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Impact of tillage and nutrient management practices on rice crop yield and nutrient uptake in calciorthents of Bihar, India

Pittala Manoj Kumar*[1], Dhirendra Kumar Roy[2], Santosh Kumar Singh[3] and Mritunjay Kumar[4]

[1]Department of Agronomy, College of Agriculture, Vellanikkara 680 656, India
Kerala Agricultural University, Thrissur, Kerala, India
[2]Department of Agronomy, [3]Department of Soil Science,
PG College of Agriculture, Pusa 848 125, Bihar, India
[4] Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar, India

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ABSTRACT

The experiment entitled "Impact of different tillage and nutrient management strategies on productivity and profitability of direct seeded rice (*Oryza sativa* L.)" was conducted in an ongoing trial at the Agronomical Research Farm (plot no. 5) of Tirhut College of Agriculture, Dholi (RPCAU, Pusa) during *Kharif* 2019. The experiment was laid out in a 'split-plot design' with tillage practices under main plot treatments and nutrient management practices as subplot treatments. The results revealed that Zero tillage + Residue management and Zero tillage increased the grain and straw yield of direct seeded rice to the tune of 14.03 %; 9.27 % and 10.15 %; 6.1 % over Conventional tillage respectively. While SSNM based on Nutrient expert and 60 % RDN + GSGN + 100% PKof RDF increased grain and straw yield of direct seeded rice to the tune of 14.91 %; 7.73 %, and 12.07 %; 5.52 % over RDF, respectively. The significantly higher total NPK uptake by the crop was found in Zero tillage + Residue management among tillage practices and in SSNM based on Nutrient expert among nutrient management treatments however, both the tillage and nutrient management practices failed to have a significant influence on grain protein content whereas total crop micronutrient viz., Zn. Fe, Cu and Mn uptake was found maximum in Zero tillage + Residue management among tillage practices and were non-significant across nutrient management treatments.

Key words: *Zero tillage, Residue management, Green seeker, Nutrient expert®*

Introduction

Ever since the beginning of agriculture, Cereals have been an excellent source of diet for mankind as they are rich in carbohydrates. A major cereal crop, Rice (*Oryza sativa* L.) is known to be a highly dominant grain crop worldwide. Rice is a constituent of major proportion of daily diet in many South-east Asian countries. Globally rice supplies 21 per cent of human per capita energy along with 15 per cent of protein per capita. Sixty per cent of the earth's population lives in Asia, which contributes to 92 per cent of rice production in the world, with an overall rice consumption of 90 per cent (Awika, 2011).

Tillage practices have a considerable impact on rice cultivation, and the magnitude of the implica-

([1]PhD Scholar, [2]Prof., [3]Assistant Prof., [4]Registrar) tions of tillage is versatile and dependent on innate soil features and climatic factors. Paddy is mainly raised by manual transplantation of rice plantlets in the puddled field to realize good harvest besides managing weeds. Manual rice transplantation after puddling, besides being tiresome, expensive and time killing, also disintegrates the soil aggregation resulting in soil compaction (Gopal *et al.,* 2010). Long-term puddling practice in rice cultivating areas affects soil aggregates, beneficial microbial activity and soil environment (Bhattacharyya *et al.,* 2012). Intensive tillage using tough implements have led to the diminished aggregation, disintegration of soil structure, and decline in soil organic matter resulting in high production cost and poor monetary returns (Labios *et al.,* 1997). In this scenario, resource conservation agriculture (CA) practices have attained substantial prominence amongst farmers due to enhancement in soil wellness, resource use competency, productivity, and ecological advantages along with the reduction in alterable cost, where zero till DSR, zero till transplanted rice and unpuddled transplanted rice were proven to be better choices over the traditional puddled transplanted rice for the establishment of rice crop (Laik *et al.,* 2014). Favors for CA systems have already been reported from South Asia; with some of the advantages of zero till practice include minimal disruption of the soil, improved superficial residue retention and soil microbial mass, minimal tillage cost, economy of energy, time & fuel and also timely sowing of succeeding crop in some cases. Moreover, superficial retention of residual crops aids in replenishing nutrients in the soil besides enhancing organic matter, percolation and WHC of soil (Chastin *et al.,* 1995).

Rational nutrient supply is a prerequisite for the growth and development of rice to maximize crop yields. However, disproportionate nutrient application diminishes nutrient uptake by crops, NUE, deteriorates the ecological quality and increases the cultivation cost. Henceforth, concerned with rice, precise nutrient regulation technologies in rice have been developed to enhance NUE in recent years, such as real-time N management (RTNM) and site-specific nutrient management (SSNM), which requires data on yield goals and potential, values of innate nutrient supply, applied fertilizer's recovery efficiencies, nutrient uptake by the plant and its relation to grain yield (Wang *et al.,* 2001). Among the major nutrients, nitrogen usage has raised several times, succeeding the green revolution, which led to the importation of N-fertilizers owing to irrational handling. Therefore, it is crucial to have effective and economical N fertilizer consumption. In this situation, the usage of a Green seeker or NDVI crop sensor, which is a handy tool, can be a boon, as it helps in the precise and effective crop input nitrogen regulation where N-level variabilities of the crop can be measured and quantified using of optical sensors that has become one among the highly used strategies for tracking crop stress and vegetative cover (Mulla, 2013). With this background, a study was carried out to understand the effect of different tillage and nutrient management practices on the grain yield and nutrient uptake of direct seeded rice in calciorthents of Bihar.

Materials and Methods

A field experiment was conducted in an ongoing long-term tillage trail, established in 2010 under a set of tillage and nutrient management treatments with the Rice-Maize cropping system at the Agronomical Research Farm (plot no. 5) of Tirhut College of Agriculture, Dholi (RPCAU) during *Kharif* 2019. The soil belongs to the great group calciorthent, textural class of sandy loam, alkaline, moderate in organic carbon (OC), nitrogen, phosphorous, potassium and deficient in sulphur and zinc. A short-duration rice variety, Prabhat, was taken as a test variety. The overall rainfall received during the field study was 1039.8 mm. The experiment was laid out in a 'split-plot design' with tillage practices under main plot treatments and nutrient management practices as subplot treatments (Table 1). SSNM stands for site-specific nutrient management, and GSGN stands for green seeker-guided nitrogen application, where 60 percent RDN was applied as basal, and the rest of the N was applied based on the real-time crop demand at regular intervals. Three splits of N were applied at 2:1:1 ratio at basal, active tillering and panicle initiation in N_1 and N_2 treatments. All the recommended crop management practices (hoeing, weeding, irrigation and pesticides etc.) were commonly followed for all the treatments and carried out throughout the growing season as and when needed. The observations were recorded by adopting the standard protocol for each parameter.

Table 1. Treatment details

Sl. No.	Treatments	Notations
Main plot: Tillage practices		
1.	Conventional Tillage (CT)	T_1
2.	Zero Tillage (ZT)	T_2
3.	Zero Tillage + Residue (ZT+R)	T_3
Sub-Plot: Nutrient management practices		
1.	Recommended dose of fertilizers (RDF) @ 120-60-40 NPK kg/ha	N_1
2.	SSNM based on Nutrient Expert® for rice @ 109-28-46 NPK kg/ha	N_2
3.	60% RDN + GSGN + 100% PK of RDF @ 104-60-40 NPK kg/ha	N_3

*CT plots were ploughed twice *fb* disking *fb* planking, while ZT and ZT+R plots remained unploughed and furrows were made for sowing
*SSNM stands for site-specific nutrient management and GSGN stands for green seeker guided nitrogen application

Results and Discussion

The data recorded and calculated during the field study was statistically analyzed and presented in Tables 2 & 3.

Yield

Statistically analyzed data concerning grain and straw yield, Harvest index and grain protein content of DSR were represented in the Table 2.

Grain and straw yield

Among tillage practices, T_3 recorded considerably superior grain and straw yield (45.04 & 64.74 q/ha) over T_1(39.50 & 59.25 q/ha) which stood at par with T_2(43.51 & 62.87 q/ha) respectively. This could be credited to the improved soil structure for plant root proliferation resulted by less soil disruption and overall porosity, aggregate stability, WHC and ease of soil-plant nutrient assimilation which are congenial for increase in the photosynthetic rate, dry matter production and the source-sink photosynthate translocation rate with better yield attributes that enhanced the grain filling (Jat *et al.*, 2019). Whereas under nutrient management treatments, N_2 recorded significantly superior grain and straw yield (45 & 64.26 q/ha) over N_1 (39.16 & 59.65 q/ha) and was statistically comparable with N_3 (43.89 & 62.94 q/ha), respectively. This could be due to need based and timely application of fertilizers that helped in realizing better grain yields.

Harvest index

Both treatments *viz.*, tillage practices and nutrient management treatments, have failed to show a significant difference in the harvest index, though the

Table 2. Effect of tillage and nutrient management practices on grain and straw yield, harvest index and grain protein content of DSR

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Grain protein (%)
Tillage practices				
T1	39.50	59.25	39.86	8.36
T2	43.51	62.87	40.89	8.35
T3	45.04	64.74	41.05	8.45
SEm±	0.64	1.05	0.51	0.08
LSD(p =0.05)	2.51	4.11	NS	NS
Nutrient management practices				
N1	39.16	59.65	39.52	8.32
N2	45.00	64.26	41.25	8.44
N3	43.89	62.94	41.04	8.44
SEm±	1.19	1.18	0.87	0.12
LSD(p=0.05)	3.65	3.63	NS	NS
LSD(p=0.05)(TxNM)	NS	NS	NS	NS

*DSR stands for direct seeded rice; DAS stands for days after sowing; NS stands for non-significant highest HI among the tillage practices was found under Zero tillage + Residue management (41.05) and SSNM based on Nutrient Expert® (41.25) among the nutrient management treatments had the highest harvest index which could be attributed to the better overall growth and development of the crop.

Grain protein content

Grain protein content was found to have no significant influence by both the tillage practices and nutrient management treatments and was the same with the interaction; however, maximum protein content was obtained with Zero tillage + Residue management (8.45 %) and SSNM based on Nutrient expert (8.44 %) across the respective treatments as this attribute is more related to the genetical aspect and less likely to be affected by these treatments.

Nutrient uptake

Total NPK uptake

A close examination of the data from Table 3 reveals that both practices affected the total NPK uptake by direct seeded rice. Significantly superior total NPK uptake was obtained in T_3 (86.71; 24.62 & 99.99 kg/ha) over T_1 (76.76;22.20 & 92.23 kg/ha) and was comparable with T_2 (83.85; 24.32 & 96.60 kg/ha) under tillage practices respectively. On the other hand, N_2 under nutrient management treatments was found to have significantly superior total NPK uptake (87.38; 24.77 & 99.51 kg/ha) over N_1 (76.09; 22.17 & 90.36 kg/ha) but stood on par with N_3 (83.85;24.19 & 98.95 kg/ha) respectively.

Total Zn, Fe, Cu and Mn uptake

Data indicates that the total micronutrient uptake by direct seeded rice crop was significantly affected only by tillage practices micro nutrient fertilizers were not applied in the nutrient management treatments. Within tillage treatments, a significantly high amount of total micronutrient uptake *viz.*, Zn, Fe, Cu and Mn was obtained in T_3 (305.14, 489.57, 54.79 & 345.94 g/ha respectively) over T_1 and was statistically comparable to T_2. Across nutrient management treatments, the highest amount of total Fe, Cu and Mn (485.10, 52.84 & 340.52 g/ha respectively) uptake was found under N_2 *fb* N_3 *fb* N_1 while total Zn uptake was found maximum under N_3 (298.63 g/ha) *fb* N_2 *fb* N_1.

The higher amount of nutrient uptake in the conservation tillage treatments was owing to the enhanced plant root proliferation by improving the exposure of plant roots to the available nutrients in soil. It might be ascribed to minimal soil disturbance and no soil compaction by the conservation tillage practices that led to a suitable soil structure allowing the roots to proliferate deep into the soil enabling deep-layer nutrient extraction (Jat *et al*., 2019). Apart from this, the continual addition of crop remains eventually increases the SOC, recycles, and replenishes the plant nutrients in the soil for longer periods of crop use. In addition, the higher content of organic matter expands the soil microbial population, enhancing the nutrient mineralization process in-

Table 3. Effect of tillage and nutrient management practices on total uptake (grain + straw) of N, P, K, Zn, Fe, Cu and Mn by DSR

Treatment	N	P (kg/ha)	K	Zn	Fe (g/ha)	Cu	Mn
Tillage practices							
T1	76.76	22.20	92.23	278.32	448.50	44.16	318.85
T2	83.85	24.32	96.60	298.37	484.42	50.36	339.53
T3	86.71	24.62	99.99	305.14	489.57	54.79	345.94
SEm±	1.38	0.23	0.83	2.48	6.50	1.36	4.99
LSD(p =0.05)	5.42	0.92	3.25	9.74	25.53	5.36	19.61
Nutrient management							
N1	76.09	22.17	90.36	286.54	459.22	46.88	328.08
N2	87.38	24.77	99.51	296.67	485.10	52.84	340.52
N3	83.85	24.19	98.95	298.63	478.17	49.60	335.72
SEm±	2.08	0.49	1.62	5.12	9.50	1.54	6.99
LSD(p=0.05)	6.42	1.50	5.00	NS	NS	NS	NS
LSD(p=0.05)(TxNM)	NS	NS	NS	NS	NS	NS	NS

*DSR stands for direct seeded rice; DAS stands for days after sowing; NS stands for non-significant creasing nutrient availability. It also minimizes soil nutrient depletion by enhancing the chelation of the nutrients from the applied fertilizers. Thus, increasing the crop yields with higher nutrient concentration enhances the total crop nutrient uptake. The above findings were in line with that of Das *et al.* (2001) and Dwivedi and Thakur (2000).

In general, an unfair nutrient application adversely impact on crop growth and development. This higher uptake under SSNM based on Nutrient Expert® could be attributed to its balanced and timely application of nutrients, where the fertilizer application was done based on the soil status and crop demand. Rajesh *et al.* (2018) reported that significantly superior NPK uptake by grain and straw was found under the SSNM approach, which could be attributed to balanced fertilization based on the targeted yield approach.

Conclusion

Results of this study indicated that direct seeding of *Kharif* rice under zero tillage + residue management practice coupled with SSNM based on Nutrient Expert for rice led to improved crop nutrient uptake and crop yield in the calciorthents of Bihar.

Competing interests

Authors have declared that no competing interests exist.

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