



Effect of Nutrient Management and Crop Residue Incorporation on Phosphorus Uptake of Maize (*Zea mays* L) at Different Growth Stages

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The uptake of phosphorus was found to increase with each successive increase in nitrogen level from 200 to 300 kg ha⁻¹ and up to 60 kg ha⁻¹ with increase in age of the crop with higher uptake at 300 kg N ha⁻¹ and 60 kg P₂O₅ ha⁻¹. Crop sown in N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake by grain. Higher nutrient uptake was recorded in F₂ (125% of F₁) and F₄ (F₂+ Kharif crop residue incorporation), while the sub plot F₁ (Recommended dose of N and P₂O₅) and F₃ (F₁+ Kharif crop residue incorporation) recorded lower nutrient uptake during both the years. The uptake of phosphorus by maize increased with each successive increment of

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nitrogen and phosphorus but the trend is not consistent. The higher level of nutrients supplied through increased dose of nitrogen along with phosphorus is conducive for extensive root proliferation, to explore a greater volume of soil and absorb larger quantities of nutrients. Enhanced uptake of nutrients often tends to correlate positively with dry matter production and concentration of nutrients in the plant under higher level of nutrient supply. Residues of corn did not affect the P uptake and the nutrients released from corn residue is not a major contributor for subsequent corn nutrient uptake in sandy loam soils as is evidenced with highest nutrient uptake in the plots received with 125 % recommended dose either with or without residue incorporation.

Keywords: Phosphorus uptake; crop residues; crop yield; nutrient recycling.

1. INTRODUCTION

Crop residues are the parts of crops left over after the usable portions have been removed. Crop residues incorporated into the soil can serve as a source of nutrient recycling for plant growth and maintenance of soil fertility [1]. The estimated annual production of crop residues in India is 501 million tonnes, containing 8.02 million tonnes of NPK [2]. Jain [3] reported that in India, large quantities of crop residues are made available every year and about one third of the residues produced are available for direct recycling on the land and if used can add 2.19 million tonnes of NPK annually.

To meet the growing demand, enhancement of maize yield in coming years across all the growing locations in a sustainable way in India is the big challenge. Maize is a heavy feeder of nutrients, especially nitrogen and phosphorus, the deficiency of which limits the growth, yield and quality of the crop. In order to meet such challenges, over dependence on chemical fertilizers alone would lead to gradual decline in organic matter content and native fertility status of the soil, which in turn reflects on the future productivity [4]. In addition, due to recent escalation in prices of nitrogenous and phosphatic fertilizers, maize growers are facing crisis in purchase of the above fertilizers. On the other hand, organic manures need to be applied in bulk to meet the heavy nutrient requirement of hybrid maize for improving the fertility status of the soil on sustained manner, which is also not possible due to the scarcity of organic manures [5]. Hence, a strategy of integrated use of nitrogen and phosphorus fertilizers in combination with any amount of cheaper organic source like previous crop residue, which is abundantly available locally should be tried to satisfy the crop requirement to produce higher yield, without impairing soil health. The application of organic residue (e.g., straw) to soils represents a valuable recycling strategy [6],

which reduces in part our dependence on mineral fertilizers.

Maize crop residues are usually burnt in the field or widely used as animal feed or used as fuel for cooking against the ample benefits obtained through their incorporation, which would actually improve the fertility status of the soil for producing higher crop yield. Being the originator of crop residues, land has the first right to seek return of the nutrients removed by the crop from it for maintaining its sustainability. It is also closest to the site of residue production, thus saving on handling and transport costs [7]. The rate of decomposition of maize crop residue is also not a problem in the soils with luxuriant microbial population including termites. Hence, it is essential to estimate the quantity of nutrient uptake by the maize crop to get the benefits of residue incorporation.

2. MATERIALS AND METHODS

The field experiment was conducted at College Farm of Agricultural College, Mahanandi campus of Acharya N. G. Ranga Agricultural University, situated at 15.51°N latitude, 78.61°E longitude and at an altitude of 233.5 m above the mean sea level, in the scarce rainfall zone of Andhra Pradesh. A composite soil sample was collected at random from 0-30 cm soil depth and analyzed for physico-chemical properties prior to start of the experiments. The soil was sandy loam in texture, neutral in reaction, low in organic carbon and available nitrogen, high in available phosphorus and potassium. The experiment was conducted in the same plots of *kharif* season and was laid out in a split-plot design with three replications.

2.1 Treatments

There were nine main plots consisting of three nitrogen levels and three phosphorus levels of *kharif* season and four sub plots comprising of fertilizer and crop residue management practices.

2.1.1 Main plot treatments

Nine main plots (residual nutrients) consisting combination of three nitrogen levels 200, 250 and 300 kg N ha⁻¹ (N₁, N₂ and N₃ respectively) and three phosphorus levels 40, 60 and 80 kg P₂O₅ ha⁻¹ (P₁, P₂ and P₃ respectively) of *kharif* season.

2.1.2 Sub plot treatments

Four sub plots (nutrient doses ± crop residues) comprising of fertilizer and crop residue management practices. F₁: Recommended dose of N and P₂O₅ (250 kg N and 80 kg P₂O₅ ha⁻¹), F₂: 125% of F₁, F₃: F₁+ *Kharif* crop residue incorporation and F₄: F₂+ *Kharif* crop residue incorporation. A common dose of 60 kg K₂O ha⁻¹ was applied to all the plots.

The crop was sown at a spacing of 75 cm × 15 cm. The test cultivar was P-3396 a single cross hybrid with the yield potential ranging from 7.5 to 8.0 t ha⁻¹. After harvest of the economic produce of *kharif* maize the stover was allowed to dry in the field itself and plot wise weight of the crop residue was recorded.

Nitrogen was applied at graded levels as per the treatments in four splits *i.e.*, one fourth at basal, one fourth at knee height stage, one fourth at flag leaf emergence and the remaining one fourth at tasseling stage.

Five plants from the destructive sampling area were cut to the base at 30 days interval and at harvest, sun dried and then oven dried at 60°C till a constant weight was obtained and expressed the dry matter in kg ha⁻¹.

Oven dried plant samples collected for dry matter estimation were finely powdered and used for chemical analysis. The nutrient uptake was calculated by multiplying the nutrient content with respective dry matter and expressed as kg

ha⁻¹. Samples collected from the crop residues from the plots were dried in shade and hot air oven to a constant weight and then ground into fine powder and used for estimation of nitrogen, content, employing the standard procedures as outlined by Jackson [8] and the nutrient content of maize crop residue was expressed in per cent.

3. RESULTS AND DISCUSSION

Phosphorus uptake differed significantly due to residual nutrient effects (main plots) and nutrient doses ± crop residues (sub plots) and their interaction at different stages during both the years.

3.1 Phosphorus Uptake at 30 Days after Sowing (DAS)

Phosphorus uptake differed significantly due to residual nutrient effects (main plots) and nutrient doses ± crop residues (sub plots) but their interaction was not significant during both the years (Table 1).

Crop sown in N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake which was however on par with N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹), N₁P₃ (200 kg N + 80 kg P₂O₅ ha⁻¹) and N₁P₂ (200 kg N + 60 kg P₂O₅ ha⁻¹) during the first year of study. Similarly during the second year N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake, however it was on par with the remaining treatments except with the crop sown in N₁P₁ (200 kg N + 40 kg P₂O₅ ha⁻¹), N₂P₁ (250 kg N + 40 kg P₂O₅ ha⁻¹) and N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹). Significantly lower phosphorus uptake was recorded in the crop sown in N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹) during both the years of study.

Chart 1. Physical and chemical characteristics of soil

Particulars	Value
A. Physical characteristics	
Sand (%)	64.94
Silt (%)	24.72
Clay (%)	10.34
Textural class	Sandy loam
B. Chemical characteristics	
Soil pH (1:2.5 Soil water suspension)	7.34
EC (dS m ⁻¹)	0.18
Organic carbon (%)	0.45
Available N (kg ha ⁻¹)	275
Available P ₂ O ₅ (kg ha ⁻¹)	153
Available K ₂ O (kg ha ⁻¹)	670

Phosphorus uptake in F₂ (125% of F₁) sub plot recorded significantly higher values which were however on par with F₄ (F₂+ *Kharif* crop residue incorporation) during the first year and the lowest phosphorus uptake was recorded in F₃ (F₁+ *Kharif* crop residue incorporation). In the second year, significantly higher phosphorus uptake was recorded in the sub plot F₄ (F₂+ *Kharif* crop residue incorporation) which was on par with F₂ (125% of F₁) and F₃ (F₁+ *Kharif* crop residue incorporation). The lowest phosphorus uptake was recorded in F₁ (Recommended dose of N and P₂O₅).

3.2 Phosphorus Uptake at 60 DAS

Phosphorus uptake did not differ significantly due to residual nutrient effects (main plots), nutrient doses ± crop residues (sub plots) and their interaction during both years except due to residual nutrient effects (main plots) in the first year (Table 2).

Crop sown in N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake which was however on par with N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹), N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) and N₂P₂ (250 kg N + 60 kg P₂O₅ ha⁻¹) during the first year of study. Similarly during the second year N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded higher phosphorus uptake however it was on par with the remaining treatments. Lower phosphorus uptake was recorded in the crop sown in N₁P₃ (200 kg N + 80 kg P₂O₅ ha⁻¹) and N₂P₁ (250 kg N + 40 kg P₂O₅ ha⁻¹) in the first and second years respectively.

Phosphorus uptake in F₂ (125% of F₁) sub plot recorded higher values of phosphorus uptake which were however on par with the remaining sub plot means during both the years of study.

3.3 Phosphorus Uptake at 90 DAS

Phosphorus uptake differed significantly due to residual nutrient effects (main plots), nutrient doses ± crop residues (sub plots) and their interaction during first year and due to residual nutrient effects (main plots) alone in the second year (Table 3).

Crop sown in N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake which was however on par with N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹), N₃P₁ (300 kg N + 40 kg

P₂O₅ ha⁻¹) and N₂P₂ (250 kg N + 60 kg P₂O₅ ha⁻¹) during the first year of study. Similarly during the second year N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake however it was on par with N₃P₁ (300 kg N + 40 kg P₂O₅ ha⁻¹), N₂P₂ (250 kg N + 60 kg P₂O₅ ha⁻¹), N₂P₁ (250 kg N + 40 kg P₂O₅ ha⁻¹), N₁P₃ (200 kg N + 80 kg P₂O₅ ha⁻¹) and N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹). Significantly lower phosphorus uptake was recorded in the crop sown in N₁P₁ (200 kg N + 40 kg P₂O₅ ha⁻¹) during both the years. Similar results were obtained with respect to nutrients by Thimmappa et al., [9], Raouf and Ali, [10].

Phosphorus uptake in F₂ (125% of F₁) sub plot recorded higher values which were on par with F₄ (F₂+ *Kharif* crop residue incorporation) and significantly lower phosphorus uptake was recorded in F₁ (Recommended dose of N and P₂O₅) during the first year. Similar trend was observed in during the second year but there was no significant difference among the sub plot treatments.

Significant interaction was observed during the first year with regard to phosphorus uptake at 90 DAS. At the same level of main plot means F₂ (125% of F₁) recorded significantly higher phosphorus uptake in N₁P₂ (200 kg N + 60 kg P₂O₅ ha⁻¹), N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) over F₁ (Recommended dose of N and P₂O₅) and N₃P₁ (300 kg N + 40 kg P₂O₅ ha⁻¹) over F₃, while F₄ (F₂ + *Kharif* crop residue incorporation) recorded significantly superior phosphorus uptake at N₂P₁ (250 kg N + 40 kg P₂O₅ ha⁻¹) over F₃. At the same level of sub plot means the main plot treatments of N₃P₁ (300 kg N + 40 kg P₂O₅ ha⁻¹) at F₁ (Recommended dose of N and P₂O₅) and N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) at F₂ (125% of F₁), F₃ (F₁+ *Kharif* crop residue incorporation) and F₄ (F₂+ *Kharif* crop residue incorporation) treatments recorded significantly higher phosphorus uptake. The lowest phosphorus uptake was recorded with N₁P₁ (200 kg N + 40 kg P₂O₅ ha⁻¹) at all sub plot levels.

3.4 Phosphorus Uptake by Stover

Phosphorus uptake differed significantly due to residual nutrient effects (main plots) during both the years, while due to nutrient doses ± crop residues (sub plots) in the first year alone. The interaction was not significant during both the years (Table 4).

Table 1. Phosphorus uptake (kg ha⁻¹) by *rabi* maize at 30 DAS as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
N ₁ P ₁	3.7	3.8	3.1	3.2	3.5	4.2	4.4	3.0	4.7	4.1
N ₁ P ₂	3.9	4.0	3.6	3.9	3.9	3.8	5.2	4.4	5.1	4.6
N ₁ P ₃	3.9	4.0	3.4	4.0	3.8	4.7	5.6	4.0	4.8	4.8
N ₂ P ₁	3.3	3.8	3.1	3.7	3.5	3.8	4.5	3.6	3.7	3.9
N ₂ P ₂	3.5	4.0	3.4	4.0	3.7	4.5	5.6	4.9	4.7	4.9
N ₂ P ₃	3.7	4.2	3.4	4.1	3.9	4.4	4.5	4.0	5.0	4.5
N ₃ P ₁	3.5	4.0	3.3	3.5	3.6	4.7	4.8	4.5	4.8	4.7
N ₃ P ₂	3.5	3.6	3.1	3.5	3.4	3.4	3.4	4.9	3.9	3.9
N ₃ P ₃	4.2	4.3	4.1	4.2	4.2	4.5	4.6	4.9	6.3	5.1
Mean	3.7	4.0	3.4	3.8		4.2	4.7	4.3	4.8	

	<i>Rabi, 2014</i>		<i>Rabi, 2015</i>	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	0.15	0.4	0.21	0.6
F	0.09	0.2	0.15	0.4
NP at F	0.26	NS	0.44	NS
F at NP	0.30	NS	0.42	NS

Table 2. Phosphorus uptake (kg ha⁻¹) by *rabi* maize at 60 DAS as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
N ₁ P ₁	24.4	25.5	24.5	26.7	25.3	21.2	21.6	18.1	18.5	19.9
N ₁ P ₂	23.9	25.8	23.5	24.7	24.5	21.1	22.1	20.6	22.8	21.7
N ₁ P ₃	22.2	21.7	22.0	23.1	22.2	19.5	24.3	23.0	24.2	22.7
N ₂ P ₁	21.2	24.9	20.4	23.4	22.5	21.5	22.6	19.6	21.1	21.2
N ₂ P ₂	28.7	30.5	27.7	29.7	29.1	26.1	26.4	26.1	26.6	26.3
N ₂ P ₃	29.5	32.1	31.0	30.7	30.8	29.0	29.7	28.6	30.8	29.5
N ₃ P ₁	25.4	26.6	25.3	26.4	25.9	29.9	31.7	29.9	31.8	30.8
N ₃ P ₂	27.1	28.9	26.7	28.7	27.8	29.1	31.7	28.7	30.0	29.9
N ₃ P ₃	32.0	32.9	31.9	32.2	32.2	31.8	32.4	30.1	33.0	31.8
Mean	26.0	27.6	25.9	27.3		25.5	26.9	25.0	26.5	

	<i>Rabi, 2014</i>		<i>Rabi, 2015</i>	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	1.68	5.0	4.09	NS
F	1.62	NS	1.81	NS
NP at F	4.54	NS	6.24	NS
F at NP	3.36	NS	8.17	NS

Crop sown in N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹) recorded significantly higher phosphorus uptake in the first year which was however on par with N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) and N₃P₁ (300 kg N + 40 kg P₂O₅ ha⁻¹). In the second year of study N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) recorded higher phosphorus uptake which was on par with N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹) and N₃P₁ (300 kg N + 40 kg P₂O₅ ha⁻¹).

Significantly lower phosphorus uptake was recorded in N₁P₂ (200 kg N + 60 kg P₂O₅ ha⁻¹) during both the years, while it was on par with N₁P₁ (200 kg N + 40 kg P₂O₅ ha⁻¹), N₁P₃ (200 kg N + 80 kg P₂O₅ ha⁻¹) and N₂P₃ (250 kg N + 80 kg P₂O₅ ha⁻¹) in the first year and with all the main plot treatments except with N₃P₂ (300 kg N + 60 kg P₂O₅ ha⁻¹) and N₃P₃ (300 kg N + 80 kg P₂O₅ ha⁻¹) in the second year.

Table 3. Phosphorus uptake (kg ha⁻¹) by *rabi* maize at 90 DAS as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
N ₁ P ₁	30.4	39.6	31.7	38.0	34.9	33.3	41.2	35.3	37.4	36.8
N ₁ P ₂	33.9	43.6	38.8	40.0	39.0	37.4	45.1	43.4	43.8	42.4
N ₁ P ₃	43.5	52.2	48.0	51.0	48.7	45.7	52.2	50.5	51.6	50.0
N ₂ P ₁	47.5	50.9	43.8	55.3	49.4	51.9	52.1	50.6	52.6	51.8
N ₂ P ₂	53.2	58.5	52.8	54.4	54.7	51.2	55.4	52.3	52.2	52.8
N ₂ P ₃	52.0	64.3	53.2	58.0	56.9	53.1	55.5	53.3	53.8	53.9
N ₃ P ₁	54.2	60.8	46.7	54.2	54.0	51.8	52.1	48.3	51.5	50.9
N ₃ P ₂	47.0	53.1	48.3	49.8	49.6	47.8	50.1	48.6	48.3	48.7
N ₃ P ₃	50.9	53.6	52.6	53.5	52.6	49.6	51.1	49.2	51.6	50.4
Mean	45.8	53.0	46.2	50.5		46.9	50.5	48.0	49.2	

	<i>Rabi, 2014</i>		<i>Rabi, 2015</i>	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	1.73	5.2	1.57	4.7
F	1.03	2.9	1.41	NS
NP at F	3.19	9.3	3.98	NS
F at NP	3.45	9.0	3.14	NS

Table 4. Phosphorus uptake by stover (kg ha⁻¹) in *rabi* maize as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
N ₁ P ₁	23.9	26.1	24.8	23.1	24.5	23.4	24.3	23.4	24.0	23.8
N ₁ P ₂	22.4	23.7	22.8	22.1	22.8	22.6	23.2	23.2	23.5	23.1
N ₁ P ₃	22.8	24.2	24.9	23.1	23.8	22.8	23.4	23.4	23.6	23.3
N ₂ P ₁	26.3	29.0	28.1	29.2	28.2	23.7	24.1	24.7	25.0	24.4
N ₂ P ₂	26.5	26.6	26.2	26.4	26.4	24.7	25.9	25.6	25.9	25.5
N ₂ P ₃	25.2	25.3	24.1	25.3	25.0	23.9	24.2	24.8	25.0	24.5
N ₃ P ₁	30.5	32.1	29.2	29.9	30.4	25.7	25.8	25.9	26.4	26.0
N ₃ P ₂	28.5	34.9	33.1	30.9	31.9	26.9	28.1	28.1	27.9	27.8
N ₃ P ₃	28.4	30.6	28.5	32.5	30.0	28.1	29.3	29.2	29.2	29.0
Mean	26.1	28.1	26.9	26.9		24.6	25.4	25.4	25.6	

	<i>Rabi, 2014</i>		<i>Rabi, 2015</i>	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	0.96	2.9	1.10	3.3
F	0.46	1.3	0.45	NS
NP at F	1.54	NS	1.60	NS
F at NP	1.93	NS	2.20	NS

Significantly higher phosphorus uptake recorded in sub plot F₂ (125% of F₁), which were however on par with F₃ (F₁+ *Kharif* crop residue incorporation) and F₄ (F₂+ *Kharif* crop residue incorporation) in the first year. During the second year F₄ (F₂+ *Kharif* crop residue incorporation) sub plot recorded higher phosphorus uptake but there was no significant difference with other sub plots.

3.5 Phosphorus Uptake by Grain

Phosphorus uptake did differ significantly due to residual nutrient effects (main plots) during both the years, while due to nutrient doses ± crop residues (sub plots) in the first year alone. The interaction was not significant during both the years (Table 5).

Crop sown in N_3P_3 (300 kg N + 80 kg P_2O_5 ha⁻¹) recorded significantly higher phosphorus uptake during both the years, which was however on par with N_3P_2 (300 kg N + 60 kg P_2O_5 ha⁻¹) and N_3P_1 (300 kg N + 40 kg P_2O_5 ha⁻¹) during the first year and with N_3P_2 (300 kg N + 60 kg P_2O_5 ha⁻¹), N_3P_1 (300 kg N + 40 kg P_2O_5 ha⁻¹), N_2P_3 (250 kg N + 80 kg P_2O_5 ha⁻¹) and N_2P_2 (250 kg N + 60 kg P_2O_5 ha⁻¹) in the second year of study. Significantly lower phosphorus uptake was recorded in the crop sown in N_1P_2 (200 kg N + 60 kg P_2O_5 ha⁻¹) during both the years. Similar results were obtained by Sobhana et al. [11],

Mahajan et al. [12], Gemechu, [13], Geremew et al., [14], Mathukia et al., [15], Amanullah and Imanullah, [16], Araei and Mojaddam, [17] and Gul et al., [18].

Phosphorus uptake in the sub plot F_2 (125% of F_1) recorded significantly higher values, which was however on par with F_4 (F_2 + *Kharif* crop residue incorporation) and F_1 (Recommended dose of N and P_2O_5) sub plots in the first year. Similar trend was observed in during the second year but there was no significant difference between the sub plot treatments.

Table 5. Phosphorus uptake by grain (kg ha⁻¹) in *rabi* maize as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_1P_1	35.3	36.0	36.0	36.2	35.9	37.4	37.8	37.1	38.0	37.6
N_1P_2	33.9	33.9	33.2	35.0	34.0	34.2	36.4	32.6	38.3	35.4
N_1P_3	37.7	40.5	37.5	40.7	39.1	38.3	42.0	40.7	43.4	41.1
N_2P_1	40.1	45.8	38.2	40.2	41.1	38.5	47.0	43.1	44.6	45.8
N_2P_2	50.0	46.5	42.9	47.8	46.8	50.1	51.9	50.3	52.1	51.1
N_2P_3	49.8	50.4	43.9	47.2	47.8	52.9	53.4	52.7	53.9	53.2
N_3P_1	57.3	54.0	50.8	49.9	53.0	54.8	55.3	55.4	56.5	55.5
N_3P_2	50.9	59.7	53.7	54.6	54.7	56.2	58.6	52.3	53.6	55.2
N_3P_3	53.0	55.6	55.2	61.4	56.3	56.3	57.1	57.0	57.9	57.1
Mean	45.3	46.9	43.5	45.9		46.5	49.9	46.8	48.7	

	<i>Rabi, 2014</i>		<i>Rabi, 2015</i>	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	1.54	4.6	2.86	8.6
F	1.20	3.3	1.48	NS
NP at F	3.48	NS	4.79	NS
F at NP	3.08	NS	5.72	NS

Table 6. Grain yield (kg ha⁻¹) of *rabi* maize as influenced by crop residue and nutrient management practices

	<i>Rabi, 2014</i>					<i>Rabi, 2015</i>				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
N_1P_1	6864	6999	6990	7024	6969	7055	7116	6998	7152	7080
N_1P_2	6954	6969	6813	7185	6980	6421	6838	6129	7197	6646
N_1P_3	6413	6890	6375	6919	6649	5881	6456	6252	6670	6315
N_2P_1	6746	7704	6431	6767	6912	5819	7421	6521	6749	6628
N_2P_2	7990	7436	6862	7649	7484	7130	7384	7148	7409	7268
N_2P_3	7738	7828	6815	7339	7430	7366	7433	7334	7493	7406
N_3P_1	7864	7406	6972	6852	7273	7183	7249	7261	7408	7275
N_3P_2	6765	7931	7129	7252	7269	7363	7677	6858	7024	7230
N_3P_3	6931	7259	7213	8026	7357	7359	7458	7441	7561	7455
Mean	7140	7380	6844	7224		6842	7226	6882	7185	

	Rabi, 2014		Rabi, 2015	
	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
NP	144.4	433	321.5	964
F	110.1	310	135.3	381
NP at F	320.4	NS	476.5	NS
F at NP	288.9	NS	643.1	NS

The highest grain yield of hybrid maize was produced with the application of 125% recommended dose of N and P₂O₅ alone, however comparable with crop residue incorporation, application of 100% recommended dose of N and P₂O₅ alone, while it was found to be the lowest with the application of 100% recommended dose of N and P₂O₅ along with crop residue incorporation. The higher level of grain yield was due to the favourable influence of consistent and adequate availability of nutrients especially nitrogen throughout the crop growth period, which favoured the production of more photosynthates coupled with better partitioning to the sink, under higher level of nutrients. The results are in conformity with the findings of Singh et al. [19], Singh and Sharma, [20], Sushila and Rai, [21], Nsanzabaganwa et al., [22], Chandel et al., [23] and Ramu [24], [25,26].

4. CONCLUSION

Residues of corn did not affect the phosphorus uptake and the nutrients released from corn residue is not a major contributor for subsequent corn nutrient uptake in sandy loam soils as is evidenced with highest nutrient uptake in the plots received with 125 % recommended dose either with or without residue incorporation. Similar results were obtained - in medium textured silty loam soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table 7. Quantity of maize residues incorporated (kg ha⁻¹)

Treatments	Quantity (kg ha ⁻¹)	
	Kharif, 2014	Kharif, 2015
N ₁ P ₁	8364	9325
N ₁ P ₂	8113	12949
N ₁ P ₃	7516	10580
N ₂ P ₁	8507	10397
N ₂ P ₂	9252	13309
N ₂ P ₃	9123	12141
N ₃ P ₁	8601	11277
N ₃ P ₂	10797	13461
N ₃ P ₃	8432	12812

Table 8. Nutrient content (%) in residues of maize (on dry weight basis)

Treatments	Nutrient content (%)					
	Kharif, 2014			Kharif, 2015		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
N ₁ P ₁	0.86	0.20	1.89	0.84	0.21	1.64
N ₁ P ₂	0.96	0.30	1.94	0.74	0.27	1.46
N ₁ P ₃	1.02	0.33	2.20	0.70	0.26	1.76
N ₂ P ₁	0.99	0.29	2.25	0.91	0.27	2.45
N ₂ P ₂	0.94	0.32	1.98	0.70	0.24	1.90
N ₂ P ₃	0.88	0.26	1.84	0.77	0.34	1.57
N ₃ P ₁	1.06	0.29	2.39	0.91	0.41	2.39
N ₃ P ₂	0.91	0.35	2.53	0.86	0.31	2.04
N ₃ P ₃	1.05	0.35	2.01	0.87	0.28	1.62

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