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Effect of Different Tillage and Nutrient Management Practices on Yield Attributes and Economics of Direct Seeded Rice

Pittala Manoj Kumar [a++*], Dhirendra Kumar Roy [b#], Santosh Kumar Singh [c†] and Mritunjay Kumar [d‡]

[a] Department of Agronomy, College of Agriculture, Vellanikkara-680656, Kerala Agricultural University, Thrissur, Kerala, India.
[b] Department of Agronomy, PG College of Agriculture, Pusa-848125, Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar, India.
[c] Department of Soil Science, PG College of Agriculture, Pusa-848125, Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar, India.
[d] Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar, India.

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

An experiment 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 'split-plot design' with tillage practices under main plot treatments and nutrient management

[++] PhD Scholar;
[#] Professor;
[†] Assistant Professor;
[‡] Registrar;
**Corresponding author: E-mail: manojpittala@gmail.com;*

practices as subplot treatments. The results revealed that yield attributes such as no. of panicles per square metre and no. of grains per panicle were significantly influenced by both tillage and nutrient management practices with higher values of both the yield attributes were recorded in Zero tillage + Residue management (239; 122) among tillage practices and site specific nutrient management (SSNM) based on Nutrient expert® (228; 119) respectively among nutrient management treatments whereas, panicle length, test weight and harvest index were not significantly influenced by any of the tillage or nutrient management practices. Zero tillage + Residue management and Zero tillage increased the grain and straw yield of direct seeded rice to the tune of 14.03% (grain); 9.27% (straw) and, 10.15%(grain); 6.1% (straw) over Conventional tillage, respectively. While SSNM based on Nutrient expert® and 60% RDN + GSGN + 100% PK of, 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. Zero tillage + Residue management among tillage practices and SSNM based on Nutrient expert® among nutrient management treatments resulted in maximum gross returns (₹ 91451, ₹ 91321 /ha); net returns (₹ 59050, ₹ 59313 /ha) and BCR (1.83, 1.86) respectively.

Keywords: Zero tillage; residue management; green seeker; nutrient expert®.

1. 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. Globally, 21 per cent of human per capita energy, along with 15 per cent protein per capita, has been supplied by rice, a constituent of a major proportion of daily diet in many South-east Asian nations. Sixty per cent of the earth's population lives in Asia, which contributes to 92 per cent of rice production worldwide, with an overall rice consumption of 90 per cent [1].

Tillage practices have a considerable impact on rice cultivation, and the magnitude of the implications 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 [2]. Long-term puddling practice in rice cultivating areas affects soil aggregates, beneficial microbial activity, and the soil environment [3]. Intensive tillage using tough implements have led to diminished aggregation, disintegration of soil structure, and decline in soil organic matter resulting in high production cost and poor monetary returns [4]. 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 [5]. 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 [6].

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 [7]. 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 economic 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 the measured and quantified using optical sensors that has become one among the highly used strategies for tracking crop stress and vegetative cover [8]. In the above backdrop, a study was carried out to understand the effect of different tillage and nutrient management practices on yield attributes and economics of direct seeded rice.

2. 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 1040 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 per cent 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, 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.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Yield

The recorded values of various yield characteristics of rice, like no. of panicles/m^2, no. of grains/ panicle, panicle length and 1000 grain weight and grain yield, are statistically analyzed and presented in the Table 2.

3.1.1 No. of panicles/m^2 and no. of grains per panicle

The number of panicles per m^2 and no. of grains per panicle of DSR were significantly influenced by both the tillage and nutrient management practices. Under tillage practices, T_3 had significantly highest no. of panicles per m^2 (239) and grains per panicle (122) (Table 2) over T_1 but stood on par with T_2. The significantly higher panicles/m^2 and grains/ panicle might be due to individual plants with larger root systems and favourable growing conditions under conservation tillage which resulted in better crop growth and development with high photosynthetic activity [9]. Likewise, N_2 obtained significantly superior no. of panicles per m^2 (228) and grains per panicle (119) (Table 2) over N_1 and was statistically comparable with N_3 across nutrient management treatments. The formation of more panicles/m^2 and grains/ panicle might be due to the balanced and timely availability of nutrients which was achieved by these precision nutrient management practices *viz.*, N_2 and N_3 [10].

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; *Treatment combinations are T1N1, T1N2, T1N3, T2N1, T2N2,T2N3, T3N1, T3N2,T3N3*

3.1.2 Panicle length and test weight (1000 grain weight)

Panicle length and test weight (1000 grain weight) of DSR were not affected by any of the treatments as they are more bounded by genetic make-up and can mostly be altered through genetic or breeding approaches [11,12]. However, among tillage practices, T3 recorded the longest panicle and highest test weight (22.9 cm & 23.11 g) *fb* T2 (22.6 cm & 22.89 g) *fb* T1 (22.4 cm & 22.5 g) (Table 2) respectively. As the conservation agriculture practices can enhance these characteristics, the higher values were recorded under these practices that eventually increased yield and productivity [13]. Similarly, under nutrient management practices, N2 recorded the longest panicle and highest test weight (22.7 cm & 23.03 g) *fb* N3 (22.6 cm & 22.81 g) *fb* N1 (22.5 cm & 22.65 g), respectively.

3.1.3 Grain yield

Among tillage practices, T_3 obtained a noticeably superior grain yield (45.04 q/ha) over T_1 (39.50 q/ha), which stood at par with T_2 (43.51 q/ha) (Table 2). This could be credited to the improved soil structure for plant root proliferation resulted by less soil disruption and overall porosity, aggregate stability, water holding capacity and ease of soil-plant nutrient assimilation, which are congenial for the increase in the photosynthetic rate of dry matter production and the source-sink photosynthate translocation rate with better yield attributes that enhanced the grain filling [14]. Whereas N_2 recorded significantly superior grain yield (45 q/ha) over N_1 (39.16 q/ha) under nutrient management treatments and was statistically comparable with N_3 (43.89 q/ha) (Table 2), which could be due to need based and timely application of fertilizers that helped in increased nutrient availability thereby realizing the better grain yields [15].

3.2 Economics

Economic parameters of various treatments such as CoC, gross, net returns and BCR are calculated and depicted graphically in Fig. 1 after a proper statistical analysis.

3.2.1 Cost of cultivation (CoC)

Common, variable cost and total CoC (₹/ha) (treatment wise) are worked out and were presented under Table 3 where the highest cost was incurred in conventional tillage among tillage practices and in RDF among nutrient management treatments.

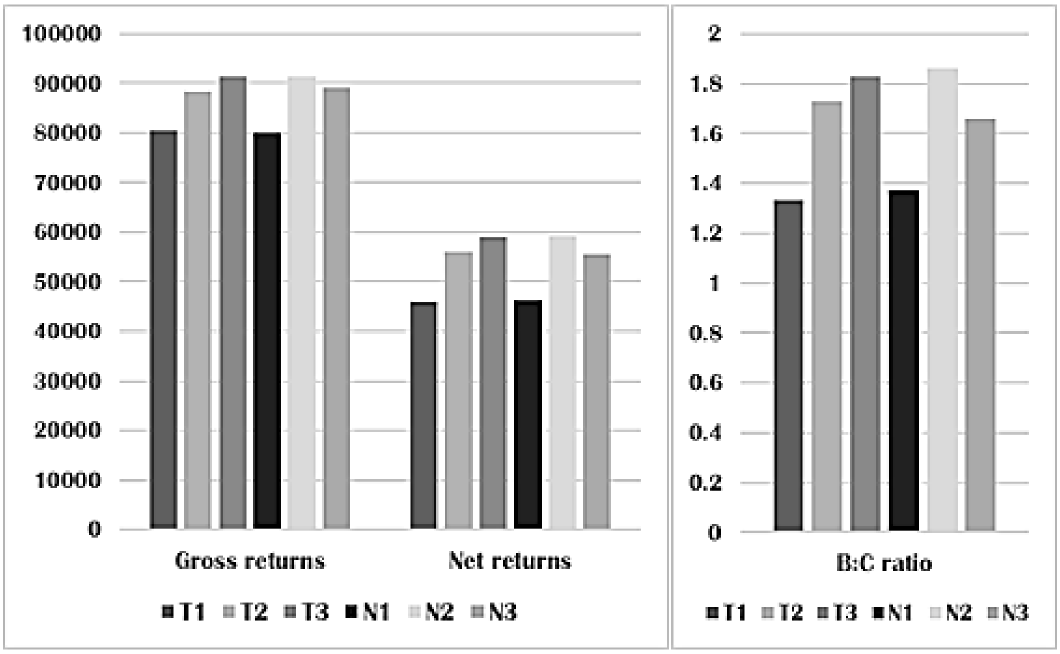

Fig. 1. Effect of tillage and nutrient management practices on gross and net returns and BCR of DSR

DSR stands for direct seeded rice; BCR stands for benefit cost ratio

Table 2. Effect of tillage and nutrient management practices on yield attributes and grain yield of DSR

Treatment	No. of panicles/m^2	No. of grains /panicle	Panicle length (cm)	Test weight (g)	Grain yield (q/ha)
Tillage practices					
T1	201	107	22.4	22.50	39.50
T2	220	115	22.6	22.89	43.51
T3	239	122	22.9	23.11	45.04
SEm±	6	2	0.3	0.16	0.64
LSD (p =0.05)	23	9	NS	NS	2.51
Nutrient management					
N1	212	111	22.5	22.65	39.16
N2	228	119	22.7	23.03	45.00
N3	219	114	22.6	22.81	43.89
SEm±	4	2	0.3	0.25	1.19
LSD (p=0.05)	12	6	NS	NS	3.65
LSD (p=0.05) (T x NM)	NS	NS	NS	NS	NS

DSR stands for direct seeded rice; DAS stands for days after sowing; NS stands for non-significant;

Table 3. Cost of cultivation of tillage and nutrient management treatments

Treatments	Common cost(₹/ha)	Variable cost (₹/ha)		Total (₹/ha)
		Tillage (main)	Nutrient (sub)	
T_1N_1	26217	3000	6095	35312
T_1N_2	26217	3000	4290	33507
T_1N_3	26217	3000	5914	35131
T_2N_1	26217	751	6095	33063
T_2N_2	26217	751	4290	31258
T_2N_3	26217	751	5914	32882
T_3N_1	26217	751	6095	33063
T_3N_2	26217	751	4290	31258
T_3N_3	26217	751	5914	32882

3.2.2 Gross and net returns

Close observation of Fig. 1 illustrates that both the tillage practices and nutrient management treatments significantly influenced the gross and net returns. T3 among tillage practices resulted in significantly superior gross and net returns (₹91451/ha & ₹59050/ha) over T_1 (₹80583/ha & ₹45933/ha) which was comparable with T2 (₹88402/ha & ₹56001/ha) respectively, while N2 among nutrient management treatment had a significantly higher gross and net returns (₹91321/ha & ₹59313/ha) over N1 (₹80015/ha & ₹46203/ha) and was at par with N3 (₹89100/ha & ₹55468/ha) respectively.

3.2.3 B:C ratio

As per the data presented in the Fig. 1, both treatments had a significant influence on the Benefit: cost ratio. Significantly higher BCR was obtained under T_3 (1.83) among tillage practices over T_1 (1.33), which stood statistically on par with T_2 (1.73). Similarly, among nutrient management treatments N_2 had shown a significantly higher BCR (1.86) over N_1 (1.37) but was statistically at par with N_3.

Lower cost of cultivation incurred under T2 and T3, along with the higher crop yields over T1 led to high net returns and BCR in conservation tillage practices. Results of Jat et al. [16], Naresh et al*.* [17], and Raju et al. [18] confirms these outcomes. Similarly, more biological yields and less CoC under N2 and N3 led to an increase in the net returns and BCR over N1, and these results align in line with the findings of Kumar et al. [15] and Anand et al*.* [19].

4. CONCLUSION

Conservation tillage practices that include minimum tillage and residue retention can alter the soil physical, chemical, and biological properties. Balanced and timely supply of nutrients to plants along with conservation tillage practices reduces cost of cultivation and improves the nutrient dynamics in the soil. Thus, cultivation of *Kharif* rice under zero tillage + residue management practice coupled with SSNM based on Nutrient Expert® for rice improved yield attributes, yield, and economics of the direct seeded rice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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