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Production efficiency and nutrient uptake by rice as influenced by tillage, residual effect of residue and nitrogen management practices under conservation agriculture

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Abstract
The field experiment was conducted during *kharif* season 2016 and 2017 at Research Farm of ICAR - National Rice Research Institute, Cuttack (Odisha) to study the effect of tillage, residual effect of residue and nitrogen management on nutrient uptake, partial factor productivity and production efficiency of rice. Findings revealed that tillage, residual effect of residue and nitrogen management had significant on yield, nutrient uptake, Partial factor productivity and production efficiency of rice. Treatment conventional tillage (CT), RDF + residue mulching (6 t ha^{-1}) and LCC based (100% RDN) registered significantly the highest grain yield, nutrient uptake (N, P and K), partial factor productivity and production efficiency in comparison to their respective treatments.

Keywords: Tillage, residue, nitrogen management, nutrient uptake and partial factor productivity

Introduction
Rice (*Oryza sativa* L.) is important cereal crops which contribute to food security and income generation in South Asia. Rice is a staple food crop for around 50 per cent of the world's population and provides more than 50 per cent of total calorie consumption in many South Asian countries (Bronson *et al*., 1997) [1]. Conservation tillage technologies include minimum soil disturbance, providing a soil cover through crop residues and dynamic crop rotations for achieving higher productivity and sustainability. Zero tillage system provides more carbon sequestration and adds sufficient soil organic matter in upper layer of soil. Zero tillage also minimize soil erosion, reduces production costs and improves soil organic carbon accumulation resulting in a improve physico-chemical and biological properties of soil such as soil aggregation, pH, soil temperature regulation, nutrient supply and balance microbial population which get the proper root growth and development with increased the potential of productivity (Lal *et al*., 2007) [2]. Rice residues supply essential plant nutrients by mineralization and improve biophysical condition and soil organic matter accumulation in soil as well as maintain soil fertility (Nyborg *et al*., 1995) [3]. The incorporation of crop residues as an essential practice for maintaining productivity of soil and enhancing the ability of farmlands to sequestration of soil organic matter. Loss of nitrogen through denitrification and volatilization are probable to be higher in dry direct seeded rice than the transplanted rice. Field to field huge variability of soil nitrogen supply, agro – climatic and varietal conditions restrict efficient use of nitrogenous fertilizer when broad based blanket recommendation is used. Real time nitrogen management approach such as leaf colour chart (LCC) have an inexpensive and simple tool which easy to use for monitoring the greenness of leaves and thereafter providing a quick estimate of the leaf nitrogen status and farmers take LCC readings at 7-10 day intervals and apply fertilizer nitrogen whenever the LCC reading fall below a critical level. With this background, the present investigation to study the effect of tillage, residual effect of residue and nitrogen management practices under conservation agriculture.

Materials and Methods
The field experiment was conducted during 2016 and 2017 at Research Farm of ICAR-National Rice Research Institute, Cuttack (Odisha). The field experiment was laid out in split-split plot design with three replications.

The treatment consisted of two tillage practices in rice *viz*., T_1 – conventional tillage (CT) and T_2 – zero tillage (ZT) in main – plot, three residual effect of residues *viz*., R_1 – RDF + no residue, R_2 – RDF + residue mulching (3 t ha^{-1}) and R_3 – RDF + residue mulching (6 t ha^{-1}) in sub - plot and two nitrogen management in rice *viz*., N_1 – LCC based (100% RDN) and N_2 – LCC based (75% RDN) in sub – sub plot.
The soil was sandy loam with acidic nature (6.31), medium in organic carbon (0.58%), nitrogen (283 kg ha^{-1}), phosphorus (22.67 kg ha^{-1}) and potassium content (152 kg ha^{-1}). The fertilizer recommendation of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O was followed in all plots. Full amount of phosphorus and potassium and 25 per cent of nitrogen were applied as basal and remaining nitrogen was applied as top dressing through leaf colour chart at weekly interval and seeds of rice variey Pooja were sowing at 40 kg ha^{-1} at a spacing of 20 cm line. After sowing, immediately light irrigation was applied for uniform germination and about 6 cm of water was applied to the rice crop in each of the irrigations. The clean grain obtained after threshing and winnowing separately treatment wise, thereafter, grain yield was weighed. The uptake of N, P and K in kg ha^{-1} was calculated by multiplying the nutrient content with the respective yield. 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) [4]. The statistical analysis of data collected on different parameters of rice as described by Gomez and Gomez (1984) [5].

Results and Discussion

Results presented in the Table 1 and 2 reveals that tillage, residual effect of residue management and nitrogen management in rice had a significant influence on yield, nutrient uptake, partial factor productivity and production efficiency. In case of tillage practices in rice, T_1 – conventional tillage (CT) produced significantly higher grain yield of rice as compared to T_2 – zero tillage (ZT). Significantly higher grain yield of rice was registered under treatment R_3 – RDF + residue mulching (6 t ha^{-1}) as compared to treatment R_1 – RDF + no residue, but it was statistically similar to treatment R_2 – RDF + residue mulching (3 t ha^{-1}). Treatment N_1 – LCC based (100% RDN) recorded significantly higher grain yield of rice as compared to treatment KN_2 – LCC based (75% RDN). This might be owning to better availability of nutrients even during later reproductive and grain filling stage, which resulted in increased rate of photosynthesis, better assimilation of carbohydrates which has direct bearing on grain weight per panicle and yield. These results are in agreement with the findings of Gangwar and Singh (2004) [6] and Gill and Walia (2013) [7].
N, P and K uptake by rice were recorded significantly higher under T_1 – conventional tillage (CT) as compared to T_2 – zero tillage (ZT). Treatment R_3 – RDF + residue mulching (6 t ha^{-1}) registered significantly higher N, P and K uptake by rice 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}). Treatment N_1 – LCC based (100% RDN) recorded significantly higher N, P and K uptake by rice as compared to treatment N_2 – LCC based (75% RDN). This might be owing to more vegetative growth and increased foraging capacity of roots which in turn increased the uptake of N, P and K by crop. The uptake of nutrient is a function of dry matter and nutrients, the increased grain yield together. Similar observations were recorded by Gangwar and Singh (2004) [6], Kour *et al.* (2005) [8], Mahajan and Timsina (2011) [9] and Singh *et al*. (2011) [10].
The effect of tillage practices in rice did not show any significant influence with respect to partial factor productivity of nitrogen, phosphorus and potassium in rice. However, significantly higher production efficiency was recorded under T_1 – conventional tillage (CT) as compared to T_2 – zero tillage (ZT). Treatment R_3 – RDF + residue mulching (6 t ha^{-1}) registered significantly highest partial factor productivity of nitrogen, phosphorus and potassium as well as production efficiency of rice which was at par to treatment R_2 – RDF + residue mulching (3 t ha^{-1}). Straw return increased the activities of soil microorganism and enzyme, which significantly promoted the availability of soil nitrogen (Xu *et al*., 2009). Treatment N_2 – LCC based (75% RDN) obtained significantly higher partial factor productivity of nitrogen in rice as compared to treatment N_1 – LCC based (100% RDN), whereas significantly higher partial factor productivity of phosphorus and potassium as well as production efficiency of rice was recorded under treatment N_1 – LCC based (100% RDN) as compared to treatment N_2 – LCC based (75% RDN). Declining trend of PFP of N with increasing dose of nitrogen has also been reported by Shivay *et al*, (2016) [11] Sharma *et al*. (2007) [12] also reported that the crop fed with high nitrogen levels increased the grain yield but showed less efficient in recording PFPN.

Table 1: Grain yield, N, P and K uptake by rice as influenced by tillage, residual effect of residue and nitrogen management (pooled)

Treatment	Grain yield (t ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Tillage				
T_1: Conventional tillage (CT)	5.96	103.89	22.95	121.40
T_2: Zero tillage (ZT)	5.42	92.39	19.51	107.34
S.Em±	0.08	1.65	0.45	2.12
CD (P=0.05)	0.51	10.01	2.72	12.90
Residual effect of residue management				
R_1: RDF + No residue	5.22	89.16	19.24	106.63
R_2: RDF + Residue mulching (3 t ha^{-1})	5.84	100.43	21.47	116.15
R_3: RDF + Residue mulching (6 t ha^{-1})	6.02	104.85	22.98	120.33
S.Em±	0.10	1.91	0.55	2.32
CD (P=0.05)	0.31	6.24	1.79	7.57
Nitrogen management				
N_1: LCC based (100% RDN)	5.90	102.40	22.31	118.10
N_2: LCC based (75% RDN)	5.49	93.88	20.15	110.64
S.Em±	0.05	1.46	0.40	1.83

CD (P=0.05)	0.16	4.51	1.24	5.63
Interaction	NS	NS	NS	NS

Table 2: Partial factor productivity and production efficiency of rice as influenced by tillage, residual effect of residue and nitrogen management (pooled)

Treatment	Partial factor productivity (kg kg^{-1})			Production efficiency (kg ha^{-1} day^{-1})
	Nitrogen	Phosphorus	Potassium	
Tillage				
T_1: Conventional tillage (CT)	39.69	23.81	89.30	37.21
T_2: Zero tillage (ZT)	36.17	21.70	81.38	33.90
S.Em±	0.64	0.54	2.00	0.50
CD (P=0.05)	NS	NS	NS	3.04
Residual effect of residue management				
R_1: RDF + No residue	34.49	20.84	78.14	32.55
R_2: RDF + Residue mulching (3 t ha^{-1})	38.95	23.35	87.59	36.49
R_3: RDF + Residue mulching (6 t ha^{-1})	40.34	24.08	90.29	37.62
S.Em±	0.68	0.54	2.01	0.52
CD (P=0.05)	2.21	1.76	6.55	1.68
Nitrogen management				
N_1: LCC based (100% RDN)	34.13	23.74	89.05	36.22
N_2: LCC based (75% RDN)	41.72	21.77	81.63	34.90
S.Em±	0.55	0.42	1.56	0.42
CD (P=0.05)	1.69	1.29	4.80	1.30
Interaction	NS	NS	NS	NS

Conclusion
The findings revealed that treatment T_1 – conventional tillage (CT), R_3 – RDF + residue mulching (6 t ha^{-1}) and N_1 – LCC based (100% RDN) registered significantly the highest grain yield, nutrient uptake (N, P and K) and production efficiency in comparison to their respective treatments. Whereas significantly higher partial factor productivity (N, P and K) was recorded under R_3 – RDF + residue mulching (6 t ha^{-1}) as compared to other treatments.

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