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Effect of Long Term Fertilizer Experiment on Pore Space, Nutrient Content and Uptake Status of Rice Cropping System

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ABSTRACT

The present study conducted under All India Coordinated Research Project (AICRP) on long-term fertilizer experiment was aimed on the effect of inorganic fertilizers, with or without organic manure on gravimetric and volumetric moisture content, total porosity, nutrient content in grain and straw, nutrient uptake in grain and straw and yield after 14 years of rice-wheat sequence during 2013-2014. The treatments selected for the study were control, 50% NPK, 100% NPK, 150% NPK, 100% NPK + Zn, 100% NP, 100% N, 100% NPK+FYM, 50% NPK + BGA and 50% NPK + GM. The investigations revealed that crop yields were lowest in the control where neither fertilizers nor manures were applied for the last fourteen years and highest in 150% NPK. The total porosity, gravimetric and volumetric moisture content of the soil is higher values recorded in 100% NPK + FYM, 50% NPK + BGA and 50% NPK + GM treatments compare to other treatments. The total uptake of nutrients is recorded better values in the integrated nutrient treatments as compare to inorganic treatments and control. Integrated use of organics and inorganics has sustained the crop yields and improves the soil health.

Key words: *Rice, Cropping system, Moisture content, Porosity, Nutrient content, Nutrient uptake, Soil health*

INTRODUCTION

The continuously growing population and increase demand for food call for greater reliance on agriculture than had ever been witnessed. The mining of nutrients from soil for ages along with their losses due to erosion and other causes if allowed to continue would severely limit crop production in the coming years. The present day agriculture all over the world has therefore become much dependent upon chemical fertilizer to produce more and more from the shrinking land area. The long term fertilizer experiments did prove valuable information on the effect of rotational cropping, use of bulky organic manures, nutrient application alone or in combination on crop yields, nutrient uptake and on changes in soil physico-chemical properties of the soil. Maintaining the soil quality at desirable level is very complex issue due to involvement of climatic, soil, plant and human factors and their interactions. There is an urgent need to adopt appropriate soil and plant management practices so as to reduce soil degradation and maintain soil quality at desired level.

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The recommended dose of NPK fertilizer alone does not sustain productivity under continuous intensive cropping system[12] where as inclusion of organic manures improves the biological soilstatus, soil fertility and crop yields[6]. Moisture content, porosity of the soil and nutrient uptake by crop have been evaluated in present study using the data collected from a long term fertilizer management experiment on rice-wheat cropping system and soil quality was evaluated.

MATERIALS AND METHODS

A long-term field experiment with rice-wheat cropping sequence was conducted on vertisols. The experiment was initiated in the rainy season of 1999 at research farm of Indira Gandi Agricultural University, Raipur, India (21.4° N, 81.39° E) under the All India Coordinated Research Project. Soil moisture content was estimated from fresh weight of soil and dry weight of soil by using the equation:

GMC (%) =Fresh weight of soil - Dry weight of soil/Dry weight*100

Volumetric moisture content was estimated by multiplying bulk density with corresponding soil moisture content.

Total porosity was estimated from the bulk density and particle density of the soil by using the equation:

Total porosity = (1 –BD/PD) × 100

Where, BD is bulk density and PD is particle density of soil solids (2.65 Mg m^{-3}).

Plant and grain sample dried at 55°C in an oven for 24 hours and were grinded and used for analysis.The 0.5g of oven dried grain and straw samples were digested in 10 ml of concentrated H2SO4 and 1g of salt mixture (9:1 K2SO4 : Cu SO4) in Kjeldahl digestion unit, and determined N content. 1 gram of oven dried grain and straw samples were digested by 10 ml of diacid mixture HNO3 : $HClO_4$ [3] using kjeldahl unit. Volume of digested grain and straw samples made up to 100ml for the estimation of phosphorus and potassium content. Nitrogen content in digested grain and straw samples were determined by Kjeldahl distillation unit[3]. Phosphorus content of digested grain and straw samples was estimated by development of Vandomolybdophosphoric acid yellow color method using blue filter[5]. Potassium content in the digested grain and straw samples was analyzed estimated by Flame photo-meter[2]. The nutrient uptake was calculated by multiplying percent concentration of a particular nutrient with grain and straw yields. The uptake of the nutrients obtained in respect of grain and straw was summed up to compute the amount of total nutrient removed by the crop.

RESULTS AND DISCUSSION

Total porosity

Porosity is directly related to bulk density because bulk density and porosity both have reciprocally related. The manure and fertilizer application exhibited a non-significant effect on total porosity of the soil (Fig 1). The 100% NPK + FYM, 50% NPK + GM and 50% NPK + BGA plots had greater micro porosity than control and 100% alone inorganic fertilizers plots at both (flowering and harvesting stage) stages of the crop. Increase in total and microporosity of the soil with fertilizer and manure treatments could be attributed to higher organic matter content, better aggregation and change in pore size distribution of soil. Hati*et al.*[4] found that total porosity of the soil increases with fertilizer and compost application, depending upon the amount of materials added.

Gravimetric and volumetric moisture content

Gravimetric and volumetric moisture (θw% and θv%) content of soil was measured at flowering and harvesting stage of the rice crop and presented in the (Table 1). The 100% NPK + FYM had the highest gravimetric moisture content (25.96%) followed by 150% NPK

(21.56%) and lowest in control (18.54%) at 45 DAT. Interaction between different treatment levels were observed to be significant effect on both 45 DAT and 95 DAT of the crop. At 45 DAT the Gravimetric moisture content was recorded low values as compare to the flowering stage of the crop. While, the data showed significant difference between the treatments for volumetric moisture content at both stages of the crop (Table 1). The 100% NPK + FYM treatment had the highest volumetric moisture content at flowering stage that was on par with 150% NPK results and the lowest volumetric moisture content was observed under control. The increase in percent moisture content in the organic manure treated plot may be due to increase in macro and micro pores of the soil and also better aggregation of soil separates. Singh *et al.*[8] reported the superiority of FYM in increasing the moisture content. These results are in close conformity with the findings of Yadav and Kumar[11], Vishwambharrao[10]. From the above results it appears that the soil receiving constantly organic matter retain more available water at deeper layer.

Table 1: Effect of LTFE on Gravimetric and volumetric moisture

Treatments	Gravimetric moisture content (θ_w %)		Volumetric moisture content (θ_v %)	
	45 DAT	95 DAT	45 DAT	95 DAT
Control	18.54	18.36	25.98	25.83
50% NPK	19.97	19.72	27.12	26.87
100% NPK	20.30	20.01	27.36	27.00
150% NPK	21.56	21.27	29.69	29.43
100% NPK + Zn	20.30	20.19	28.34	28.93
100% NP	19.91	19.35	27.64	26.9
100% N	18.70	18.44	26.70	23.93
100% NPK + FYM	25.96	24.48	33.60	34.84
50 % NPK + BGA	20.83	20.48	27.50	27.05
50% NPK + GM	22.49	21.79	29.41	28.61
CD (P = 0.05)	2.30	1.63	4.03	4.35

Nutrient content in grain

The nitrogen, phosphorus and potassium content in grain were non-significantly influenced with the different levels of fertilizer and manure application (Fig.1). The higher levels of nitrogen, phosphorus and potassium concentrations in grain were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The grains of 150% NPK treatment contained the highest levels of nitrogen concentration and highest levels of potassium and phosphorus were recorded in 100% NPK + FYM on the other hand, the control showed the lowest nitrogen, potassium concentration in grain and phosphorus recorded in 100% N alone treatment. Similar results were also found by Singh *et al*[9].

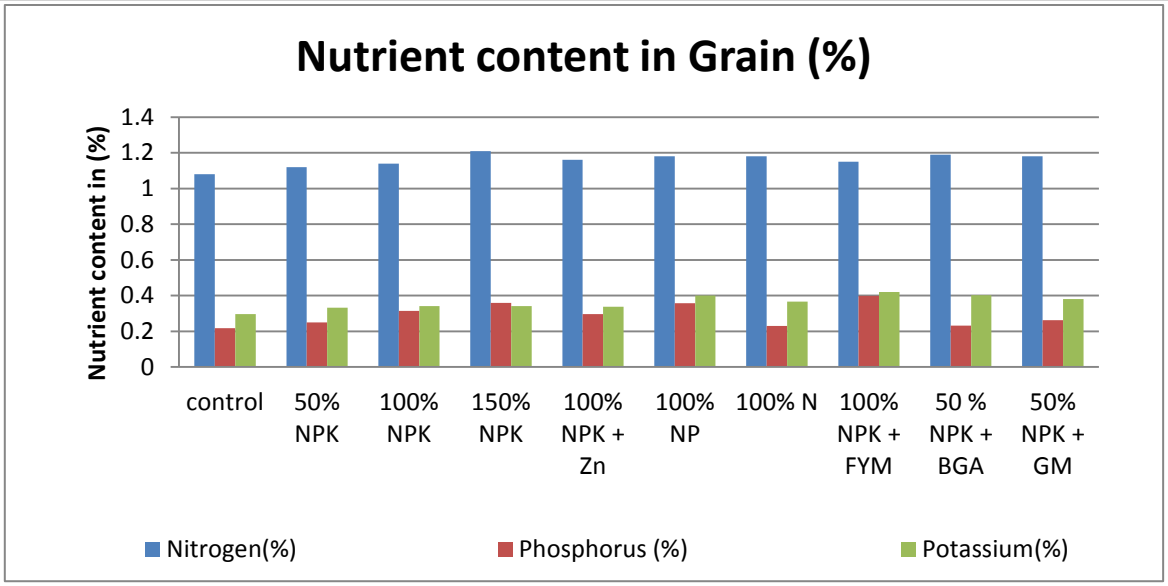


Fig. 1: Effect of continuous application of fertilizers and manures on percent content of nitrogen, phosphorus and potassium in grain

Nutrient content in straw

The effect of different treatments on nitrogen, phosphorus and potassium content in straw was found to be significant (Fig.2). The higher level of nitrogen concentration recorded in 50% NPK + GM, phosphorus concentrations recorded in 100% NPK and potassium concentrations recorded in 150% NPK treatment. While the lower values of nitrogen and phosphorus concentration in straw was recorded in control and lower potassium concentration was recorded in 100% N treatment. The lower concentration in straw in control plot may be a result of mining of nutrient with continuous cropping without incorporation of nutrient over a long period of time.

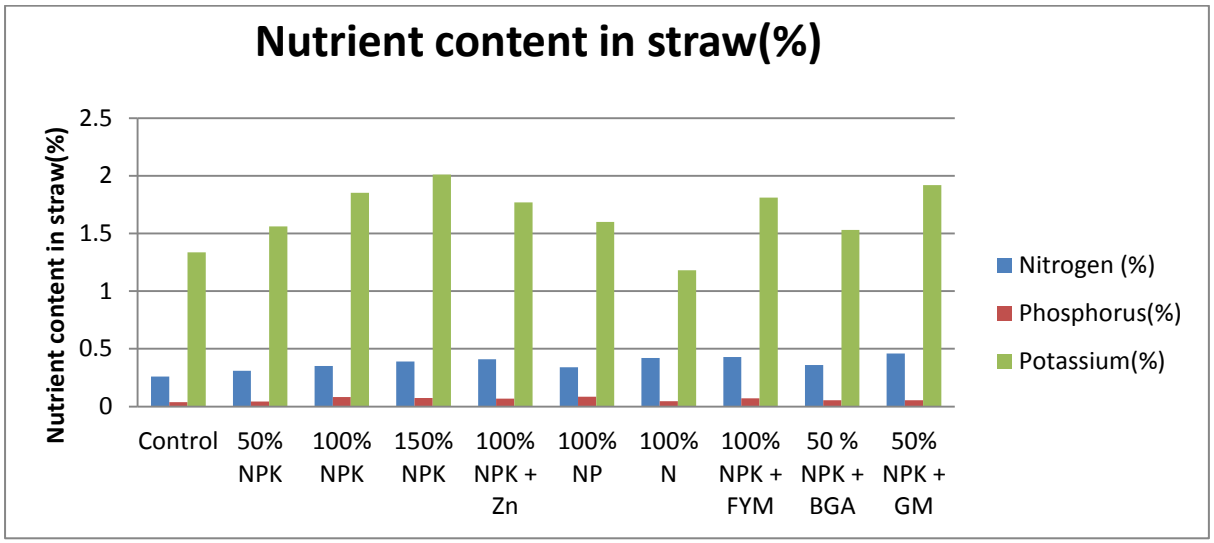


Fig. 2: Effect of continuous application of fertilizers and manures on percent content of nitrogen, phosphorus and potassium in straw

Nutrient uptake by grain and straw

Nutrient uptake was calculated by multiplying the concentration of nutrient elements in grain and straw with their respective yield. The sum of uptake by grain and straw was considered total uptake by rice crop.

Nitrogen uptake

The total nitrogen uptake was significantly affected by different treatments (Table 2). Among the treatments, highest total nitrogen uptake was observed in 150% NPK which was similar to those of two other treatments i e 100% NPK + FYM and 50% NPK + GM. Total nitrogen uptake in these three treatments had significantly higher values as compared to those of others like 100% NP, 100% NPK + Zn, 100% N, 100% NPK, 50% NPK + BGA, 50% NPK and control. Nitrogen uptake by both grain and straw of rice was significantly affected by the different treatments under study. The nitrogen uptake by grain varied from 25.36 to 61.41 kg ha-1. The highest nitrogen uptake (61.41 kg ha-1) by grain was recorded in the treatment 150% NPK which was significant over all other treatments. The treatment 150% NPK was followed by the treatments 100% NPK + FYM with nitrogen uptake of 55.80 kg ha-1. The lowest nitrogen uptake (25.36 kg ha-1) by grain was obtained due to the treatment control. The addition of nitrogen only strongly increased the nitrogen uptake by grain amounting to 46.96 kg ha-1. The uptake further increased remarkably due to combined application of nitrogen and phosphorus. The inorganic fertilizers and combined renew application of organic fertilizers was found encouraging over nitrogen alone application.

Table 2: Effect of Long - term application of fertilizers and manures on nitrogen uptake

Treatments	Nitrogen uptake (Kg ha^{-1})	
	Grain	**Straw**
Control	25.36	7.081
50% NPK	32.95	15.08
100% NPK	49.62	19.57
150% NPK	61.41	27.05
100% NPK + Zn	47.87	22.48
100% NP	51.27	20.24
100% N	46.96	23.05
100% NPK + FYM	55.80	28.36
50 % NPK + BGA	44.20	17.01
50% NPK + GM	48.41	30.09
Cd (p = 0.05)	8.27	7.17

In straw, the nitrogen uptake ranged from 7.081 to 30.09 kg ha-1. The highest nitrogen uptake (30.09 kg ha-1) by straw was recorded in the treatment 50% NPK + GM, which was significantly different from the rest of the treatments under study. The lowest nitrogen uptake (7.081 kg ha-1) was observed in the treatment control and the second lowest nitrogen uptake was found in the treatment 50% NPK with nitrogen uptake (15.08 kg ha-1). The continuous application of inorganic fertilizers alone and in different combinations with organic fertilizers showed a significant increase in nitrogen uptake by straw. The uptake of nitrogen by straw was 7.081 kg ha-1 in control plot. Application of nitrogen alone significantly increased the nitrogen uptake (23.05 kg ha^{-1}) over the control plot. The highest nitrogen uptake was found in the plots which received 150% NPK treatment (88.47 kg ha-1) followed by 100% NPK + FYM treatment (84.17 Kg ha-1) and lowest nitrogen uptake was found in control (32.44 kg ha-1).

Table 3: Effect of long - term application of fertilizers and manure on phosphorus uptake

Treatments	Phosphorus uptake (Kg ha^{-1})	
	Grain	Straw
Control	5.64	1.15
50% NPK	6.32	2.07
100% NPK	13.59	4.58
150% NPK	18.15	5.21
100% NPK + Zn	12.09	3.81
100% NP	15.53	4.99
100% N	9.29	2.22
100% NPK + FYM	19.00	4.82
50 % NPK + BGA	8.68	2.52
50% NPK + GM	10.52	3.48
Cd (p = 0.05)	6.31	1.72

Table 4: Effect of long - term application of fertilizers and manure on potassium uptake

Treatments	Potassium uptake (Kg ha^{-1})	
	Grain	Straw
Control	7.09	35.20
50% NPK	9.71	72.92
100% NPK	14.84	103.12
150% NPK	17.64	142.55
100% NPK + Zn	13.90	98.39
100% NP	17.33	93.91
100% N	14.31	65.62
100% NPK + FYM	20.19	117.60
50 % NPK + BGA	14.78	70.20
50% NPK + GM	15.34	124.03
Cd (p = 0.05)	5.48	28.51

Phosphorus uptake

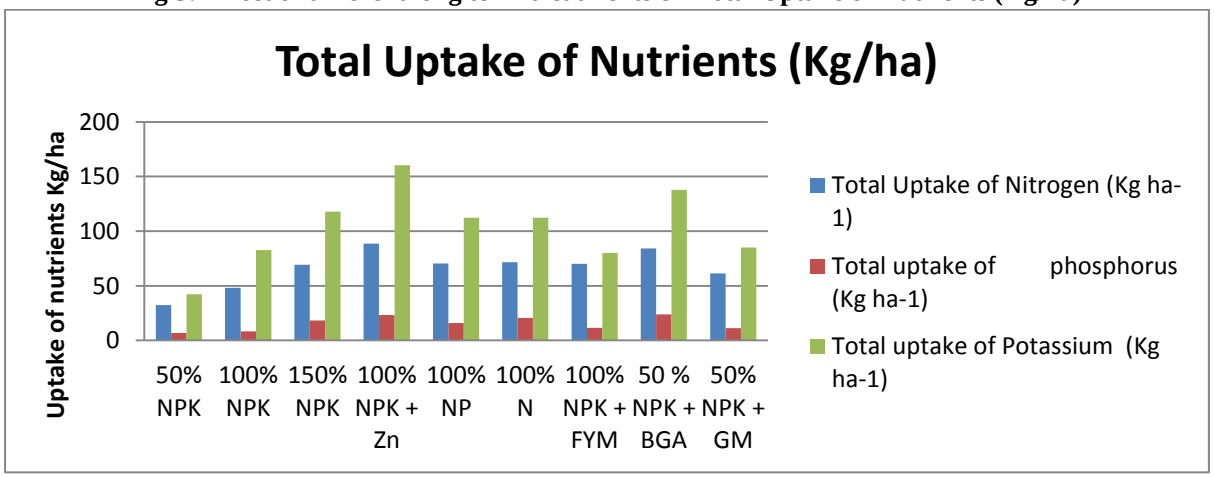
The effect of different treatments on total phosphorus uptake was found to be significant (Table 3). The treatments 100% NPK + FYM, 150% NPK, 100% NP and 100% NPK were statistically at par and significantly higher than 100% NPK + Zn, 50% NPK + GM, 100% N, 50% NPK + BGA, 50% NPK and control. Application of 100% NPK + FYM produced higher phosphorus uptake (23.82 kg ha-1) followed by 150% NPK (23.36 kg ha-1) and lowest in control (6.80 kg ha-1). The phosphorus uptake in both grain and straw of rice was significantly influenced due to various treatments used in the experiment. The phosphorus uptake by grain was varied from 5.64 to 19.00 kg ha-1. The maximum phosphorus uptake by grain was observed in the 100% NPK + FYM (19.00 kg ha-1) treatment followed by 150% NPK treatment. The phosphorus uptake by straw was also influenced significantly by different treatments. It was the highest (5.21 kg ha-1) under 150% NPK treatment followed by 100%

NP (4.99 kg ha-1) treatment; it was higher than
100% NPK + FYM (4.82 kg ha-1) treatment. The total uptake was the highest in 100% NPK + FYM (23.82 kg ha-1) treatment. The uptake due to 150% NPK (23.36 kg ha-1) was significantly lower than 100% NPK + FYM and the higher than rest of the treatments under study. Mehedi *et al.*[7] stated that total phosphorus uptake increased with the increasing levels of phosphorus.

Potassium uptake

The effect of continuous application of organic and inorganic fertilizers on total uptake of potassium was found significant (Table 4). The total uptake of potassium was significantly higher with 150% NPK treatment over other treatments like 100% NPK, 100% NPK + Zn, 100% NP, 50% NPK + BGA, 50% NPK, 100% N and Control. Although the treatments like 50% NPK + GM, 100% NPK + FYM were also statistically at par in total uptake of potassium with that of 150% NPK treatment. 150% NPK treatment recorded significantly higher total potassium uptake (160.2 kg ha-1) followed by 50% NPK + GM (139.37 kg ha-1) and lowest in control (42.29 kg ha-1). The K uptake by both grain and straw of rice was significantly influenced by various treatments under study. The K uptake by grain was varied from 7.09 to 20.19 Kg ha-1. The maximum K uptake (20.19 kg ha-1) by grain was observed in the treatment 100% NPK + FYM, which was statistically different from all the treatments. This was followed by the treatment 150% NPK (17.64 kg ha-1). The minimum K uptake by grain was recorded 7.09 kg ha-1 due to the control. The K uptake by rice straw was ranged from 35.20 to 142.55 kg ha-1. The highest K uptake (142.55 kg ha-1) was observed in the treatment 150% NPK. This was followed by treatment 50% NPK + GM (124.03 kg ha-1). Like K uptake by grain, the lowest K uptake (35.20 kg ha-1) was recorded in the treatment control which was statistically different from all the treatments under study. The total K uptake by grain and straw of rice was also influenced significantly due to different treatments and the total uptake ranged from 42.29 to 160.2 kg ha-1. Highest total K uptake was recorded in 150% NPK (160.2 kg ha-1). This was followed by 50% NPK + GM (139.37 kg ha-1) and the lowest total K uptake was recorded in control (42.29 kg ha-1).

Fig 3: Effect of different long term treatments on Total Uptake of Nutrients (Kg/ha)



CONCLUSION

The study showed that long-term application of organic materials (farm yard manure, blue green algae and green manure) along with fertilizers increased the soil porosity, moisture content and nutrient uptake, grain and straw yield of rice. Hence, long-term integrated nutrient management by applying organic manures and inorganic fertilizers has potential for improving the soil physical and chemical fertility status for increasing the crop yield for sustainable agriculture.

REFERENCES

1. Antil, R. S., Narwal, R. P., Singh, B. and Singh, J. P., Long- term effects of FYM and N on soil health and crop productivity under pearl millet-wheat cropping system. *Indian Journal of Fertilizers* **7:** 14-32 (2011).
2. Black, C. A., *Soil-plant relationships.* John Wiley and Sons, Inc. New York, London. pp 403 (1968).
3. Chapman, H. D. and Pratt, P. E., *Method of analysis for soil, plant and water*. University of California, USA (1961).
4. Hati, K. M., Swarup, A., Dwivedi, A. K., Mishra, A. K. and Bandyopadhyay, K. K., Changes in soil physical properties and organic carbon status at the topsoil horizon of a vertisol of central India after 28 years of continuous cropping, fertilization and manuring. *Agriculture, Ecosystems and Environment* **119(1/2):** 127-134 (2007).
5. Jackson, M. L., *Soil chemical Analysis*. Prentice Hall Inc. Englewood Cliffs, New Jercy, USA (1973).
6. Mandal, U. K., Singh, G., Victor, V. S. and Sharma, K. L., Green manuring: its effect on soil properties and crop growth under rice-wheat cropping system. *European Journal of Agronomy* **19:** 225-237 (2003).
7. Mehedi, H. M., Abedin Mian, M. J. and Mostofa, A. H., Effect of long term application of manures and fertilizers on soil properties, yield and nutrient uptake by T-Aman rice. *Bangladesh Research Publications Journal* **3(1):** 774-786 (2009).
8. Singh, A. K., Amgain, L. P. and Sharma, S. K., Root characteristics, soil physical properties and yield of rice as influenced by integrated nutrient management in rice-wheat system. *Indian Journal of Agronomy* **45(2):** 217-222 (2000).
9. Singh, R., Singh, S. and Prasad, K., Effect of fertilizer, FYM and row spacing on transplanted rice. *Crop Research* **22(2):** 296-299 (2001).
10. Vishwambharrao, K. S., Effect of integrated nutrient supply system on soil physical and chemical environment and productivity of rice in rice-wheat cropping sequence. *M. Sc. (Agriculture) Thesis,* Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh (2005).
11. Yadav, D. S. and Kumar, A., System based integrated nutrient management in sustainable crop system in Uttar Pradesh. *Fertilizer News* **38(7):** 45-51 (1993).
12. Yaduwanshi, N. P. S., Substitution of inorganic fertilizers by organic manures and the effect on soil fertility in a ricewheat rotation on reclaimed soil in India. *Journal of Agricultural Sciences* **140:** 161-168 (2003).