-fallow cropping system.

Experimental

Materials and Reagents

Experimental site, year and climate: The field trial was carried out in Instructional farm, Krishi Vigyan Kendra, Angul during *kharif* seasons of 2011 and 2012. The geographical location of the area has 84^0 16′ to 85^0 23′ E longitude and 20^0 31′ to 21^0 41′ N latitude and average elevation of 300 m above mean sea level. Climate of the region is fairly hot and humid monsoon. The average rainfall in both the year during the study period from June to November was 1037 mm. The mean maximum and mean minimum temperature registered in both the year were 34.2^0 C and 20.8^0 C respectively.

Initial soil status: The soil of the experimental site was slightly acidic in reaction (pH-5.8), E.C(0.17 %), sandy loam loam in texture with medium in organic carbon (0.43 %), available nitrogen (292 kg ha^{-1}), phosphorus(12.2 kg ha^{-1}) and potash (205 kg ha^{-1}) contents.

Experimental design: The experimental trial was laid out in randomized block design with three replications. The treatments comprised of different integrated nutrient management practices(INM) *viz.* T_1-Control(no use of fertlisers and manures), T_2- 50 % RDF,T_3-100 % RDF, T_4- 50 % RDF+ 10t FYM, T_5- 100% RDF+5t FYM, T_6-50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each and T_7-100% RDF+5t FYM+ Azotobacter, Azospirillum & PSB @5kg ha^{-1} each.

Estimations: After two crop cycles (Rice-Fallow) surface (10-15 cm) soil samples were collected and analysed for chemical properties like pH, Electrical conductivity(EC), Organic carbon(OC), available Nitrogen(N), Phosphorus(P), Potassium(K), Sulphur(S) , exchangeable Calcium(Ca) and Magnesium (Mg) [5-8].

Procedures: Rice was transplanted during 2nd week of July and harvested during 1st week of November and Recommended dose of fertilizers(RDF) were applied @ 60:30:30 kg NPK ha^{-1}. Twenty five days old seedlings of HYV rice "Pratikshya" were transplanted during both the year at a spacing of 20 cm X 15 cm. Full dose of P & K and half dose of N of RDF were applied as basal during puddling while remaining N was applied in two equal splits *i.e.* late tillering and panicle initiation stage. The Farmyard manure(FYM) were incorporated into soil during final puddling with biofertilisers *i.e.* Azotobacter, Azospirillum and Phosphorus Solubilising Bacteria (PSB).

Calculations: At the end of each season grain and straw yields of rice were recorded. The economic parameters like net returns and benefit cost ratio were worked by using prevailing market price of inputs and outputs. Observation on different yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, net return and B:C ratio.

Statistical analysis: The datas were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 [9].

Results and Discussions

***Organic carbon, pH and Electrical conductivity*:** The organic carbon is the indication of soil fertility and its production potential. Organic carbon(OC) content of surface soil(**Table 1**) increased significantly(0.009 to 0.031%) with incorporation of FYM and biofertilisers with chemical fertilizers as compared to control [10]. The increase in OC content may be attributed to addition of organic materials and better root growth. The subsequence decomposition of these roots might have resulted in increase OC content of the soil. The increase in OC status is due to combined use of organic manure, bio & chemical fertilizers. The organic carbon content increases from the initial value with the addition of organic manure. Similarly, among the treatments the pH varies between 5.7 and 6.2 and electrical conductivity varies between 0.16 to 0.22 dSm^{-1} by the addition of FYM and bio fertilisers in combination with chemical fertilizers [11-13].

Available Primary nutrients: Available nitrogen content of surface soil after harvest of rice significantly increased with application of FYM and bio fertilizers in combination with chemical fertilizers over sole fertilizer application and control (**Table 1**). The available nitrogen in surface soil differ from 155 to 211 kg ha^{-1} and maximum (211 kg ha^{-1}) was obtained in application with 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each. The increase in available nitrogen due to organic material application resulted in the greater multiplication of soil microbes caused the addition of organic materials enhanced the conversion of originally bound N to organic form. The favorable soil conditions under FYM and biofertilisers application might have helped in the mineralization of soil N leading to build up higher available N [14-16].

Table 1 Effect of treatments on pH, EC, Organic carbon and available primary nutrients status of post harvest soil

(pooled data over 2 years)

Treatments	pH	EC	O.C	Available primary nutrients (Kg ha^{-1})		
	(1:2.5)	(dSm^{-1})	(%)	N	P	K
T_1-Control	5.7	0.18	0.415	155	9.94	139
T_2-50 % RDF	5.8	0.21	0.424	192	13.18	157
T_3- 100 % RDF	5.8	0.22	0.427	198	15.35	175
T_4-50 % RDF+ 10t FYM	6.0	0.16	0.438	206	23.23	192
T_5-100% RDF+5t FYM	5.9	0.17	0.431	201	19.67	187
T_6 -50% RDF+10 t FYM + Azotobacter,Azospirillum & PSB @5kg ha^{-1} each	6.2	0.16	0.446	211	25.50	198
T_7- 100% RDF+5t FYM+ Azotobacter, Azospirillum & PSB @5kg ha^{-1} each	6.1	0.17	0.435	204	21.07	190
SEm$\pm$	0.0101	0.0015	0.0006	1.146	0.0344	1.316
C.D at 5 %	0.0338	0.0045	0.0019	3.532	1.061	4.054

Incorporation of FYM in combination with chemical fertilizer recorded significantly higher phosphorus content in surface soils. The results(**Table 1)** indicated that significantly higher available P content (25.50 kg ha^{-1}) of post harvest soil was observed with 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each over control (9.94 kg ha^{-1}). The increased available P content of soil might be due to release of organic acids during decomposition which in turn helped in releasing phosphorus and due to solubilisation of the native P in the soil through release of various organic acids. The decomposition of organic matter is accompanied by release of appreciable quantities of Co_2. It has been observed in calcareous soils that Co_2 production plays an important role in increasing the phosphate availability [17, 18]. The organic material forms a protective cover on sesqueoxide and thus reduces the phosphate fixing capacity of the soil. Organic manure enhanced the labile P in soil through complexation of cations like Ca^{+2} and Mg^{+2} when it is applied in combination with inorganic fertilizers. Generally, addition of FYM and bio fertilisers with inorganic fertilizers had the beneficial effect in increasing the phosphate availability.

The available potassium content of surface soils (**Table 1**) differed significantly(187 to 198 kg ha^{-1}) due to various levels of organics in combination with inorganic sources of nutrients which may be due to addition of organic matter and maximum (198 kg ha^{-1}) was obtained in application with 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} . The beneficial effect of FYM and bio fertilizers on available potassium may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay. Increase of available potassium content under integrated nutrient management might be due to reduction of K fixation and release of K from interaction of organic matter with clay besides addition of K to the available pool [19, 20, 21, 22].

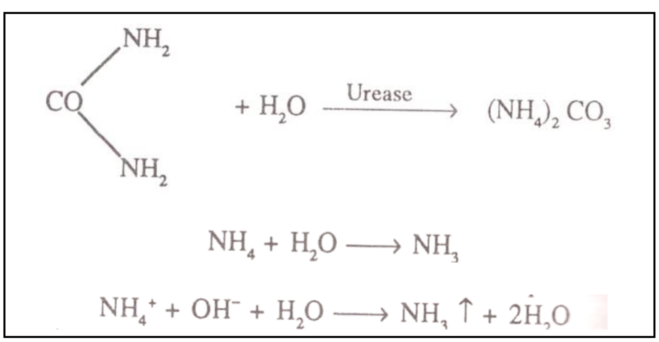


Figure 1 Nitrogen Transformation

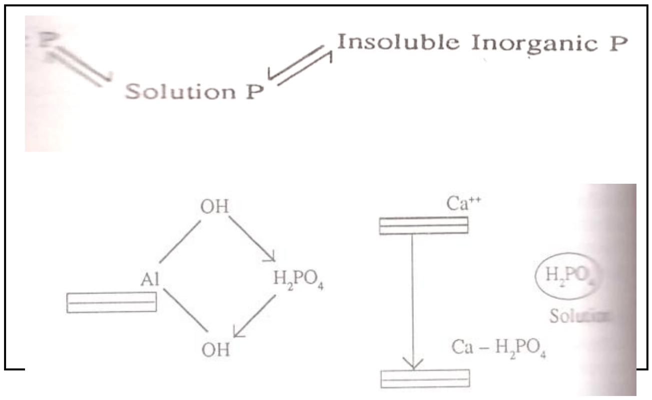


Figure 2 Phosphorus Transformation

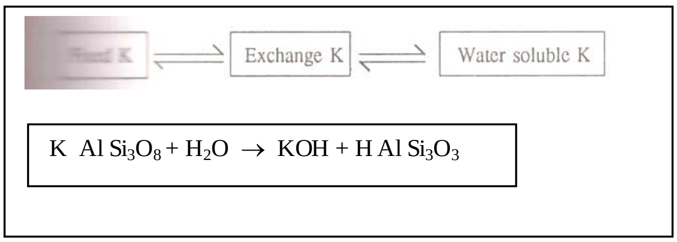


Figure 3 Potassium Transformation

Available Secondary nutrients: Exchangeable calcium(0.22%) and magnesium (0.09%) content was maximum(**Table 2**) in the treatment receiving application with 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each might be attributed due to the dissolution of calcium carbonate and other insoluble forms of calcium and magnesium by root exudates and also by various products of microbial activity [23, 24].

Soil application of 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each recorded (**Table 2**) higher available sulphur content of soil(25.7 kg ha^{-1}) than other treatments. The increase in available sulphur content might be attributed to the mineralization of added humic substances. Reduction in sulphate fixation, release of sulphur from native source by enhanced microbial degradation and possible reasons for increased sulphur availability[25].

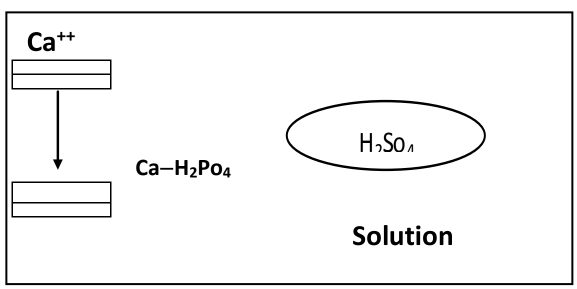


Figure 4 Calcium exchange

Exchangeable Mg $\rightarrow$ Slowly available Mg $\leftarrow$

Figure 5 Magnesium exchange

Table 2 Effect of treatments on secondary nutrients status of post harvest soil
(pooled data over 2 years)

Treatments	Available secondary nutrients		
	Exchangeable Ca (%)	Exchangeable Mg (%)	Available S (kg ha^{-1})
T_1-Control	0.13	0.01	17.50
T_2-50 % RDF	0.14	0.02	19.66
T_3- 100 % RDF	0.17	0.05	20.84
T_4-50 % RDF+ 10t FYM	0.21	0.08	24.62
T_5-100% RDF+5t FYM	0.19	0.06	23.76
T_6 -50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each	0.22	0.09	25.70
T_7- 100% RDF+5t FYM+ Azotobacter, Azospirillum & PSB @5kg ha^{-1} each	0.20	0.07	23.98
SEm$\pm$	0.0021	0.0018	0.183
C.D at 5 %	0.0065	0.0056	0.565

Yield: Grain and straw yields were significantly influenced by application of fertilizers alone or in combination of FYM and bio fertilisers over control (**Table 3**). Soil application of 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} recorded the maximum grain yield(51.43 q ha^{-1}) which is 25.6 per cent higher than control with harvest index 49.81 percent. The straw yield of rice followed the same trends as grain yield with each of the treatments. This could be attributed to decomposition of FYM and bio fertlisers , which favoured for greater release of nutrients and their continuous availability in soil for sustaining higher grain and straw yield of rice. The higher yield of rice was obtained when fertilizers were applied in combination of FYM and bio fertilisers [26-28].

Table 3 Effect of treatments on grain yield, straw yield and harvest index
(pooled data over 2 years)

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1-Control	32.35	41.26	43.95
T_2-50 % RDF	39.58	49.25	44.56
T_3- 100 % RDF	41.46	52.45	44.15
T_4-50 % RDF+ 10t FYM	49.57	51.26	49.16
T_5-100% RDF+5t FYM	45.82	49.74	47.95
T_6 - 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} each	51.43	51.82	49.81
T_7- 100% RDF+5t FYM+ Azotobacter, Azospirillum & PSB @5kg ha^{-1} each	48.14	51.47	48.33
SEm$\pm$	0.409	0.235	0.1455
C.D at 5 %	1.259	0.725	0.476

Economics: Cost of cultivation was higher in all the INM treatments over control and sole chemical fertilizer application. However, the gross returns were higher in INM treatments than control and sole chemical fertilizer application (**Figure 1)**. The net return from unfertilised rice crop was Rs.15886 ha^{-1}. Among the treatments, 50% RDF+10 t FYM + Azotobacter, Azospirillum & PSB @5kg ha^{-1} recorded (**Figure 6**) the maximum gross return (Rs.69470 ha^{-1}) with additional net return of Rs.10418 ha^{-1} as compared to control owing to higher grain yield. Maximum B:C ratio (1.76) was recorded in 50 % RDF followed by 100 % RDF (1.72) owing to lower cost of cultivation and higher return. Minimum cost of cultivation (Rs.28688 ha^{-1}) was occurred in control plot in comparison to other treatments due to saving of fertilizer and manure cost [29, 30].

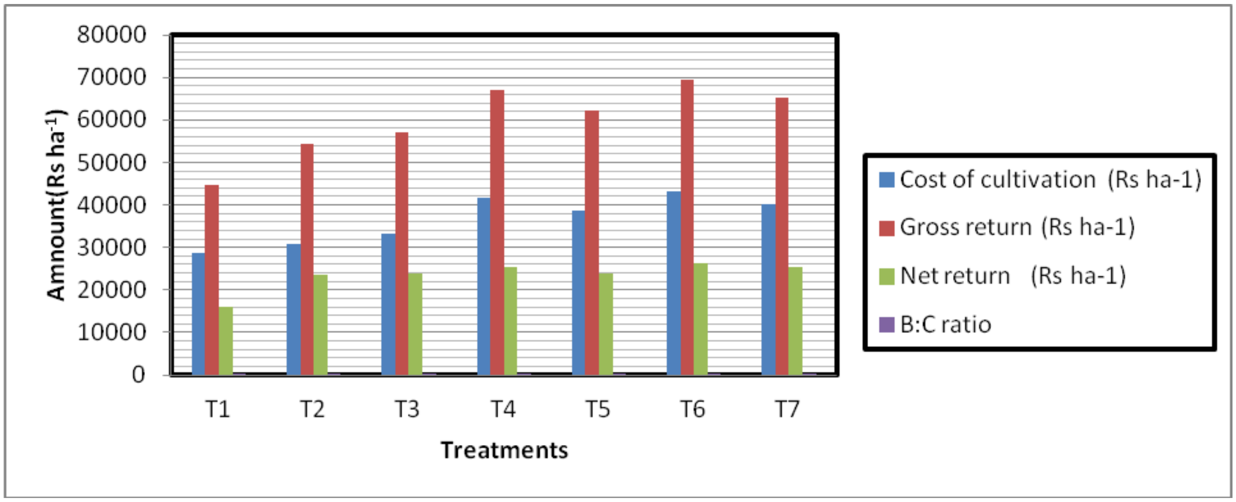


Figure 6 Effect of treatments on Cost of cultivation, Gross return , Net return and B:C ratio

Conclusion

Hence, it could be concluded from the investigation that integrated nutrient management coupled with organic manures, bio fertilisers and chemical fertilizers influenced greatly on variation in soil chemical properties and enhances the yield, economics of crop and fertility status of soil.

References

[1] Yellamanda Reddy T, Sankara Reddi G H , Principles of Agronomy. Kalyani publishers, Third revised Edition, ISBN 81-272-0282-7, 2004, p123.
[2] Schnitzer M, Advances in Agronomy, 2000, 68:3-54.
[3] Ramalakshmi C S , Rao P C , Sreelatha,T, Madhavi M, Padmaja G , Sireesha A, Oryza.2013, 5(3):241-248.
[4] Anonymous, Odisha Agriculture Statistics , Directorate of Agriculture, Odisha, India, 2011-12, p20-39.
[5] Piper C S, Academic Press., New York, 1996, p.77.
[6] Subbaiah B V, Asija G L, Current science, 1959, p25.260.
[7] Jackson, M L, Prentice Hall of India Private Limited, New Delhi, 1973.
[8] Muhr G R, Datta N P , Shankarasubramoney M, Leley R L, Donahue R L, USAID, New Delhi, 1965, p.77.
[9] Cochran W G, Cox G M, Experimental Designs. Asia Publishing House, Kolkata,1977, 95-132 and 142-181.
[10] Qin Z, Huang Y, Zhuang Q,Global Biogeochemical Cycles, 2013, 27:1-12.
[11] Datta M, Singh N P, Journal of the Indian Society of Soil Science, 2010, 58(1):94-98.
[12] Hoffmann, H, Soil pH and plant health in home garden, Garden note-174, Western Australian Agriculture Authority, ISSN 0817-5969, 2010.

[13] Hartsock N J, Mueller T G, Thomas G W, Barnhisel , Wells K L , Sheare S A, In. P.C. Robert et al. (ed.) Proc. 5th international conference on precision Agriculture, ASA Misc. Publ., ASA, CSSA, and SSSA, Madison, WI, 2000.
[14] Kundu D K, Ladha J K, Soil Science Society of America Journal,1997, 61:839:845.
[15] Porpavai S, Devasenapathy P, Siddeswaran, K , Jayaraj T, Journal of cereals and oilseeds, 2011, 2(3):43-46.
[16] Talanur S I , Badanur V P, Journal of the Indian Society of Soil Science, 2003, 51(1):37-41.
[17] Thakur H C, Sharma N N, Indian Journal of Agril. Sci,1988, 58(9):708- 709.
[18] Vinegla B, Garcia ruiz R, Lietor J, Ochoa V, Carreira, A, Biogeochemistry, 2006, 78:151-172.
[19] Barik A.K., Raj A, Saha R.K, Crop Research, 2008, 36(1,2 & 3):4-7.
[20] Sangeetha M, Singhram P, The Asian Journal of Soil Science, 2007, 2(1)86-89.
[21] Mongia A D, Gangwar B, Shyamsingh V, Kumar BAK., Fertiler News, 1989, 34(4):81-85.
[22] Rangel Y A, Swedish University of Agricultural Sciences Uppsala, 2008, p.47-49.
[23] Miyazawa M, Pavan M A, Ziglio C O, Franchini J C, Brazilian Archives of Biology and Technology, 2001, 44(2).
[24] Wadu M C W, Michaelis V K, Kroeker S , Akinremi O O, Soil Science Society of America Journal, 2013, 77(6):2004-2013.
[25] Blum S C, Lehmann J, Solomon D, Caires E F , Alleoni L R F, Geoderma, 2013, 200 &201:156-164.
[26] Sharma M P, Bali S V , Gupta D K ,Indian Journal of Agricultural Sciences, 2001, 71,82-86.
[27] Kumpawat B S, Indian Journal of Agronomy, 2001, 35(1):421-424.
[28] Kumar A L, Yadav D S, Singh R M , Achal , Indian J. Agron,2001, 46(4):573-577.
[29] Kumar V, Jayakrishna U K, Nair C S, Pushpakumar R, Nair V R, Oryza, 1993, 30:302-304.
[30] Tomar S , Tiwari A S, Indian Journal of Agronomy, 1990, 35(1/2):30-35.

Publication History

Received	22nd Jan 2015
Revised	04th Feb 2015
Accepted	16th Feb 2015
Online	28th Feb 2015