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Long-term effect of fertilizer application and their substitution practices on soil available N, P and K under the surface and sub-surface layer of soil.

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Abstract: *To study the long-term effect of fertilizer application and their substitution practices on soil available N, P and K field experiment was conducted at Norman E. Borlaug Crop Research Centre of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during 2014-2015. The content of available N, P and K improved significantly over the control. The content of N, P and K ranged from 225.79 to 328.72 Kg ha^{-1}, 14.06 to 26.36 Kg ha^{-1} and 112.21 to 132.53 Kg ha^{-1}, respectively at the surface layer and 91.14 to 150.96 Kg ha^{-1}, 11.26 to 16.66 Kg ha^{-1} and 102.31 to 119.31 Kg ha^{-1}, respectively at the sub-surface layer. The partial replacement of N through FYM, wheat straw and mung straw caused significant increase in nutrient status of N, P and K in soil. In all the treatments of sub-subsurface layer nutrient status of N, P and K decreased as compared to surface layer.*

The treatment where 25 per cent N was applied through FYM and 75 per cent through NPK fertilizer and where 50 per cent N was applied through mung straw and 50 per cent through NPK were found best among all the treatments. The Farmyard manure and green gram straw were observed to be the best organic sources of N for substitution of chemical N, with respect to soil fertility and crop yield.

Key words: *long-term, fertilizer application, available NPK, Soil depth*

INTRODUCTION

'The fertilizers are very important sources of plant nutrients and have played a prominent role in increasing food grain production of the country. Nitrogen from rice-wheat system can often be lost v*ia* ammonia volatilization, denitrification and leaching. Nitrification acts as a key process in determining fertilizer-use-efficiency by crops as well as N losses from soils. Loss of N via ammonia volatilization can be substantial when urea is top-dressed. Placement of fertilizer N beneath the soil surface or transportation of N to subsoil layers along with irrigation water can be a useful management option to reduce NH_3 volatilization.

In the rice-wheat system, response of wheat to fertilizer P application is more common than its application to rice. Moreover, the residual response of P applied to wheat on rice is greater than applied to rice on wheat. The availability of soil and residual fertilizer P increases under submergence and at high temperature prevailing during the rice season, and rice has greater ability to utilize the residual P from Fe-P and Al-P fraction than **(Goswami and Singh, 1976; Gill and Meelu, 1983)**.

Increasing levels of sodicity with sodic water use generally decreased K and increases Na contents in plants; also K uptake is reduced with high Na and low Ca status in soil solution under sodic conditions. Though crops grown on alkali soils of Indo-Gangatic plains did not respond to K

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application initially because of high ststus of avail;able K, but with continuous cultivation, crops have started responding depending upon the level of K depletion. The reason for lack of crop responses is presence of K-bearing micaceous and illitic minerals capable of releasing sufficient K, their dissolution and greater contribution of non-exchangeable K to its total uptake in plants. It has been observed that externally applied K reduces the release from non-exchange reserves and due to its low leaching a large portion of applied K remains in surface 30 cm soil **(Swarup, 1998)**.

MATERIALS AND METHOD

The soil sample from 0-15cm and 15-30cm depth was collected after the harvest of wheat from the long term experiment going on since Kharif 1983 under AICRP-IFS at Norman E. Borlaug Crop Research Centre, Pantnagar. The experiment was laid in Randomized block design with twelve treatments and three replications as follows:

Treatments	Rice (*Kharif*)	Wheat (*Rabi*)
T_1	Control	Control
T_2	50% RDF through inorganic source	50% RDF through inorganic source
T_3	50% RDF through inorganic source	100% RDF through inorganic source
T_4	75% RDF through inorganic source	75% RDF through inorganic source
T_5	100% RDF through inorganic source	100% RDF through inorganic source
T_6	50% RDF through inorganic source + 50% N through FYM	100% RDF through inorganic source
T_7	75% RDF through inorganic source + 25% N through FYM	75% RDF through inorganic source
T_8	50% RDF through inorganic source + 50% N through Wheat straw	100% RDF through inorganic source
T_9	75% RDF through inorganic source + 25% N through Wheat straw	75% RDF through inorganic source
T_{10}	50% RDF through inorganic source + 50% N through Mung straw	100% RDF through inorganic source
T_{11}	75% RDF through inorganic source + 25% N through Mung straw	75% RDF through inorganic source
T_{12}	Farmers' Practices	Farmers' Practices

Note: Recommended dose: N=120kg/ha, P_2O_5=60kg/ha, K_2O = 40kg/ha
Farmers' practice dose: N =120kg/ha, P_2O_5 = 48kg/ha, K_2O = 24kg/ha

Available Nitrogen

Available nitrogen was estimated by alkaline KMnO4 method **(Subbiah andAsija, 1956)**which is based on the extraction of inorganic and readily oxidizablenitrogen from organic compounds. The nitrogen was extracted with 0.32 per cent KMnO4 and distilled by 2.5 per cent NaOH. The liberated ammonia was absorbed was estimated titrimetrically using standard acid.

Available Phosphorus

Available phosphorus was extracted by Olsen's method **(Olsen*et al.*, 1954)** using 0.5 M NaHCO3 (pH 8.5) and developing the blue colour with ascorbic acid method of **Murphy and Riley (1962)**. The intensity of blue colour was recorded on spectrophotometer at 660 nm.

Available Potassium

Available potassium in soil was determined by extraction with 1 N ammonium acetate (pH 7) and K concentration was determined by flame photometer **(Perur*et al.*,1973)**.

Statistical Analysis

The statistical analysis was carried out by the procedure outlined by **Snedcor** and **Cochran (1967)**. The significance was tested at the 5 per cent level of significance. The data on "Long-term effect of fertilizer application and their substitution practices on soil available N, P and K under the surface and sub-surface layer of the soil" were subjected to RBD analysis by using software STPR3.

RESULTS & DISCUSSION

Available nitrogen

The nitrogen content of the soil ranged from 225.79 to 328.72 kg ha^{-1} at the surface and 91.14 to 150.96 Kg ha^{-1}at the sub-surface. The highest value of available N was recorded in T_{10} treatment (328.72 kg ha^{-1}) where application of 50% Nitrogen substituted through mung straw followed by T_5 (301.05 kg ha^{-1}) where 100% NPK was applied alone. In case of T_{12} treatment (farmers' practices) available N was found 275.96 kg ha^{-1} while, the lowest value of available N was found in T_1 treatment (225.79 kg ha^{-1}) which was under control. The availability of N in T_{10} (50% NPK + 50% FYM), T5 (100% NPK) and T_{12} (farmers' practices dose of NPK) treated plots were showed 45 %, 33% and 22 % respectively, greater than T_1 which was under control. The surface soil showed high values of available N as compare to sub-surface soil. This indicated that availability of N decreased with increase in depths. The sub-surface soil showed significant values of available N. The nitrogen content of the soil decreased in all the treatments from its initial value (392 kg ha^{-1}). The T_1 (control) treatment showed 73% decreased in available N over initial value followed by 70% in T_2 (50% recommended dose of fertilizer through inorganic source) and 51% in T_9 (75% NPK + 25% wheat straw), whereas T_5 (100% NPK) and T_{10} (50% NPK + 50% mung straw) treatments showed 30% and 19% respectively, decreased in available N over initial value, which showed slight decrease in nitrogen among all the treatments.

The highest value of available N was recorded in T_{10} treatment where application of 50% nitrogen substituted through mung straw. This could be attributed to the high N contained in the crop residue which was added continuously over the years and conserved against the losses. This results was supported by **Sharma and Gupta (1998), Sharma and Sharma (2002)**.

The availability of N in T_{10} (50% NPK + 50% mung straw) and T_5 (100% NPK) treated plots were showed 45 % and 33% respectively, greater than T_1 control. It could be because of the N addition through fertilizers and crop residues containing nitrogenous compounds. **Tyagi (1989)** also reported the similar results.

The treatment wise trend in subsurface layer was almost similar as was observed under surface layer. The nitrogen content decreased with soil depth, this might be attributed to lower nitrification efficiency due to low organic carbon in subsurface soil. Similar effect was reported by **(Heumann *et al.*, 2002)**.

Available Phosphorus

The available form of Phosphorus in soil ranged between 14.06 to 26.36 Kg ha^{-1} and 11.26 to 16.66 kg ha^{-1} at the surface and sub-surface depths, respectively. The highest value of available Phosphorus was recorded in T_{10} treatment (26.36 kg ha^{-1}) where 50 per cent of N was applied through mung straw along with 50 per cent through NPK followed by T_7 treatment (24.86 kg ha^{-1}) where 75% NPK applied with 25 per cent FYM while, the lowest value of available Phosphorus was recorded in T_1 (14.06 kg ha^{-1}) which was under control. The T_{12} treatment which was under farmers' practices showed 21.56 Kg ha^{-1} of available Phosphorus. The T_{10} and T_7 treatments showed 87% and 76% respectively, more value of available P than T_1 (under control) while, T_{12} treatment under farmers' practices showed 53% more over T_1.

The data showed that at surface soil almost all other treatments were found to be significant over control except T_2 treatment where 50% NPK was applied alone, while at sub-surface soil application of FYM, mung straw and Wheat straw along with inorganic fertilizer NPK were found to be significant as compared to inorganic fertilizer alone over control. The phosphorus content of the soil decreased with increase in depths. The Phosphorus content of the soil increased in all the treatments from its initial value 18 kg ha^{-1}, except in control treatment. The T_{10} (50% NPK + 50% mung straw) treatment showed 46% increase in available P over initial value followed by 38% in T_7 (75% NPK + 25 % FYM) and 31% in T_{11} (75% NPK + 25% mung straw), respectively.

The T_{10} and T_7 treatments showed 87% and 76% respectively, more value of available P than T_1 under control. This might be due to the soil available P was either maintained or significantly improved due to addition of different organic manures, on decomposition, solubilize insoluble organic P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil. This result was supported by **(Mondal*et al*., 2008)**. **Maitra*et al*. (2008)** also found similar improvement in soil available P status in a TypicUstrochrept of Uttar Pradesh due to integrated nutrient management in sunhemp. **Bhandari*et al*. (1992)and Kumar (1996)** also found similar effect of crop residue and FYM on soil availablephosphorus.

The Phosphorus levels in the layer 0-15 cm deep showed a marked increase with the application of organic manure, as a consequence of the supplying of this element by manure. In the subsurface layer, as a reflection of the low mobility of this element in soil. Similar result was reported by **Dias*et al*. (2000) and Villani*et al*.(1998)** under the Availability of phosphorus in a Brazilian Oxisol cultivated witheucalyptus after nine years as influenced by phosphorus-fertilizer source, rate, and placement.

The combined application of organic manure and inorganic fertilizer increased the available P status of the soil under rice-wheat crop rotation reported by **Jayasree*et al*. (2000)**, which might be due to the fact that organic anion competes withphosphate ions for binding sites on soil particles thereby reducing the P fixation.

Available Potassium

The available potassium of soil varied from 112.21 to 132.53 kg ha^{-1} at surface and 102.31 to 119.31 kg ha^{-1} at sub-surface depths of soil. The available K increased in treatments receiving mung straw, FYM and Wheat straw with NPK. Among these treatments plot T_{11} receiving 25 per cent organic residue through mung straw with 75 per cent NPK showed highest value of 132.53 kg ha^{-1} available potassium followed by T_7 treatment 128.52 kg ha^{-1} where 25 per cent of N applied through FYM with 75 per cent through NPK, while the lowest value was recorded under control plot T_1 112.21 kg ha^{-1}. The value of available potassium under T_{12} treatment where farmers' practices applied was found to be 117.87 kg ha^{-1}. The T_{11} and T_7 treatments showed 18% and 14% respectively, more values of available potassium over control T_1 whereas, T_{12} treatment showed 5% more value of available P over control. The Potassium content of the soil decreased in all the treatments from its initial value 125 kg ha^{-1} except T_6, T_7 and T_{11} treatment. The T_{11} (75% NPK + 25% mung straw) treatment showed 27% increase in available K over initial value followed by 23% in T_7 (75% NPK + 25 % FYM) and 21% in T_6 (50% NPK + 50% FYM), respectively.

The sub-surface soil showed significant value of available potassium, whereas surface soil showed non-significant value of available potassium. The potassium content of the soil decreased with increase in depths. Increase in available K in T_6, T_7 and T_{11} treatments due to addition of organic residue may be ascribed to the reduction of K-fixation and release of K due to interaction of organic matter with clays, besides the direct K addition to the soil. Similar result was reported by **(Urkurkar*et al*., 2010; Subehia and Sepehya, 2012)**.

The release of organic acid and other microbial products through the mineralization of organic matter might have influenced the availability of potassium. Similar result was reported by **(Katyal*et al*., 2002)**.

The lowest value of available potassium was found in control plot. This might be due to continuous cropping without fertilization which declines the available pool of potassium in the soil. **Singh *et al*. (1999)** also observed similar result in rice-wheat cropping.

The treatment wise trend in subsurface layer was almost similar as was observed under surface layer. However, the availability of potassium decreased with increase in depth. The higher amount of K in the surface layer could be attributed to more exposure of K bearing minerals to weathering and or upward translocation of K from subsurface layers by capillary rise or due to addition of K through plant residues, manures and fertilizers. Similar results were reported by **(Rao *et al*., 2013)**.

CONCLUSION

The continuous use of FYM and crop residues in partial replacement of fertilizer nitrogen significantly increased nutrient status of the soil. The

Table
Long-term effect of different treatments on available N, P and K content at surface and subsurface soil

Treatments	*N (kg ha-1)*		*P (kg ha-1)*		*K (kg ha-1)*	
	0-15cm	*15-30 cm*	*0-15cm*	*15-30 cm*	*0-15cm*	*15-30 cm*
T1	225.79	91.14	14.06	11.26	112.21	102.51
T2	229.97	107.68	18.53	13.90	113.76	109.38
T3	267.60	102.56	17.1	13.66	117.33	105.09
T4	275.96	103.73	18.16	13.80	116.60	113.67
T5	301.05	118.72	20.86	12.06	119.02	112.46
T6	288.51	112.89	21.06	15.03	126.27	113.72
T7	273.65	103.86	24.86	16.20	128.52	118.56
T8	268.03	108.72	22.10	15.66	117.13	111.10
T9	259.24	96.17	22.63	15.93	124.13	112.24
T10	328.72	150.96	26.36	17.06	122.36	117.03
T11	291.72	104.53	23.66	16.30	132.53	119.31
T12	275.96	108.71	21.56	16.66	117.87	108.54
SEm±	23.17	9.80	1.39	0.87	6.37	3.84
CD at 5%	NS	28.75	4.08	2.57	NS	11.26
Initial value (1983)	392	-	18	-	125	-

farmyard manure observed to be the best organic sources of N among all other organic sources with respect to soil fertility. Substitution of chemical fertilizers up to 50 per cent through FYM and Green gram straw can sustain crop productivity and soil fertility on long term basis.

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