

Effect of different tillage and nutrient management practices on yield attributes and economics of direct seeded rice

ABSTRACT

The 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 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 SSNM based on Nutrient expert (228; 119) 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 %; 9.27 % and, 10.15 %; 6.1 % over Conventional tillage, respectively. While SSNM based on Nutrient experts 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 experts 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. Twenty one per cent of human per capita energy, along with 15 per cent protein per capita, has been supplied by rice universally, a constituent of a major proportion of daily diet in many South-east Asian countries. 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.

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 (Gopal *et al.*, 2010). Long-term puddling practice in rice cultivating areas affects soil aggregates, beneficial microbial activity and the soil

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environment (Bhattacharyya *et al.*, 2012). 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 (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 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 measured and quantified by the use of optical sensors that has become one among the highly used strategies for tracking crop stress and vegetative cover (Mulla, 2013). 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. MATERIAL 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 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 @ 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.

Table 1. Treatment details

* CT plots were ploughed twice *fb* disking *fb* planking, while ZT and ZT+R plots remained unploughed and furrows were made for sowing

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

SSNM stands for site-specific nutrient management and GSGN stands for green seeker guided nitrogen application

3. RESULTS AND DISCUSSION

3.1 Yield attributes and yield

The recorded values of various yield characteristics of rice, like no. of panicles/m², 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/m² and no. of grains per panicle

The number of panicles per m² and no. of grains per panicle of DSR were significantly influenced by both the tillage and nutrient management practices. Under tillage practices, T₃ had significantly the highest no. of panicles per m² and grains per panicle (239 & 122) over T₁ (201 & 107) but stood on par with T₂ (220 & 115). The significantly higher panicles/m² and grains/ panicle might be due to individual plants with larger root systems and favourable growing conditions resulted in better crop growth and development with high photosynthetic activity (Singh *et al.*, 2018). Likewise, N₂ obtained significantly superior no. of panicles per m² and grains per panicle (228 & 119) over N₁ (212 & 111) and was statistically comparable with N₃ (219 & 114) across nutrient management treatments. Likewise, T₃ obtained significantly highest no. of (122) over T₁ (107) among tillage practices and was comparable with T₂ (115). Whereas, N₂ under nutrient management treatments obtained significantly highest no. of grains per panicle (119) over N₁ (111) but it stood statistically at par with N₃ (114). The formation of more panicles/m² and grains/ panicle might be due to the balanced and timely availability of nutrients which was achieved by these precision nutrient management practices *viz.*, N₂ and N₃ (Raghavendra *et al.*, 2017).

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. 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 & 22.50 g). As the conservation agriculture practices can enhance these characteristics, the higher values were recorded under these practices that eventually increased yield and productivity (Karki *et al.*, 2018). Similarly, under nutrient management practices, N₂ recorded the longest panicle and highest test weight (22.7 cm & 23.03 g) *fb* N₃ (22 cm & 22.81 g) *fb* N₁ (22.5 cm & 22.65 g), respectively.

3.1.3. Grain yield

Among tillage practices, T₃ obtained a noticeably superior grain yield (45.04 q/ha) over T₁ (39.50 q/ha), which stood at par with T₂ (43.51 q/ha). 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 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 (Jat *et al.*, 2019). Whereas N₂ recorded significantly superior grain yield (45 q/ha) over N₁ (39.16 q/ha) under nutrient management treatments and was statistically comparable with N₃ (43.89 q/ha), which could be due to need based and timely application of fertilizers that helped in realizing the better grain yields (Kumar *et al.*, 2019).

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					
T ₁	201	107	22.4	22.50	39.50
T ₂	220	115	22.6	22.89	43.51
T ₃	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					
N ₁	212	111	22.5	22.65	39.16
N ₂	228	119	22.7	22.03	45.00
N ₃	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.

3.2 Economics

Economic parameters of various treatments such as CoC, gross, net returns and BCR are calculated and depicted graphically in figures 1 & 2 after a proper statistical analysis.

3.2.1. Cost of cultivation (CoC)

Common, variable cost and total CoC (₹/ha) (treatment wise) were 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.

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 ₁ N ₁	26217	3000	6095	35312.00
T ₁ N ₂	26217	3000	4290	33507.00
T ₁ N ₃	26217	3000	5914	35131.00

T ₂ N ₁	26217	751	6095	33063.00
T ₂ N ₂	26217	751	4290	31258.00
T ₂ N ₃	26217	751	5914	32882.00
T ₃ N ₁	26217	751	6095	33063.00
T ₃ N ₂	26217	751	4290	31258.00
T ₃ N ₃	26217	751	5914	32882.00

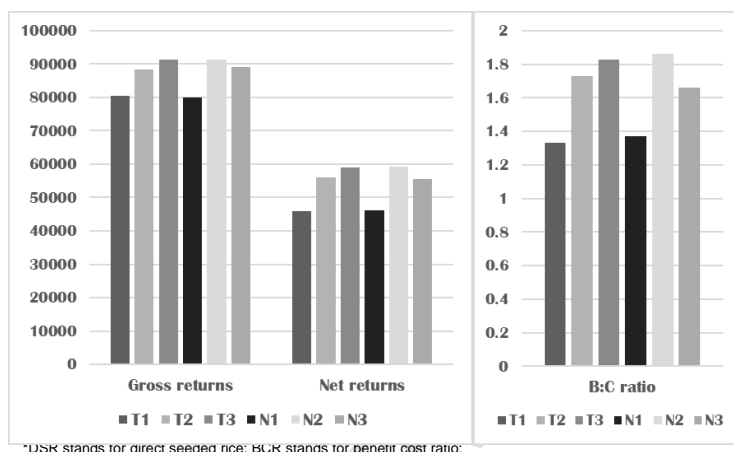


Fig. 1 & 2 Effect of tillage and nutrient management practices on gross and net returns and BCR of DSR

3.2.2. Gross and net returns

Close observation of Figure 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 Conventional tillage (₹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, both treatments had a significant influence on the Benefit: cost ratio. Significantly higher BCR was obtained under Zero tillage + Residue management (1.83) among tillage practices over Conventional tillage (1.33), which stood statistically on par with Zero tillage (1.73). Similarly, SSNM based on Nutrient experts among nutrient management treatments had shown a significantly higher BCR (1.86) over RDF (1.37) but was statistically at par with 60% RDN + GSGN + 100% RDP + 100% RDK (1.66).

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.* (2014), Naresh *et al.* (2014), and Raju *et al.* (2012) 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.* (2019) and Anand *et al.* (2017).

5. CONCLUSION

The findings of this study indicated that 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.

REFERENCES

- Anand, S. R., Vishwanatha, J. and Rajkumar, R. H. 2017. Site-specific nutrient management (SSNM) using “nutrient expert” for hybrid maize (*Zea mays* L.) under zero tillage in Thungabhadra project (TBP) command area of Karnataka. *International Journal of Current Microbiology and Applied Science* 6(8): 3597-3605.
- Bhattacharyya, R., Tuti, M. D., Bisht, J. K., Bhatt, J. C., and Gupta, H. S. 2012. Conservation tillage and fertilization impact on soil aggregation and carbon pools in the Indian Himalayas under an irrigated rice-wheat rotation. *Soil Science* 177: 218–228.
- Chastin, T. G., Ward, J. K., and Wysocki, D. J. 1995. Stand establishment response of soft winter wheat to seedbed residue and seed size. *Crop Science* 35: 213-218.
- Gopal, R., Jat, R. K., Malik, R. K., Kumar, V., Alam, M. M., Jat, M. L., Mazid, M. A., Andrew, M. D., and Gupta, R. 2010. Direct dry seeded rice production technology and weed management in rice-based system. Technical Bulletin, CIMMYT, New Delhi.
- Jat, M. R., Singh, R. G., Kumar, M., Jat, M. L., Parihar, C. M., Bijarniya, D., Sutaliya, J. M., Jat, M. K., Parihar, M. D., Kakraliya, S. K. and Gupta, R. K. 2019. Ten years of conservation agriculture in a rice-maize rotation of eastern gangetic plains of India: yield trends, water productivity and economic profitability. *Fields Crops Research* 232: 1-10.
- Jat, R. K., Sapkota, T. B., Singh, R. G., Jat, M. L., Kumar, M. and Gupta, R. K. 2014. Seven years of conservation agriculture in a rice-wheat rotation of Eastern Gangetic Plains of South Asia: Yield trends and economic profitability. *Field Crops Research* 164(1): 199-210.
- Karki, S., Yadav, R. K., and Karki, T. K. 2018. Effect of tillage, residue, and nutrient management practices on yield attributes of rice. *Azarian Journal of Agriculture* 5(5): 160-165.
- Kumar, M., Naik, B. M., Karthika, M., Kumar, N. and Kumar, A. 2019. Effect of Tillage and Nutrient Management Practices on Yield and Economics of Rice (*Oryza sativa* L.) – Maize (*Zea mays* L.) Cropping System in North Bihar. *International Journal of Current Microbiology and Applied Sciences* 8(3): 1365-1370.
- Labios, R. V., Villancio, V. T., Labios, J. D., Salazar, A. M. and Delos Sanos, R. E. 1997. Development of alternative cropping pattern in rainfed lowland areas with small farm reservoirs. *Philippine Agriculturist* 80: 187 – 199.
- Laik, R., Sharma, S., Idris, M., Singh, A.K., Singh, S.S., Bhatt, B.P., Saharawat, Y., Humphreys, E., and Ladha, J.K., 2014. Integration of conservation agriculture with best management practices for improving system performance of the rice-wheat rotation in the Eastern Indo-Gangetic Plains of India. *Agriculture Ecosystems and Environment* 195: 68–82.

- Mulla, D. J. 2013. Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosystem Engineering* 114 (4): 358-371.
- Naresh, R. K., Tomar, S. S., Kumar, D., Samsher, Purushottam, Singh, S. P., Dwivedi, A. and Kumar, V. 2014. Experiences with Rice Grown on Permanent Raised Beds: Effect of Crop Establishment Techniques on Water Use, Productivity, Profitability and Soil Physical Properties R. K. *Rice Science* 21(3): 170-180.
- Raghavendra, Rao, K. N. and Wani, S. P., 2018. soil test based nutrient management approaches on growth and yield of dry direct seeded rice (Dry Dsr). *International Journal of Pure & Applied Bioscience* 6(2): 1586-1592.
- Raju, R., Thimmappa, K. and Tripathi, R. S. 2012. Economics of zero tillage and conventional methods of rice and wheat production in Haryana. *Journal of Soil Salinity and Water Quality* 4(1), 34-38, 2012.
- Singh, H., Singh, U.P., Singh, S.P. and Singh, Y. 2018. Effect of crop establishment and nutrient management on productivity and profitability of rice under rice-wheat system. *International Journal of Chemical Studies* 6(3): 165-170.
- Wang, G., Dobermann, A., Witt, C., Sun, Q., and Fu, R. 2001. Performance of Site-Specific Nutrient Management for Irrigated Rice in Southeast China. *Agronomy Journal* 93: 869-878.