Research Article

EFFECT OF CROP ESTABLISHMENT METHODS AND PRECISION NUTRIENT MANAGEMENT ON GROWTH, YIELD ATTRIBUTES AND YIELD OF RICE UNDER RICE-WHEAT SYSTEM

ABSTRACT:

Rice-wheat system is the major contributor in food security of India. The significance of the system is well addressed by time to time but, excessive use of resources, stagnation in yield, environment deterioration including erosion and nutrient mining are the greater challenge it possess. To address the issue a study was carried out at Banaras Hindu University's Agricultural Research Farm in Varanasi during the *Kharif* and *Rabi* seasons of 2019-20 and 2020-21, respectively. The experiment plotted in a split plot statistical design with three replications and four crop establishment methods: CE$_1$: Conventional till rice (puddled transplanted)-Conventional till wheat, CE$_2$: Conventional till direct seeded rice (DSR)-Conventional till wheat, CE$_3$: Conventional till DSR-Zero-till wheat (rice residue retained), and CE$_4$: Zero-till DSR-Zero-till wheat (residue retention in rice and wheat) crop establishment method among the main plot treatments and Rice-Wheat Crop Manager (RWCM)-based nutrient recommendation among the sub plot treatments. CE$_4$ treatment among main plot and N$_3$ among nutrient management practices produced higher values of plant height and number of tillers at 30, 60, 90 days after sowing and at harvest, as well as yield attributes *i.e.* maximum number of panicles m^2 and grains per panicle, than the other treatments. The same treatments also resulted in increased rice grain yield. There was approximately 12 % higher grain yield under CE$_4$ over CE$_1$ and 8 % higher grain yield in N$_3$ over N$_1$ was recorded. These results might be due to better nutrient availability, better organic carbon which leads to improved microbial activity, and better moisture availability under these treatments. It may be concluded that conservation agriculture-based crop establishment *i.e.* CE$_4$: Zero-till DSR-Zero-till wheat (residue retention in rice and wheat) and RWCM-based nutrient application, may be favourable for improved growth, yield attributes and yield in the rice crop under the region of eastern Uttar Pradesh.

Keywords: ZTDSR, conservation agriculture, residue retention, rice growth

1. INTRODUCTION:

The rice-wheat system contributed maximum calorie in the food basket of the IGP region. Puddling has been shown to have detrimental effects on the soil environment, particularly on healthy microbes and soil aggregation (Jat *et al*., 2014; Haque *et al*., 2016). The drying of the soil and the emergence of cracked soil blocks impede the preparation of the land for the next upland crop. As a result, to prepare a healthy seedbed for the crop that follows rice, heavy tillage and irrigation are needed, which delays planting and ultimately lowers the yield of the dryland crop[23-26]. The use of machine-driven processes including tillage, sowing/transplanting, harvesting, and threshing has become more pressing due to the growing shortage of human labour (Jat *et al*. 2013). According to Parihar *et al*. (2017), mechanisation and input-intensive agricultural practices have a negative influence on soil quality and environmental pollution. This highlights the need for alternative crop management strategies that could reduce energy use, safeguard the environment, and maintain crop productivity that is comparable to or even higher than current practices. Rice productivity in India has been stagnant and may decline in the future due to over-exploitation of natural resources (Ladha *et al*. 2009), low seed replacement rate, poor irrigation water, fertiliser, and crop residue management (Ladha *et al*. 2009), consistent cropping patterns over time, and a lack of awareness among farmers about the consequences of poor cultivation practices. According to several studies (Verhulst *et al*., 2010; Kumar *et al*., 2019; Gathala *et al*., 2020b; Jat *et al*., 2014), conservation agriculture (CA) can improve crop establishment and timely sowing, maintain or increase yield, reduce water and energy use, lower production costs and increase income, and improve soil quality. It can also increase system resilience. Rice seedlings are often put onto repeatedly tilled, puddled, and flooded fields in the standard manner of rice farming. However, it is also possible to transplant seedlings without puddling, which can reduce the cost of rice production overall as well as water, energy, labour, and other factors (Krupnik *et al*., 2014; Haque *et al*., 2016; Hossen *et al*., 2018; Gathala *et al*., 2021).

There was non-significant increase in fertilizer N efficiency in rice grown in different Asian countries during the past 30 years, the average plant recovery efficiency of fertilizer N in rice is still only about 30% (Dobermann, 2000; Dobermann and Cassman, 2002). Application of other macronutrients, such as K, has lagged behind leading to imbalanced plant nutrition and negative K input–output balances in many parts of Punjab and Asia. Environmental pollution by nutrient leaching or runoff from rice fields has become another concern across Asia (Dobermann *et al*., 2002). The site specific nutrient management (SSNM) approach provides scientific principles for determining field-specific fertilizer nitrogen (N), phosphorus (P), and potassium (K) requirements for crops. The SSNM approach provides algorithms that can be used to determine field-specific fertilizer requirements matching the needs and conditions of individual farmers. Recent advances in information and communication technology (ICT) offer ample opportunities to use mobile phones to provide farmers with field-specific nutrient management recommendations calculated by decision making tools using algorithms based on SSNM. Use of SSNM based fertilizer recommendations were shown to increase yields, net income of farmers, and provide positive impacts on the environment when compared with existing fertilizer practices.

MATERIALS AND METHODS:

The present investigation was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* and *rabi* season of 2019-20 and 2020-21, in South-eastern part of Varanasi city of India ($25^0$18'N latitude and $83^0$31'E longitude at an altitude of 128.93 meter above sea level). The experimental soil was gangetic alluvial sandy clay loam with pH 7.22. It was moderately fertile-being low in available organic carbon (0.41%) as well as available nitrogen (213.59 kg ha-1) and medium in available phosphorus (23.23 kg ha-1) as well as available potassium (223.50 kg ha-1). The experiment was laid out in split-plot design replicated thrice with four crop establishment methods *viz.*, CE_1: Conventional till rice (puddled transplanted) — Conventional till wheat { farmers practice} [CT rice–CT wheat], CE_2: Conventional till direct seeded rice — Conventional till wheat [CTDSR–CT wheat], CE_3: Conventional till direct seeded rice — Zero-till wheat + rice residue retained [CTDSR–ZT wheat + R R], CE_4: Zero-till direct seeded rice — Zero-till wheat + residue retention in rice and wheat [ZTDSR–ZT wheat + RW R] in main plots and three nutrient management practices *viz.*, N_1: Farmers Practices (FP), N_2: Recommended fertilizer dose (RFD), N_3: Rice - Wheat Crop Manager (RWCM) recommendation in sub plots during both the years. In nutrient management treatments, fertilizer applications to rice was done as per the treatment requirement. Half dose of N and full doses of P_2O_5, K_2O and Zn were applied as basal before sowing and remaining half dose of N was top dressed in two equal splits at active tillering and panicle initiation stage in rice in farmers practice (N_1) and also in RFD (N_2) as per requirement/recommendation. For conventional till direct seeded rice (CTDSR) and zero till direct seeded rice (ZTDSR) treatments, a pre-sowing irrigation was given. In ZTDSR plots, the crop was established without any preparatory tillage. Need based spot application of glyphosate (1.5%) was done in ZT treatments before the seeding to knock down the previous weeds. In CTDSR treatment the ploughing was done twice with tractor drawn cultivator followed by planking. In CTPTR method the experimental area was tilled dry and wet followed by puddling with cage wheel and then field was leveled. In SSNM, fertilizer was applied as per RWCM recommendation. The sources of fertilizers were urea, Di-ammonium phosphate (DAP), muriate of potash (MOP) and ZnSO4. The doses of fertiliser for N_1 treatment were 164-50-32-4 kg N-P_2O_5 –K_2O –Zn ha^{-1} whereas in N_2 it was 150-60-60-5 kg N-P_2O_5 –K_2O –Zn ha^{-1} during both the years of experimentation and in N_3, the doses were based on RWCM based nutrient recommendations. Under the treatment N_3 90-33-33-8.33 kg N-P_2O_5 –K_2O –Zn ha^{-1} were applied in first year and 93-33-33-9 kg N-P_2O_5 –K_2O –Zn ha^{-1} were applied in second years of experimentation.

2. RESULT AND DISCUSSION

2.1 GROWTH PARAMETERS:

Data indicates that maximum plant height and number of tillers recorded at 30 60, 90 DAS/DAT (Days after sowing/transplanting) and at harvest (Table number 1) was achieved under the CA-based crop establishment method *i.e.* CE_4: ZTDSR-ZT wheat + RW R over the rest of the crop establishment method *i.e.* CE_3, CE_2, and CE_1, but CE4 and CE3 were found at par with each other in term of plant height at all the stages of observation among the main plot treatments, while under the sub plot treatments, N_3: Rice wheat crop manager based nutrient recommendation observed maximum plant and higher number of tillers at all the stages of observation, however, N_3 was observed on par with N_2: Recommended fertiliser dosage (RFD) in terms of plant height. A similar trend was seen throughout the second year of evaluation.

The reason for rice's better performance in terms of plant height and number of tillers in the afore mentioned treatments could be due to better nutrient availability, better organic carbon, which leads to improved microbial activity, and better moisture availability, all of which contribute to better initial crop growth under CA based system (Choudhary *et al.*, 2020; Jat *et al.*, 2019).Optimised nutrient usage during SSNM may result in higher cell division, enlargement, photosynthesis, and protein synthesis, leading to quantitative improvements in plant growth traits such as tillering and height of plant (Singh *et al.*, 2014) and efficient/optimum utilization of nutrients by synchronizing the crop's nutrient demand with the nutrient supply from the soil and fertilizers also help in better growth (Shrestha *et al.*, 2020). Similar results were also obtained by Shahi *et al.*, 2022 and Singh et al., (2018).

Table 1: Effect of crop establishment and nutrient management on plant height (cm) on Rice

Treatments	30 DAS/DAT		60 DAS/DAT		90 DAS/DAT		At harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Crop establishment (CE)								
CE_1: CT rice – CT wheat	25.57	26.33	52.16	54.53	82.22	81.92	79.15	82.56
CE_2: CTDSR – CT wheat	27.29	28.03	56.96	57.79	84.66	86.23	82.44	84.24
CE_3: CTDSR – ZT wheat	27.61	28.38	58.06	58.94	85.45	87.56	84.02	86.15
CE_4: ZT rice – ZT wheat	28.95	29.77	61.37	64.30	89.11	91.18	87.63	91.02
Sem ±	0.52	0.51	0.71	0.68	1.09	1.04	0.98	0.94
CD (P=0.05)	1.55	1.49	2.29	2.17	3.29	3.17	3.11	2.98
Nutrient management (N)								
N_1: Farmers Practices	26.27	26.85	53.85	54.76	82.09	82.94	80.45	81.73
N_2: Recommendation Fertilizer Dose	27.39	28.33	57.88	58.40	85.72	87.07	83.71	86.62
N_3: RWCM Recommendation	28.41	29.20	59.70	60.51	88.26	90.15	85.76	89.63
Sem ±	0.40	0.37	0.61	0.57	0.98	0.93	0.87	0.82
CD (P=0.05)	1.20	1.12	1.94	1.79	2.85	2.73	2.65	2.51
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of crop establishment and nutrient management on number of tillers (m^2) on Rice

Treatments	30 DAS/DAT		60 DAS/DAT		90 DAS/DAT		At harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Crop establishment (CE)								
CE_1: CT rice – CT wheat	139.70	143.28	350.89	359.35	332.75	339.57	301.89	307.89
CE_2: CTDSR – CT wheat	228.61	232.73	365.01	375.56	350.47	354.75	322.54	325.92
CE_3: CTDSR – ZT wheat	232.70	237.77	370.82	378.09	353.77	358.90	325.87	329.24
CE_4: ZT rice – ZT wheat	242.04	247.08	381.31	387.98	367.81	370.69	337.79	343.87
Sem ±	1.62	1.59	3.39	3.32	3.21	3.16	3.09	3.02
CD (P=0.05)	4.82	4.65	10.23	9.98	9.79	9.62	9.52	9.39
Nutrient management (N)								
N_1: Farmers Practices	202.39	205.67	359.03	367.29	342.01	346.79	315.24	319.37
N_2: Recommendation Fertilizer Dose	211.42	216.54	363.90	375.25	350.94	355.72	321.71	325.95
N_3: RWCM Recommendation	218.47	223.43	378.10	383.21	360.66	365.44	329.11	334.87
Sem ±	1.45	1.42	3.08	3.01	2.91	2.87	2.80	2.74
CD (P=0.05)	4.42	4.27	9.40	9.17	9.00	8.84	8.75	8.63
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

2.2 YIELD ATTRIBUTES AND YIELD

Table number 2 presents data on the number of panicles per m^2 and the number of grains per panicle and grain yield. The number of panicles and number of grains were recorded significantly higher under the CE_4 crop establishment technique (ZTDSR-ZT wheat + RW R), followed by CE_3, CE_2, and CE_1. Among the nutrient management approaches, RWCM-based nutrient recommendation (N_3), observed the highest number of panicles and per m^2 number of grains per panicle compared to other nutrient management practices. N_3 were found at par with N_2 in terms of number of panicles in first year only. A higher value of above parameters were also seen in second year under the same treatments..

The rice production was significantly influenced by various crop establishment methods and nutrient management strategies used throughout both years of study. The ZTDSR-ZTW + RW R treatment (CE_4) produced significantly greater yield than the other main plot treatments *i.e.* crop establishment methods. In the sub plot treatment, *i.e.* nutrient prescription based on RWCM (N_3), resulted in a significantly higher yield than the other sub plot treatments but RFD (N_2) was found at par with N_3. The same trend was found in the second year also. The ZTDSR-ZTW + RW R treatment (CE_4) improved rice crop establishment and light interception, resulting in more effective use of integrated inputs which resulted in better yield attributes and grain yield (Choudhary *et al*., 2020; Yadav et al., (2021). Improved nutrient delivery throughout rice's active growth and development phases and synchronizing crop nutrient demand with soil, fertilizer nutrient distribution and effective nutrient utilization by the crop in a timely manner and in appropriate proportions, based on its specific nutrient requirements at different growth stage might be attributed to achieve higher yield attributes and yield may be the cause of the rise in yield-contributing features under SSNM-based treatments (Singh *et al*. 2014; Shahi *et al*., 2022). Similar results were observed by Shahi *et al*., 2022; Pooniya *et al*.; (2021); Singh *et al*., (2014).

Table 3: Effect of crop establishment and nutrient management on yield attributes and grain yield of Rice

Treatments	Panicles (m^{-2})		Grains $panicle^{-1}$		Grain yield (Quintal ha^{-1})	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Crop establishment (CE)						
CE_1: CT rice – CT wheat	234.96	239.33	107.64	110.14	43.21	43.76
CE_2: CTDSR – CT wheat	253.87	260.46	115.33	118.90	44.93	45.55
CE_3: CTDSR – ZT wheat	260.91	268.28	118.87	124.08	46.28	46.96
CE_4: ZT rice – ZT wheat	279.58	288.85	126.88	132.78	48.62	49.32
Sem ±	3.89	3.84	1.93	1.91	0.76	0.77
CD (P=0.05)	11.97	11.79	5.82	5.77	2.29	2.31
Nutrient management (N)						
N_1: Farmers Practices	248.64	252.21	110.78	114.19	44.06	44.65
N_2: Recommendation Fertilizer Dose	256.32	263.35	116.64	120.70	45.52	46.16
N_3: RWCM Recommendation	267.02	277.14	124.13	129.45	47.70	48.39
Sem ±	3.57	3.49	1.84	1.81	0.76	0.75
CD (P=0.05)	11.09	10.77	5.59	5.47	2.29	2.33
Interaction	NS	NS	NS	NS	NS	NS

CONCLUSION:

Rice crop contributes major calorie into food basket of India under the rice-wheat cropping system but due to intensive agriculture and excessive use of external inputs results in degradation of soil, water and bio-diversity hence affecting rice production. The Conservation Agriculture (CA)-based crop establishment in rice is a potential option to address the above issues. ZTDSR-ZTW + RW R treatment (CE_4) and nutrient recommendation based on Rice-Wheat Crop Manager-RWCM (N_3) recommendation (N_3), recorded better growth *i.e.* maximum plant height and number of tillers, better yield attributes, *i.e.* maximum number of panicles per m^2 and maximum number of grains per panicle, and higher yield than the other main and sub plot treatments. ZTDSR-ZTW + RW R (CE_4) crop establishment, along with RWCM (N_3) based nutrition recommendations, can improve rice growth and yield in eastern Uttar Pradesh's rice-wheat system. Conservation agriculture approaches in rice can increase soil health and production while lowering costs and energy needs in the near future. Future research should focus on effective weed management and residue management techniques for CA-based crop establishment methods in rice.

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