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Effect of tillage, residue and residual of nitrogen management on protein yield, factor productivity and nutrient uptake by maize under rice - maize cropping system

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Abstract
Field experiment was conducted on effect of tiilage, residue and residual of nitrogen management practices at Institute Research Farm of ICAR – National Rice Research Institute, Cuttack (Odisha) during the rabi of 2016-17 and 2017-18 years. The experiment was laid out in split – split plot design with three replications. The results revealed that significantly higher nutrient uptake (N, P and K), partial factor productivity (nitrogen, phosphorus and potassium), protein yield and productivity of maize was recorded under treatment R_3 – RDF + residue mulching (6 t ha^{-1}) as compared R_1 – RDF + no residue, but protein content was found non – significant influence by different treatment of maize.

Keywords: Tillage, residue, protein yield, nutrient uptake and maize

Introduction
Rice – maize cropping system has become very dominant alternative for diversification under prevailing rice based cropping system in Asia. The drivers for substituting *Rabi* rice in rice based cropping system by maize comprise better suitability after harvest of long duration rice varieties with higher productive and profitable compared to the other *Rabi* season crops (Ali *et al*., 2009) [1]. Maize is an important cereal crop with various uses and known as 'Queen of Cereals Crop', being C_4 plant, high productive and requires less water, can be grown successfully under limited water resource conditions. Conventional maize planting results in extreme use of energy, which may constitute 25 – 30 per cent of total energy use in rice and maize cultivation (Sidhu *et al*., 2004) [9]. Further, achieving proper tilth for sowing maize after rice takes longer time. Hence, conservation tillage practices such as zero and minimum tillage are gaining more attention in recent years. Adoption of non-till helps in timeliness of sowing each in rotation, and hence leads to increase in productivity (Mohammad, 2009) [6]. The zero tillage for *rabi* maize may also help in advanced sowing, earlier crop emergence, less weed growth and use of residual soil moisture. During dry season in the coastal region temperature during the growth period does not go below 10 ^{0}C. Radiation is excellent and maize being a photo – insensitive crop has better option for adaption in the changing climatic scenario. In India, rice residue is produced huge quantities but farmers have no alternate uses of residue and usually disposed by burning because rice residue is reduce yield of succeeding crop due to poor plant population establishment and increase attack of pest and diseases (Singh *et al*., 2002) [10]. Crop residue is main input source of organic carbon under rice based cropping system and contributed to the increase in soil organic matter concentration, improvement hydrothermal regime and physical condition of soil (Jat *et al*., 2009) [5]. The aim of nutrient management to provide an adequate supply of all essential plant nutrients for a crop growth during the growing season and the amount of any nutrient is limiting at any time which is a potential for loss in crop yield. The LCC is an ideal and inexpensive tool to enhance nitrogen use in rice (Singh and Singh, 2003) [11]. Nitrogen fertilizer management through using LCC shade 3 as a threshold level resulted higher grain yield and enhance nitrogen use efficiency in direct seeded rice in North Western India (Singh *et al*., 2006) [12]. Hence, an investigation was carried out to know the effect of tillage, residue and residual of nitrogen management on protein yield and nutrient uptake by maize under rice – maize cropping system.

Material and Methods

The studies carried out at Institute Research Farm of ICAR – National Rice Research Institute, Cuttack (Odisha) during *rabi* 2016-17 and 2017-18 to know the effect of tillage, residue management and residual effect of nitrogen management in rice based cropping system. The experiment was laid out in split – split plot design with three replications. The experiment site was sandy loam soil in texture with acidic nature, medium available nitrogen, phosphorus and potassium content. The treatment includes, main plot consists of two tillage practices (T_1 – conventional tillage and T_2 – zero tillage), sub plot consists of three residue management [R_1 – RDF + no residue, R_2 – RDF + residue mulching (3 t ha^{-1}) and R_3 – RDF + residue mulching (6 t ha^{-1})] and sub – sub include of two residual of nitrogen management in rice [N_1 – LCC based (100 % RDN) and N_2 – LCC based (75 % RDN)]. The dose of fertilizers *i.e.* 150:50:50 kg ha^{-1} of nitrogen, phosphorus and potassium were applied in maize, respectively. Urea, single super phosphate and muriate of potash (MOP) were calculated and applied treatment wise. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal. Remaining half nitrogen was top dressed in two equal splits at knee height and tasseling stages. Irrigation was given immediately after sowing for ensure proper germination and plant stand. Irrigation was scheduled on basis of crop water requirement and duration of dry spell or period without rainfall and adequate drainage facility was provided by making drainage channel in the field. Partial factor productivity was obtained by dividing grain yield by the applied nutrient and production efficiency was calculated with the help of standard procedure given by Tomar and Tiwari (1990) [13]. The statistical analysis of data collected on different parameters of rice as described by Gomez and Gomez (1984) [4]. The protein content was computed by multiplying the respective nitrogen content of grain by the constant of 6.25 and then protein yield was worked out using the following formula:

Protein yield (kg ha^{-1}) = Grain yield (q ha^{-1}) × Protein content in grain

Results and discussion

Nutrient uptake (N, P and K)

The findings indicated that the effect of tillage practices in maize and residual of nitrogen management in rice did not have significant impact on N, P and K uptake by maize during 2016-17 and 2017-18 (Table 1). However, T_1 – conventional tillage (CT) and N_1 – LCC based (100 % RDN) recorded higher N, P and K uptake by maize in comparison to their respective treatments during 2016-17 and 2017-18. In case of the residue management in maize, treatment R_3 – RDF + residue mulching (6 t ha^{-1}) recorded significantly higher N, P and K uptake by maize as compared to treatment R_2 – RDF + residue mulching (3 t ha^{-1}) and R_1 – RDF + no residue during 2016-17 an 2017-18. The interaction among tillage practices in maize, residue management in maize and residual of nitrogen management in rice were found non – significant with respect to N, P and K uptake by maize during 2016-17 and 2018-19. This might be due to higher concentration of N, P and K in maize crop along with higher yield ultimately leads to higher uptake of nutrients (N, P and K), as uptake is derived by multiplication of nutrient concentration in grain and stover with respective yields. Singh *et al*. (1991) also noted higher nutrient uptake of N, P and K as an effect of mulching in winter maize. Nitrogen uptake was significantly higher with paddy straw and paddy husk mulching as compared to no mulch and improved the nitrogen use efficiency (Chakraborty *et al*., 2010) [3]. Shaheen *et al*. (2010) [8] also concluded that mulching gave statistically superior over no mulch with respect to total N and P uptake.

Partial factor productivity and production efficiency

The data on partial factor productivity of nitrogen, phosphorus and potassium as well as production efficiency of maize as influenced by tillage, residue management in maize and residual of nitrogen management in rice are presented in Table 2. The effect of tillage practices in maize and residual of nitrogen management in rice failed to give significant influence on partial factor productivity of nitrogen, phosphorus and potassium in maize as well as production efficiency of maize during both the years and on mean basis. However, T_1 – conventional tillage (CT) and N_1 – LCC based (100 % RDN) recorded higher partial factor productivity of nitrogen, phosphorus and potassium in maize as well as production efficiency of maize in comparison to their respective treatments during 2016-17 and 2017-18. Among the residue management in maize, treatment R_3 – RDF + residue mulching (6 t ha^{-1}) recorded higher partial factor productivity of nitrogen, phosphorus and potassium in maize as well as production efficiency of maize as compared to treatment R_1 – RDF + no residue, but it was at par to treatment R_2 – RDF + residue mulching (3 t ha^{-1}) during 2016-17 and 2017-18. The interaction effect of the tillage practices in maize, residue management in maize and residual of nitrogen management in rice remained unaffected with respect to partial factor productivity of nitrogen, phosphorus and potassium in maize as well as production efficiency of maize during 2016-17 and 2017-18. This might be due to higher leaf area index (LAI) and crop growth rate (CGR) as well as higher yield attributes and yields of maize. Pierre *et al*. (2008) [7] also reported that PFP of N, P and K decreased with increasing application rates of crop residue.

Protein content (%), protein yield (kg ha^{-1}) and protein productivity (kg ha^{-1} day^{-1})

The results revealed that the effect of tillage practices in maize and residual of nitrogen management in rice did not have significant impact on protein content in grain, protein yield and protein productivity of maize during 2016-17 and 2017-18 (Table 3). However, T_1 – conventional tillage (CT) and N_1 – LCC based (100 % RDN) recorded higher protein content, protein yield and protein productivity of maize in comparison to their respective treatments during 2016-17 and 2017-18. Among the residue management in maize, the significantly higher protein yield and protein productivity of maize were registered under treatment R_3 – RDF + residue mulching (6 t ha^{-1}) as compared to treatment R_2 – RDF + residue mulching (3 t ha^{-1}) and R_1 – RDF + no residue, whereas protein content in grain of maize was noted non – significantly during 2016-17 and 2017-18. The interaction among the tillage practices in maize, residue management in maize and residual of nitrogen management in rice were found non-significantly with respect to protein content in grain, protein yield and protein productivity of maize during 2016-17 and 2017-18. This might be due to more production of photosynthates in leaves and uptake of nutrient from soil and more availability of soil moisture under residue mulch, which kept proper water balance in the plant system, which might have resulted into efficient biochemical processes involved in the biosynthesis of protein content. Similar results were reported by Andrija *et al*. (2009) [2] and Zamir *et al*. (2013) [14].

Table 1: N, P and K uptake by maize (grain and stover) as influenced by tillage, residue and residual of nitrogen management

Treatment	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage						
RT_1: Conventional tillage (CT)	158.32	160.11	52.36	54.71	141.19	141.33
RT_2: Zero tillage (ZT)	154.36	154.76	50.48	52.28	136.83	137.61
SEm±	5.21	5.79	1.72	1.78	4.60	4.35
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Residue management						
RR_1: RDF + No residue	137.69	139.89	44.37	46.24	128.13	128.69
RR_2: RDF + Residue mulching (3 t ha^{-1})	160.13	160.40	52.16	54.49	138.50	138.90
RR_3: RDF + Residue mulching (6 t ha^{-1})	171.21	172.01	57.73	59.75	150.39	150.82
SEm±	3.28	3.34	1.63	1.65	3.94	4.57
CD (P=0.05)	10.70	10.91	5.30	5.37	12.85	14.89
Residual of nitrogen management						
RN_1: LCC based (100 % RDN)	154.37	155.60	50.03	52.44	137.35	137.48
RN_2: LCC based (75 % RDN)	158.31	159.27	52.81	54.55	140.66	141.46
SEm±	4.12	4.09	1.29	1.31	3.31	2.79
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

Table 2: Partial factor productivity and production efficiency of maize as influenced by tillage, residue and residual of nitrogen management

Treatment	"Partial factor productivity (kg kg^{-1})"						Production efficiency (kg ha^{-1} day^{-1})	
	Nitrogen		Phosphorus		Potassium			
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage								
RT_1: Conventional tillage (CT)	20.65	20.72	21.55	21.62	80.83	81.07	64.14	64.33
RT_2: Zero tillage (ZT)	20.18	20.24	21.06	21.12	78.97	79.21	62.67	62.86
SEm±	0.41	0.45	0.44	0.47	1.76	1.83	1.49	1.54
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Residue management								
RR_1: RDF + No residue	17.28	17.34	18.03	18.10	67.63	67.87	53.67	53.86
RR_2: RDF + Residue mulching (3 t ha^{-1})	21.33	21.39	22.26	22.32	83.47	83.71	66.24	66.43
RR_3: RDF + Residue mulching (6 t ha^{-1})	22.64	22.70	23.63	23.69	88.60	88.84	70.31	70.50
SEm±	0.43	0.48	0.48	0.50	1.87	1.92	1.50	1.56
CD (P=0.05)	1.40	1.57	1.56	1.63	6.09	6.26	4.89	5.09
Residual of nitrogen management								
RN_1: LCC based (100 % RDN)	20.55	20.61	21.44	21.51	80.42	80.66	62.99	63.18
RN_2: LCC based (75 % RDN)	20.28	20.35	21.17	21.23	79.38	79.62	63.82	64.01
SEm±	0.32	0.37	0.36	0.39	1.46	1.53	1.14	1.16
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Protein content in grain, protein yield and protein productivity of maize as influenced by tillage, residue and residual of nitrogen management

Treatment	Protein content in grain (%)		Protein yield (kg ha^{-1})		Protein productivity (kg ha^{-1} day^{-1})	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Tillage						
RT_1: Conventional tillage (CT)	7.51	7.57	507.99	513.52	4.84	4.89
RT_2: Zero tillage (ZT)	7.44	7.47	490.00	493.68	4.67	4.70
SEm±	0.11	0.17	9.65	8.05	0.09	0.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Residue management						
RR_1: RDF + No residue	7.32	7.46	413.49	423.82	3.94	4.04
RR_2: RDF + Residue mulching (3 t ha^{-1})	7.53	7.54	524.40	526.81	4.99	5.02
RR_3: RDF + Residue mulching (6 t ha^{-1})	7.57	7.57	559.10	560.16	5.32	5.33
SEm±	0.10	0.16	9.92	9.05	0.09	0.08
CD (P=0.05)	NS	NS	32.36	29.51	0.30	0.27
Residual of nitrogen management						
RN_1: LCC based (100 % RDN)	7.51	7.53	504.19	506.36	4.80	4.82
RN_2: LCC based (75 % RDN)	7.44	7.52	493.80	500.83	4.70	4.77
SEm±	0.09	0.13	7.96	6.67	0.07	0.06
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

Conclusion

Residue management had positive effect on partial factor productivity, production efficiency, protein yield and productivity of maize as it enhanced protein production of maize. Among the residue management in maize, treatment R_3 – RDF + residue mulching (6 t ha^{-1}) registered significantly higher nutrient uptake, partial factor productivity of nitrogen, phosphorus and potassium, production efficiency, protein yield and protein productivity of maize as compared to other residue management practices.

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