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Effect of crop establishment and nutrient management on productivity and profitability of rice under rice-wheat system

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Abstract
A field experiment was conducted during 2014-2015 and 2015-2016 at the Agricultural Research Farm, Banaras Hindu University, Varanasi (U.P.) India. Field experiments were laid out in split plot design replicated thrice with four crop establishment methods *viz*., Conventional Till (CT) rice– Conventional Till (CT) wheat, Conventional Till Direct Seeded (CTDSR) rice–CT wheat, CTDSR– Zero till (ZT) wheat, ZT rice–ZT wheat in main plots and three nutrient management practices viz., Farmers practice (164 kg N, 50 kg P_2O_5, 32 kg K_2O and 4 kg Zn ha^{-1}), Recommended fertilizer dose (150 kg N, 60 kg P_2O_5, 60 kg K_2O and 5 kg Zn ha^{-1}) and site specific nutrient management – rice, wheat crop manager (SSNM- RWCM) recommendation for rice 2014 transplanted, (Direct Seeded Rice) DSR and zero till basal application 38 kg N, 26.5 kg P_2O_5, 19.5 kg K_2O, 5.25 kg Zn/ha, at active tillering (AT) 45 kg N/ha and at panicle initiation (PI) 45 kg N/ha and 19.5 kg K_2O /ha. In 2015 transplanted rice basal application 31.5 kg N, 33.5 kg P_2O_5, 18 kg K_2O and 5.25 kg Zn/ha, at (AT) 37.5 kg N/ha and at (PI) 37.5 kg N and 18.0 kg K_2O /ha and in DSR and zero till rice basal application 33.5 kg N, 36.0 kg P_2O_5, 19.5 kg K_2O and 5.25 kg Zn/ha, and at active tillering 39.0 kg N/ha and at panicle initiation 39.0 kg N and 19.5 kg K_2O/ha have been applied in ricein sub-plots during both the years. Crop establishment methods differed significantly in respect of yield attributes and grain yield of rice. However, pooled data revealed that, ZT rice–ZT wheat recorded higher grain, as compared to other crop establishment method. Among nutrient management practices, SSNM-RWCM (N_3) recorded significantly higher grain and yield attributes of rice over farmers practice and it was at par with recommended fertilizer dose. ZT rice–ZT wheat method recorded highest system productivity followed by CTDSR –ZT wheat, CTDSR–CT wheat and CT rice–CT wheat in both the years. Lowest cost of cultivation, highest net returns, B: C ratio and system profitability was recorded by ZT rice–ZT wheat crop establishment method during both years of experiment followed by CTDSR–ZT wheat, CTDSR rice–CT wheat and CT rice–CT wheat. Among nutrient management practices, SSNM-RWCM in rice (N_3) recoded significantly higher productivity and profitability during both years of study.

Keywords: crop establishment methods, nutrient management, rice productivity and profitability

1. Introduction
Rice is the most important staple food in Asia. More than 90% of the world's rice is grown and consumed in Asia, where 60% of the world's population lives. Over about 13.5mha of the Indo-Gangetic plains (IGP) spread over the four countries. The rice–wheat production systems are fundamental to employment, income, and livelihoods for hundreds of millions of rural and urban poor of South Asia (Jat *et al*., 2014) [11]. Multiple challenges associated with plough based conventional production practices in rice-wheat rotation including declining factor productivity, shrinking farm profits due to increasing energy and labour costs, an emerging irrigation water crisis and recent challenges of climate change are leading to a major threat to food security of South Asia. Hence the major challenge is to increase the productivity to meet the growing food demand without adverse environmental impact.

Traditional practice of manual transplanting of rice seedlings in random geometry after intensive dry and wet tillage and conventionally tilled broadcast seeding of wheat contributes significantly to these challenges, making this system unsustainable. Puddling results in poor soil-physical condition for establishment and raising the succeeding crops (Tripathi *et al.*, 2003) [21]. This practice is water, capital and energy intensive, and deteriorates soil health (Sharma *et al.*, 2003) [18]. Puddling leads to the formation of a hard-pan at shallow depths deteriorates soil physical properties and delays planting of a succeeding wheat crop. Timely planting of wheat is crucial as yield reductions of 1–1.5% per day occur for each day after the optimum sowing date, November 15 in the IGP (Hobbs and Morris, 1996) [8]. In addition, a hard-pan at shallow depths created by repeated puddling inhibits root elongation of the post-rice crop, which can ultimately reduce crop yield (Boparai *et al.,* 1992) [3]. Published studies demonstrate an 8% reduction in wheat yield when sown after puddled transplanted rice compared with wheat sown after direct sown rice (DSR) in non-puddled conditions (Kumar *et al*., 2008) [12].

In the conventional systems involving intensive tillage, there is gradual decline in soil organic matter through accelerated oxidation and burning of crop residues causing pollution, greenhouse gases emission, and loss of valuable plant nutrients. Conservation agriculture (CA) practices are recognized as a powerful tool to address the issues related to land and environmental degradation. CA has great relevance to restore the degraded ecologies where farm income and fatigue in yield have become major concern. Conservation technologies involve minimum soil disturbance, providing a soil cover through crop residues or other cover crops and crop rotations for achieving higher productivity. This has emerged as way for transition to the sustainability of intensive cropping systems. Hence, several long-term studies have been conducted globally to introduce conservation agriculture technologies in selected cropping systems as a main-ways of improving crop yields, soil health and income, whilst reducing requirement of energy and environmental degradation with special emphasis on irrigated cropping system in South Asia and elsewhere have been a success.

Resource-conserving technologies (RCTs) such as zero-tillage (ZT) and un-puddled transplanting have been shown to be beneficial in terms of improving soil health, water use, crop productivity and farmers' income (Gupta and Sayre, 2007; Gupta and Seth, 2007; Singh *et al*., 2009) [6,7, 20]. Due to rising cost of labour and excessive water use in puddling for transplanting rice in the irrigated eco-systems, direct seeding of rice is gaining popularity in south-east Asia (Balasubramanian and Hill, 2002) [1]. Direct-seeded rice needs only 34% of the total labour requirement and saves 29% of total cost of the transplanted crop (Ho and Romli, 2002). ZT is widely adopted in wheat by farmers in the North-western IGP of India, particularly in areas where rice is harvested late. ZT minimizes the loss on account of delayed sowing as it advances the wheat sowing by 10-15 days and also saves the time and cost involved in field preparation (Sharma *et al*., 2002; Chandana *et al.,* 2010) [19, 4]. However, to get the full benefits of ZT, both rice and wheat need to be grown with a 'double zero-tillage' system (Jat *et al.,* 2006; Bhushan *et al*., 2007) [10, 2]. Important factors that are forcing a shift from the traditional puddled-transplanting system to unpuddled direct seeding of rice are shortages of labour and water, and escalating fuel prices.

Successful implementation of a conservation agriculture system depends to a large extent on a good understanding of the dynamics of nutrients in the soil and nutrient management which requires serious attention. Reluctance on the part of farming community in adoption of zero tillage sowing of rice-wheat in a large area is mainly due to associated with management of nutrient. Nutrients are driven by an interaction of several factors; tillage, doses, timing and type of fertilizer management practice.

2. Materials and Methods

2.1 Study site and soil

Experimental field was located at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India during *kharif* season of 2014 and 2015. Two years trial was established during monsoon 2014 involving various combinations of tillage, crop establishment methods and nutrient management practices in a rice–wheat rotation. The geographical situation of the farm lies at 25°18′ N latitude and 83° 31′ E longitude at an altitude of 75.7 meters from the mean sea level in the Northern Gangetic Alluvial plains. The soil of the experimental field was sandy clay loam in texture with *p*H 7.30. It was moderately fertile being low in organic carbon (0.43%) and available nitrogen (208.19 kg ha^{-1}), but medium in available phosphorus (24.80 kg ha^{-1}) and potassium (221.60 kg ha^{-1}). Climatologically Varanasi district enjoys a subtropical climate and is subjected to extremes of weather conditions i.e. extremely hot summer and cold winter. This region falls in semi-arid to sub-humid type of climate. Normally the period for the onset of monsoon in this domain is third week of June and it lasts up to the end of September or sometimes extends up to the first week of October. The area also experiences some winter shower due to cyclonic rains during December to February. The period between March to May is generally dry. Long term average of annual rainfall for this region amounts to 1081.5 mm of which 944.5 mm (87.33 per cent) is received during the monsoon or rainy season (June to September) and 137.0 mm (12.67 per cent) during post monsoon season or post rainy season. The mean annual Potential Evapo-transpiration (PET) is 1525 mm. The temperature begins to rise from middle of February and reaches its maximum by May-June (mean maximum 39°C). But it has tendency to decrease from July onwards and eventually touches minimum in December-January (mean minimum 9.3°C). The maximum temperature usually fluctuates between 22°C to 40. 7°C while minimum temperature varies from 8.6 to 29.9°C.

2.2 Treatments and experimental design

Field experiments were laid out in split plot design replicated thrice with four crop establishment methods *viz*., CE_1: Conventional till rice (puddled transplanted) – Conventional till wheat (line sowing) {farmers practice}[CT rice–CT wheat], CE_2: Conventional till direct seeded rice – conventional till wheat (line sowing) [CTDSR rice–CT wheat], CE_3: Conventional till direct seeded rice – Zero-till wheat[CTDSR–ZT wheat], CE_4: Zero-till direct seeded rice — Zero-till wheat [ZT rice–ZT wheat] in main plots and three nutrient management practices *viz*., N1: Farmers practice, N_2: Recommended fertilizer dose andN_3: SSNM-RWCM in sub-plots during both theyears. In zero-till rice plots, the crop was established without any preparatory tillage. In CTDSR treatment the ploughing was done twice with tractor drawn cultivator followed by planking. In CT method the experimental area was tilled dry and wet followed by puddling with cage wheel, levelled and thereafter layout was done. Glyphosate (1 kg ha^{-1}) was sprayed in all zero-till treatments before seeding during both the years. Recommended herbicides pendimethalin at 1.0 kg a.i. ha^{-1} as pre-emergence and post emergence herbicides bispyribac 25 gm a.i. ha^{-1} at 20 DAS/DAT in rice were applied with 500 l ha^{-1} of water with help of knapsack sprayer, fitted with flat-fan nozzle.

2.3 Crop management

2.3.1 Seed rate and crop geometry

In CTDSR and ZT rice treatments sowing was done by using tractor drawn zero-till seed-cum-fertilizer planter with a row spacing of 20 cm apart and seeding depth was maintained at 2–3 cm using depth control wheel of the planter. Rice variety 'Sarju-52' was used at the rate of 30 kg ha^{-1}. Seeding was done on 17th June during 2014 and 27th June during 2015 in CTDSR and ZT Rice treatments. On the same day seeds were sown in nursery for conventional till rice (puddled transplanted) and 30 day old seedlings were manually transplanted in line (farmers practice) in both the years.

2.3.2 Water management

During both years of rice experimentation, a satisfactory/sufficient monsoon showers was received. Total rainfall and distribution was more uniform during the second year as compared to first year during the crop period. However, during first year two irrigation were provided one as pre-sowing irrigation and another at grain filling stage. During second year, no irrigation was provided.

2.3.3 Nutrient management

Three nutrient management practices viz., Farmers practice (164 kg N, 50 kg P_2O_5, 32 kg K_2O and 4 kg Zn ha^{-1}), Recommended fertilizer dose (150 kg N, 60 kg P_2O_5, 60 kg K_2O and 5 kg Zn ha^{-1}) and SSNM- RWCM recommendation for rice 2014 transplanted, DSR and zero till basal application 38 kg N, 26.5 kg P_2O_5, 19.5 kg K_2O, 5.25 kg Zn/ha, at active tillering (AT) 45 kg N/ha and at panicle initiation (PI) 45 kg N/ha and 19.5 kg K_2O /ha. In 2015 transplanted rice basal application 31.5 kg N, 33.5 kg P_2O_5, 18 kg K_2O and 5.25 kg Zn/ha, at (AT) 37.5 kg N/ha and at (PI) 37.5 kg N and 18.0 kg K_2O /ha and in DSR and zero till rice basal application 33.5 kg N, 36.0 kg P_2O_5, 19.5 kg K_2O and 5.25 kg Zn/ha, and at active tillering 39.0 kg N/ha and at panicle initiation 39.0 kg N and 19.5 kg K_2O/ha have been applied in sub-plots during both the years.

2.4 Statistical analysis

Analysis of variance (ANOVA) for split plot design was performed using the CoStat Software (Gomez and Gomez, 1984) [5]. The differences between treatment means were compared using a LSD test at $P < 0.05$ (Gomez and Gomez, 1984).

3. Results and Discussion

Growth characters

The observations on growth attributes *viz.*, plant height (cm), number of tillers (m^{-2}), dry matter accumulation (g m^{-2}) were recorded at 40, 80 DAS/DAT and at harvest and presented in Tables 1, 2 &3.

Since, stage of observation greatly differed from establishment method (CT rice) to establishment method (DSR), the data on growth attributes at 40 & 80 DAS/DAT showed more variations among crop establishment methods. At harvest, crop establishment methods did not differ significantly in plant height (cm), however number of tillers (m^{-2}), dry matter accumulation (g m^{-2}) differ significantly in zero till rice over conventional till rice and was on par with CTDSR during both the years. However, maximum plant height, number of tillers and dry weight at harvest were recorded by ZT rice during both the years. Minimum plant height and dry weight at harvest were recorded by CT during both the years.

Various nutrient management practices had significant influence on growth attributes *viz.*, plant height, number of tillers (m^{-2}), dry matter accumulation (g m^{-2}) during both the years of experimentation. At all the stages, significantly higher growth attributes were recorded by nutrient application based on RWCM- SSNM approach (N3) compared to farmers practice (FP) (N_1) and it was on par with recommended fertilizer dose (RFD) (N_3) treatment during both the years. It was also observed that all growth attributes were comparatively higher in second year as compared to first year.

Table 1: Effect of crop establishment methods and nutrient management on plant height (cm) at different stages of rice

Treatments	40 DAS/DAT		80 DAS/DAT		At harvest	
	2014	2015	2014	2015	2014	2015
Crop establishment methods(CE)						
CE_1: CT rice – CT wheat	67.9	68.2	84.4	84.2	86.6	87.9
CE_2: CTDSR – CT wheat	40.3	40.5	76.1	76.3	86.3	87.6
CE_3: CTDSR – ZT wheat	39.9	39.8	75.9	75.9	86.7	88.0
CE_4: ZT rice – ZT wheat	39.6	39.9	76.7	76.9	88.2	88.9
SEm±	1.10	1.11	1.13	1.15	0.81	0.82
LSD(P=0.05)	3.80	3.85	3.90	3.97	NS	NS
Nutrient management practices(N)						
N_1: Farmers Practices (FP)	48.6	48.7	77.6	77.6	85.7	87.0
N_2: Recommended Fertilizer Dose (RFD)	46.6	46.8	78.3	78.4	86.7	88.1
N_3: SSNM- RWCM Recommendation	45.6	45.8	78.9	79.1	88.4	89.3
SEm±	1.18	1.17	1.07	1.07	0.77	0.79
LSD(P=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Effect of crop establishment methods and nutrient management on number of tillers (m^{-2}) at different stages of rice

Treatments	40 DAS/DAT		80 DAS/DAT		At harvest	
	2014	2015	2014	2015	2014	2015
Crop establishment methods(CE)						
CE_1: CT rice – CT wheat	322.0	324.9	388.0	391.0	330.0	333.6
CE_2: CTDSR – CT wheat	315.4	316.7	404.9	410.4	350.4	354.2
CE_3: CTDSR – ZT wheat	317.4	318.7	407.1	413.3	354.6	359.7
CE_4: ZT rice – ZT wheat	319.4	318.0	416.1	420.6	362.1	370.7
SEm±	2.30	1.99	4.38	4.64	5.86	3.71
LSD(P=0.05)	NS	NS	15.14	16.06	20.28	12.82

Nutrient management practices(N)						
N_1: Farmers Practices (FP)	320.6	322.0	396.7	399.8	341.3	345.3
N_2: Recommended Fertilizer Dose (RFD)	317.2	317.5	406.1	409.4	352.1	356.9
N_3: SSNM- RWCM Recommendation	318.0	319.2	409.3	417.3	354.4	361.4
SEm±	3.61	2.98	2.97	3.06	3.21	4.24
LSD(P=0.05)	NS	NS	8.91	9.18	9.61	12.71

Table 3: Effect of crop establishment methods and nutrient management on dry matter accumulation (g m^{-2}) at different stages of rice

Treatments	40 DAS/DAT		80 DAS/DAT		At harvest	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**
Crop establishment methods(CE)						
CE_1: CT rice – CT wheat	233.3	235.2	1369.2	1386.0	1700.7	1706.7
CE_2: CTDSR – CT wheat	215.6	217.9	1249.6	1265.1	1748.8	1750.4
CE_3: CTDSR – ZT wheat	218.7	222.0	1275.7	1308.2	1750.0	1755.0
CE_4: ZT rice – ZT wheat	225.2	227.8	1301.2	1338.4	1766.0	1770.0
SEm±	3.71	3.73	10.47	10.03	7.09	5.63
LSD(P=0.05)	NS	NS	36.23	34.72	24.53	19.49
Nutrient management practices(N)						
N_1: Farmers Practices (FP)	226.0	228.0	1282.9	1308.4	1731.7	1734.2
N_2: Recommended Fertilizer Dose (RFD)	222.4	225.1	1304.8	1328.0	1744.7	1749.7
N_3: SSNM- RWCM Recommendation	221.2	224.1	1309.1	1336.9	1747.8	1752.8
SEm±	2.28	2.44	7.30	6.75	3.96	4.04
LSD(P=0.05)	NS	NS	21.89	20.22	11.89	12.11

Table 4: Effect of crop establishment methods and nutrient management on yield attributes of rice

Treatments	No. of panicles m^{-2}		Panicle length (cm)		Spikelet panicle^{-1}		Fertility percentage		Test weight (g)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Crop establishment methods(CE)										
CE_1: CT rice – CT wheat	304.0	311.0	23.7	23.6	114.7	115.0	81.3	82.2	22.64	22.64
CE_2: CTDSR – CT wheat	329.7	335.4	23.5	23.6	116.3	116.8	82.0	84.1	22.64	22.65
CE_3: CTDSR – ZT wheat	333.6	339.6	23.7	23.7	116.7	117.6	82.8	84.5	22.64	22.65
CE_4: ZT rice – ZT wheat	342.1	346.1	23.8	23.9	118.1	120.1	83.8	85.8	22.67	22.69
SEm±	4.91	4.72	0.17	0.17	1.35	1.34	1.08	1.00	0.03	0.06
LSD(P=0.05)	17.00	16.32	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management practices(N)										
N_1: Farmers Practices (FP)	319.7	325.2	23.4	23.4	112.9	115.0	80.8	83.0	22.61	22.59
N_2: Recommended Fertilizer Dose (RFD)	330.4	336.5	23.7	23.7	117.0	117.8	83.3	84.1	22.65	22.67
N_3: SSNM- RWCM Recommendation	331.9	337.4	23.9	23.9	119.4	119.3	83.4	85.5	22.69	22.71
SEm±	2.98	2.86	0.10	0.10	0.97	1.05	0.73	0.52	0.03	0.05
LSD(P=0.05)	8.93	8.57	0.30	0.31	2.91	3.15	2.17	1.56	NS	NS

Yield attributes

Data revealed that there is significant difference in panicles m^{-2} among different establishment methods. However, conventional till rice (CE_1) having lowest panicles and ZT rice recorded comparatively higher panicles m^{-2} during both the year of study. Conventional till DSR recorded comparatively higher panicles from conventional till rice during both the years. In general, panicles m^{-2} was higher during the second year as compared to first year [Table 4].

Among nutrient management treatments, significantly maximum number of panicles m^{-2} was recorded by nutrient application based on RWCM recommendation (N_3) as compared to Farmers practice (N_1) and it was on par with recommended fertilizer dose (N_1) during both the years.

Crop establishment methods shows non-significant difference on panicle length, spikelet panicle^{-1}, fertility percentage and test weight.

Among nutrient management treatments, maximum panicle length, spikelet panicle^{-1}, fertility percentage and test weight was recorded by nutrient application based on SSNM-RWCM recommendation (N_3) as compared to Farmers practice (N_1) and it was on par with recommended fertilizer dose (N_1) during both the years.

Yield

The findings of the present study showed that grain yield and harvest index were differed significantly among crop establishment methods [Tables 5] during both the years of experimentation. However, pooled data of two years revealed that, ZT rice–ZT wheat recorded higher grain yield as compared to other crop establishment method. Similar or high yield attributes and yield in ZT rice than CT rice were reported earlier by many researchers [Shad and De Datta (1986) [17], Hobbs *et al*. (2002) [9], Mazid *et al*. (2002) [15] and Yadav *et al*. (2014)] [22].

Among various nutrient management practices, SSNM-RWCM recorded significantly higher yield and yield attributes over farmers practice and it was at par with Recommended Fertilizer dose (RFD). This could be attributed to efficient nutrient management under these treatments [Tables 5] which enabled better growth and development of rice. These findings are corroborated by Mauriya *et al.* (2015) [14] and Nagegowda *et al.* (2011) [16]

Economics

The adoption of any technology in modern agriculture can only be acceptable and adoptable by farmers if it is economically viable. Economic viability is a function of gain and loss. The gross return obtained by yield of crop varied markedly due to different treatments, which ultimately influenced the net return and benefit: cost ratio. ZT rice recorded higher net return than conventional rice (CT rice) and CTDSR methods in both the years of experimentation [Table 6]. This is mainly due to saving in labour, power and capital as land preparation was excluded in this treatment. As a result, there was reduction in overall cost of production, thus leading to maximum net return and lowest net return was recorded under CT rice because of higher cost of production. Similar views have been expressed by Malik and Yadav (2006) [13] and Singh *et al*. (2009) [20]. Economic evaluations of nutrient management practices revealed that the higher net returns were recorded by SSNM-RWCM recommendation than other nutrient management practices [Table 4]. This could be attributed to higher grain yield of rice and low cost of production (SSNM-RWCM).

Table 5: Effect of crop establishment methods and nutrient management on grain yield, straw yield and harvest index of rice

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
Crop establishment methods(CE)									
CE_1: CT rice – CT wheat	3881.1	3926.7	3903.9	6310.4	6384.9	6347.7	38.1	38.1	38.1
CE_2: CTDSR – CT wheat	4126.1	4207.2	4166.7	6319.0	6377.9	6348.4	39.5	39.7	39.6
CE_3: CTDSR – ZT wheat	4141.7	4389.4	4265.6	6359.7	6406.4	6383.1	39.4	40.7	40.0
CE_4: ZT rice – ZT wheat	4253.7	4442.6	4348.1	6462.1	6502.1	6482.1	39.7	40.6	40.1
SEm±	67.50	31.08	38.69	49.96	27.79	26.54	0.21	0.11	0.13
LSD(P=0.05)	233.56	107.53	133.89	NS	NS	91.83	0.74	0.38	0.43
Nutrient management practices(N)									
N_1: Farmers Practices (FP)	3949.3	4073.5	4011.4	6326.4	6380.6	6353.5	38.4	39.0	38.7
N_2: Recommended Fertilizer Dose (RFD)	4167.2	4308.0	4237.6	6370.4	6417.2	6393.8	39.5	40.1	39.8
N_3: SSNM- RWCM Recommendation	4185.4	4342.9	4264.2	6391.6	6455.8	6423.7	39.5	40.2	39.9
SEm±	36.48	32.01	24.96	19.09	21.65	15.34	0.16	0.13	0.10
LSD(P=0.05)	109.37	95.98	74.81	NS	NS	46.00	0.48	0.38	0.31

Table 6: Effect of crop establishment methods and nutrient management on economics of rice

Treatments	Net returns (`ha^{-1})		B:C ratio	
	2014	2015	2014	2015
Crop establishment methods (CE)				
CE_1: CT rice – CT wheat	37845	41371	1.18	1.32
CE_2: CTDSR – CT wheat	47856	51885	1.87	2.07
CE_3: CTDSR – ZT wheat	48176	54599	1.88	2.18
CE_4: ZT rice – ZT wheat	51430	57038	2.12	2.42
SEm±	1065	508	0.04	0.02
LSD(P=0.05)	3687	1759	0.14	0.06
Nutrient management practices (N)				
N_1: Farmers Practices (FP)	44106	48737	1.67	1.90
N_2: Recommended Fertilizer Dose (RFD)	46025	50987	1.67	1.90
N_3: SSNM- RWCM Recommendation	48849	53946	1.95	2.20
SEm±	547	509	0.02	0.02
LSD(P=0.05)	1639	1525	0.06	0.06

Conclusion
It can be concluded that ZT rice–ZT wheat crop establishment method with SSNM-RWCM recommendation (N_3) should be followed to achieve higher yield, productivity and profitability in rice.

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