Influence of different tillage and nutrient management practices on growth performance of direct seeded rice

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 both tillage and nutrient management practices significantly influenced all the growth parameters of direct seeded rice. Significantly higher plant height, no. of tillers/m^2, dry matter production and superior CGR at all the stages of crop growth were recorded in Zero tillage + Residue management over conventional tillage among tillage practices which was statistically at par with Zero tillage and in SSNM based on Nutrient expert over RDF among nutrient management treatments which was statistically at par with 60 % RDN + GSGN + 100% PK of RDF. Zero tillage + Residue management and Zero tillage increased the grain yield of direct seeded rice to the tune of 14.03 and 10.15 per cent over Conventional tillage, respectively. While SSNM based on Nutrient expert and 60 % RDN + GSGN + 100% PK of RDF increased grain yield of direct seeded rice to the tune of 14.91 and 12.07 per cent over RDF, 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 the 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. 21 per cent of human per capita energy along with 15 per cent protein per capita has been supplied by rice universally, a constituent of 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 in the world, 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 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. 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, the nitrogen usage has raised several times, succeeding 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 the 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 the growth and development 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 N1 and N2 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)	T1
2.	Zero Tillage (ZT)	T2
3.	Zero Tillage + Residue (ZT+R)	T3
	Sub-Plot: Nutrient management practices	
1.	Recommended dose of fertilizers (RDF) @ 120-60-40 NPK kg/ha	N1
2.	SSNM based on Nutrient expert for rice @ 109-28-46 NPK kg/ha	N2
3.	60% RDN + GSGN + 100% PK of RDF @ 104-60-40 NPK kg/ha	N3

* 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

3. RESULTS

3.1 Plant Height

Plant height taken at various growth stages is provided in Table 2, which shows that both tillage practices and nutrient management treatments significantly affected plant height of DSR at all the stages, i.e., 25, 50, 75 DAS and at harvest. Among tillage practices, T_3 showed significantly superior plant height over T_1 at all stages, which stood on par with T_2. The highest plant was found in T_3 at harvest (98.3 cm) *fb* T_2 (92.6 cm) *fb* T_1 (87 cm). Among nutrient management practices, N_2 recorded significantly superior plant height over N_1 at all stages but stood on par with N_3. Likewise, Maximum plant height was achieved at harvest under N_2 (95 cm) *fb* N_3 (93 cm) *fb* N_1 (89.9 cm).

3.2 Tillers/m^2

Tillers /m^2 as affected by tillage and nutrient management treatments are tabulated (Table 2), which clearly shows that both the practices significantly influenced the no. of tillers/m^2 of DSR at 25, 50, 75 DAS and at harvest. No. of tillers/m^2 were significantly superior under T_3 over T_1 at all stages that stood on par with T_2 among tillage practices. The highest no. of tillers/m^2 at harvest were recorded by T_3 (242) *fb* T_2 (223) *fb* T_1 (209). Across nutrient management practices, N_2 stood significantly superior over N_1 which were statistically at par with N_3 at all stages. Highest no. of tillers /m^2 at harvest were recorded by N_2 (233) *fb* N_3 (225) *fb* RDF (218).

Table 2. Effect of tillage and nutrient management practices on plant height and number of tillers of DSR

Treatment	Plant height (cm)				No. of tillers/m^2			
	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Tillage practices								
T_1	30.2	54.6	82.1	87.0	146	290	226	209
T_2	32.6	59.1	87.6	92.6	159	302	242	223
T_3	35.4	63.7	91.9	98.3	170	322	264	242

SEm±	0.9	1.3	1.2	2.0	3	5	6	5
LSD (p =0.05)	3.6	5.1	4.7	7.7	12	20	23	20
Nutrient management								
N_1	31.6	57.1	84.6	89.9	153	296	236	218
N_2	34.2	61.1	89.4	95.0	163	313	253	233
N_3	32.4	59.2	87.5	93.0	157	304	244	225
SEm±	0.7	0.9	1.2	1.3	2	4	4	4
LSD (p=0.05)	2.0	2.8	3.6	3.9	7	13	11	11
LSD (p=0.05) (T x NM)	NS	NS	NS	NS	NS	NS	NS	NS

3.2 Dry matter production

Dry matter production as affected by different tillage and nutrient management treatments are tabulated (Table 3), which shows that both practices had a significant influence. As the growth stages advanced, a gradual scaling up in the dry matter was noted, and, at the harvest stage, it had maximum value. Across the tillage practices, T_3 had significantly superior dry matter production over T_1 at every stage but stood comparable to T_2 where peak dry matter at harvest was obtained by T_3 (905.29 g/m^2) *fb* T_2 (851.06 g/m^2) *fb* T_1 (799.35 g/m^2). Among nutrient management treatments, N_2 showed maximum dry matter over N_1 at all stages but was statistically at par with N_3 and the peak value at harvest was achieved by N_2 (889.55 g/m^2) *fb* N_3 (844.91 g/m^2) *fb* N_1 (821.24 g/m^2).

3.3 Crop growth rate

The crop growth rate (CGR) has been presented in Table 3.The data reveals that both the practices had a significant influence on CGR only during the first two growth periods i.e., 0-25 DAS and 25-50 DAS but both had failed to show a significant influence during the last two growth periods i.e., 50-75 DAS and 75 DAS - At harvest. However, irrespective of the treatments, a continuous increase in the CGR was noticed for the first three growth periods and in the last growth period, i.e., from 75 DAS to harvest, there was a decrease in CGR. Among the tillage practices, T_3 showed significantly superior CGR during 0-25 DAS and 25-50 DAS over T_2 and T_1 and maximum CGR was noticed during 50-75 DAS under T_3 (19.18 g/m^2 /day) *fb* T_2 (18.43 g/m^2 /day) *fb* T_1 (17.23 g/m^2 /day). Similarly, N_2 among the nutrient management treatments showed significantly superior CGR over N_2 and N_1 during the first two growth periods. Likewise, maximum CGR was observed during 50-75 DAS under N_2 (18.94 g/m^2 /day) *fb* N_3 (18.24 g/m^2 /day) *fb* N_1 (17.65 g/m^2 /day).

Table 3. Effect of tillage and nutrient management practices on dry matter production and crop growth rate of DSR

Treatment	Dry matter (g/m^2)				Crop growth rate (g/m^2/day)			
	25 DAS	50 DAS	75 DAS	At harvest	0-25 DAS	25-50 DAS	50-75 DAS	75 DAS-Harvest
Tillage practices								
T_1	28.19	153.11	583.80	799.35	1.13	5.00	17.23	7.70

T_2	33.54	171.80	632.49	851.06	1.34	5.53	18.43	7.81
T_3	36.66	190.19	669.57	905.29	1.47	6.14	19.18	8.42
SEm±	1.05	5.29	11.25	17.18	0.04	0.17	0.38	0.62
LSD (p =0.05)	4.11	20.77	44.17	67.44	0.16	0.68	NS	NS
Nutrient management								
N_1	30.89	164.51	605.80	821.24	1.24	5.35	17.65	7.69
N_2	34.45	178.79	652.20	889.55	1.38	5.77	18.94	8.48
N_3	33.05	171.80	627.86	844.91	1.32	5.55	18.24	7.75
SEm±	0.76	3.21	10.53	14.73	0.03	0.10	0.40	0.45
LSD (p=0.05)	2.34	9.90	32.44	45.38	0.09	0.31	NS	NS
LSD (p=0.05) (T x NM)	NS	NS	NS	NS	NS	NS	NS	NS

3.5 Grain yield

Among tillage practices, T_3 recorded considerably 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) whereas, under nutrient management treatments, N_2 recorded significantly superior grain yield (45 q/ha) over N_1 (39.16 q/ha) and was comparable with N_3 (43.89 q/ha) statistically.

4. DISCUSSION

Growth parameters like plant height, no. of tillers, dry matter production and crop growth rate differed significantly in both practices. The highest values across all the growth parameters at various growth stages were obtained under Zero tillage + Residue management, whereas the lowest values were obtained under Conventional tillage among tillage practices (Table 2 and 3). This might be due to the less soil compaction and loose soil structure in zero tillage plots that allowed root penetration into the deeper soil layers extracting more nutrients. Moreover, the regular addition of crop residue over the years raised the organic matter of soil, causing a rise in the soil microbiome, thus enhancing the mineralization process and increasing nutrient availability to the plants. The crop residue also helped in conserving soil moisture provided by rainfall and irrigation. Thus, sufficient water availability to plant led to cell turgidity and peak meristematic activity that led to better foliage production, improved photosynthesis and, consequently, better plant growth and development. Singh (2015) also reported similar results.

Among nutrient management practices, better growth parameters were reflected in SSNM based on Nutrient expert *fb* RDN 60% + GSGN + 100% PK of RDF treatments over RDF. In general, rice crop requires a timely and balanced amount of nutrition and this balanced nourishment might be achieved by SSNM based on Nutrient expert and RDN 60% + GSGN + 100% PK of RDF treatments. Our findings closely agreeing with Singh (2017) and Anand *et al.*, 2017.

5. 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 growth parameters and yield of the crop.

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