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AK Singh
V.K.S. College of Agriculture, Dumraon, Bihar, India

AK Jain
V.K.S. College of Agriculture, Dumraon, Bihar, India

Correspondence
AK Jain
V.K.S. College of Agriculture, Dumraon, Bihar, India

Effect of residue incorporation on maize yield, nutrient uptake and soil health under maize-wheat crop sequence

AK Singh and AK Jain

Abstract
Effect of residue incorporation in acid soil with NPK fertilizers raised soil pH, available P & K status. However exchangeable Ca, Mg and available B content of soil was not affected when compared to NPK application alone. Residue incorporation with NPK fertilizers increased crop yield of maize as compared to NPK alone. Uptake of P and K by maize-wheat sequence in acid soil increased with in –situ incorporation of crop residues with NPK fertilizers as compared to application of NPK alone.

Keywords: Residue incorporation, NPK, In-situ

Introduction
India produces about 500 Million tonne (Mt) of crop residue every year, of which cereal crops (rice, wheat, maize, millets) residue's share is about 70%. Generation of cereal residues is highest in Uttar Pradesh (53 Mt) followed by Punjab (44 Mt) and West Bengal (33 Mt). India amounts to 84-141 Mt yr^{-1} whereas cereals contribute 23% (MNRE, 2009) [6]. Crop residues are carbon-rich materials that contain much nitrogen, phosphorus, potassium and microelements. Crop residue input is a sustainable way of improving soil quality without disturbing its biological balance. The decomposition of crop residues can increase the contents of organic carbon and available phosphorus, potassium in soils, which can provide nutrients for microorganisms and crops. In addition, soil moisture, aggregate stability and porosity also can be improved. Crop residues are good sources of plant nutrients and are important components for the stability of agricultural ecosystem.
Reasonable crop residue returning mode is required to improve soil health. First, the addition of nutrients from organic crop residues should be synchronized with crops demand. Second, crop residue returning combined with partial nitrogen fertilizer, straw ripening agent, and lime can promote the decomposition of crop residues by improving the activities of soil microorganisms. Third, soil conditions, climate and crop residues quality may affect the decomposition process of crop residues and produce negative effects. Therefore, the systematic crop residue returning theory needs to be established to ensure the soil health. Incorporation of crop residue decreased the bulk density and increased the soil porosity thus significantly enhanced the water holding capacity of soil (Das *et al.*, 2001) [5].

Materials and Methods
Field experiment was started in Kharif with maize-wheat cropping sequence. Total treatments is 8 as control no manures and fertilizers, crop residue (CR) 10 t ha^{-1} (Maize straw for wheat crop & wheat straw for maize crop), 50% N+PK+CR, 75% N+PK+CR, 100% N+PK+CR, 50% N+PK, 75% N+PK and 100% N+PK. In this experiment 3 replication and design RBD and Maize (Suwan) + Wheat (K 9107). Fertilizers dose is $N_{100}+P_{60}+K_{40.}$ The aim of the present study was to assess the availability and status of P, K, Ca, Mg, S, B, Zn and heavy metals in soil and plant as affected by the long term use of manures, fertilizers, lime, residue incorporation and crop rotation in an Alfisol of Ranchi.

Results and Discussion
Crop residues i.e. maize straw and wheat straw of the harvest of crops were incorporated in soil @ 10 t ha^{-1} either alone or with graded doses of NPK fertilizers and its impact on crop yields and uptake of plant. Data presented in table-1 indicate that straw and grain yield of maize increased from 22 and 11 qha^{-1} in control plot to 44 and 21.5 qha^{-1} with continuous incorporation of crop residue for past 14 years.

Residue incorporation with NPK fertilizers further increased the straw and grain yield of maize with highest value recorded in 100% NPK +CR plots. It was clear that plots receiving only NPK fertilizers as well as crop residue. (Raghavendra *et al.*, 2018) [8] also reported. Gaur *et al* (1995) [3] advocated the direct incorporation of organic residues in soil for favourable soil environment. Mishra *et al.* (1998) [4] also found increased yield of groundnut in acid soils with waste incorporation.

Table 1: Yield and uptake (kgha^{-1}) of P & K by Maize as affected by residue incorporation in soil

Treatments	Yield (Q/ha)		Total P uptake by Maize	Total K uptake by Maize
	Grain	Straw		
Control	11.0	22.33	3.02	11.94
Residue (R)	21.50	44.50	6.04	24.35
R+50% N+P+K	22.50	51.00	7.33	54.87
R+75% N+P+K	27.16	53.83	8.49	61.79
R+100% N+P+K	33.66	83.33	14.27	102.24
50% N+P+K	14.00	32.66	4.54	32.62
75% N+P+K	22.83	52.50	7.46	53.65
100% N+P+K	30.16	68.66	10.73	78.18
S.Em	0.59	1.67	0.24	2.21
CV 5%	1.80	5.08	0.74	6.71
CP %	4.50	5.68	5.50	7.30

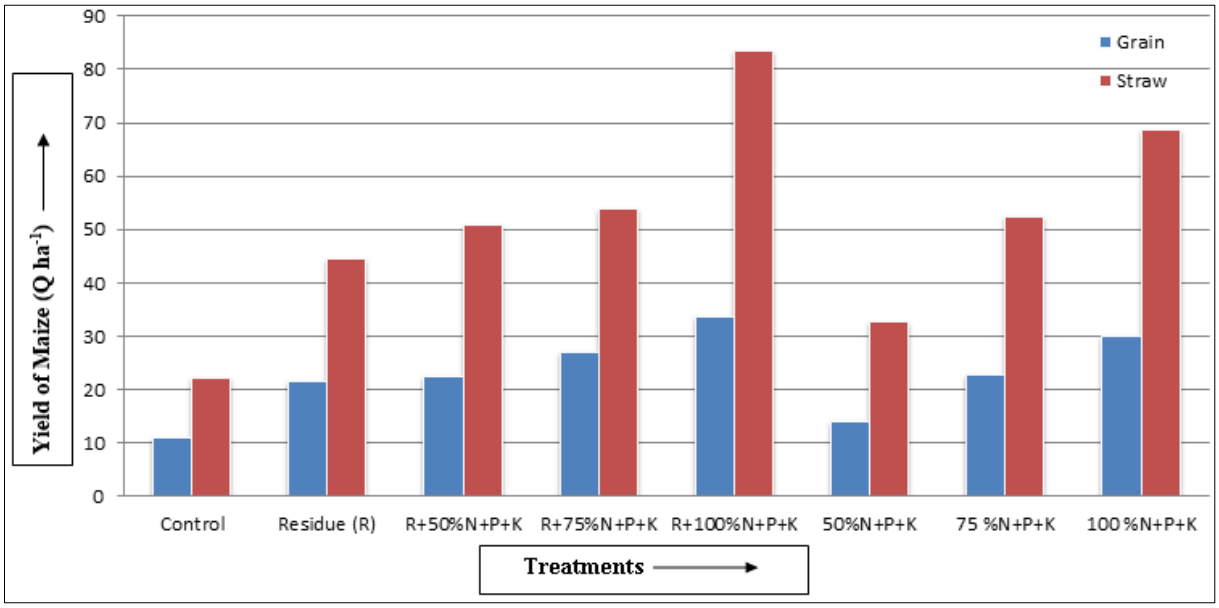

Fig 1: Effect of residue incorporation on yield (Q 1)

Total P uptake by Maize: Date presented in table-1 revel wide variation among treatments on the total P uptake by maize. Total uptake by maize in Control, CR and 100% N + PK + CR plot were 3.02, 6.04 and 14.27 kg ha^{-1} which clearly signify the treatment differences. Compared to NPK + CR plots, only NPK treated plots resulted in lower values of P uptake by maize. The results obtained in the present study are in agreement with the finding of Gupta *et al.* (1988) [1] & Dhillon and Dhillon (1991) [2], who observed increase in available P status of soil due to addition of legume residues.

Total K uptake by Maize

Date (table -1) clearly indicate that total K uptake by maize significantly increased over Control in order: CR > 50% N + PK+ CR > 75% N + PK+ CR > 100% N + PK+ CR with and without crop residues reveal significant difference. Total K uptake by maize had a wide range of variation from 11.94 to 102.24 kg ha^{-1} with different treatments. Actually to check the mining of K from soils, addition of crop residues is probably the best option.

Table 2: Effect of fertilizer use with crop residue incorporation on soil property

Treatments	With residue incorporation		Without residue incorporation	
	pH (1: 2.5 soil: water)	Org. C (g kg^{-1})	pH (1: 2.5 soil: water)	Org. C (g kg^{-1})
Control	5.80	5.27	5.60	4.60
50% NPK	5.80	5.53	5.73	5.70
75% NPK	5.80	5.53	5.50	5.77
100% NPK	5.70	5.57	5.46	5.87
CD at 5%	-	0.18	-	0.18

The incorporation of maize residues into the soil via tillage has the potential to reduce the soil bulk density and increase the SOM content, SOC storage, soil porosity, percentage of soil macroaggregates, and availability of N and K (Bai *et al.* 2011) [7].

Conclusion

In-situ incorporation of crop residues in acid soil with balanced NPK fertilizers improves crop productivity, soil health & plant nutrition. 50% NPK + crop residues result in high yield advantage and uptake of such plant nutrients, which are often limiting in acid Alfisols. Ph of soil reduced and organic carbon increased after long term application of crop residues. At the end we can conclude that in application of crop residues crop yield as well as soil properties improve.

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