Original Research Article

EFFECT OF CROP ESTABLISHMENT AND NUTRIENT MANAGEMENT ON WHEAT GROWTH UNDER RICE-WHEAT SYSTEM

ABSTRACT

The rice-wheat system contributes significantly to India's food security. The system's significance is properly handled from time to time, but excessive resource consumption, yield stagnation, environmental deterioration including erosion, and nutrient mining pose the greatest challenges. To address the issue, a research was conducted at Banaras Hindu University's Agricultural Research Farm in Varanasi during the 2019-20 Kharif and 2020-21 Rabi seasons, respectively. The experiment plotted in a split plot statistical design with three replications and four crop establishment methods: CE1: Conventional till rice (puddled transplanted)-Conventional till wheat, CE2: Conventional till direct seeded rice (DSR)-Conventional till wheat, CE3: Conventional till DSR-Zero-till wheat (rice residue retained), and CE4: Zero-till DSR-Zero-till wheat (residue retention in rice and wheat) crop establishment method among the main plot treatments and nutrient management *i.e.* Farmers practice (N_1), Recommended fertilizer dose (N_2) and Rice-Wheat Crop Manager (RWCM-N_3)- based nutrient recommendation among the sub plot treatments. Data recorded on growth parameters *i.e.* plant height, number of tillers and SPAD value at different stages are presented in this paper. CE4 treatment among main plot and N3 among nutrient management practices produced higher values of plant height, number of tillers at 30, 60, 90 days after sowing and at harvest as well as higher SPAD value at 30, 60 and 90 days after sowing than the other treatments. 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. CE4: 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 wheat crop under the region of eastern Uttar Pradesh.

Keyword: Zero till wheat, CA, Crop establishment, RWCM

INTRODUCTION

The rice–wheat (RW) cropping system occupies about 13.5-Mha area in the Indo-Gangetic Plains (IGP), and provides food for more than 400 million people of South Asia (Kumar *et al*. 2018). This system occupied about 10.5 million hectares in India and large area in Pakistan (2.2 million ha), Nepal (0.5 million ha) and Bangladesh (0.8 million ha). High productivity of the RW system with conventional management practices in the IGP at the cost of over exploitation of natural resources such as water, soil, and energy is a great concern of future sustainability (Choudhary *et al*., 2020; Singh et al., 2009). The productivity and sustainability of the intensive tillage and energy-based RW system are threatened because of the inefficiency of traditional/conventional practices and natural resource degradation (especially land, air, and water).

The production and productivity of RW system noticeably increased due to use of high yielding varieties and improved crop management practices and had contributed significantly in green revolution (GR) primarily in North- Western India. However, this GR contribution is not very prominent in eastern IGP which is characterize as highly populated, small farm holding size, poor input and output marketing infrastructure, poor access to new technologies and frequent climatic aberration (floods, drought and temperature), shorter wheat growing season compared to Western IGP. The major challenges associated with conventional production practices in rice-wheat system including stagnate and declining crop productivity, decreasing farm profits due to increasing energy and labour costs, degradation of natural resources like soil and water ,decline in irrigation water and an emerging issue of climate change are major problem for the food security of South Asia.

Farmers of Indo-Gangetic Plains of Eastern India usually grow wheat after intensive dry tillage, planking and using broadcasting method of sowing or sometimes seed-cum-fertilizer drills. The tillage operations are energy and input intensive, and also create problems in timely seeding of the succeeding crop (Bhushan et al., 2007; Jat et al., 2019). The tillage and crop establishment accounts to 25–30% cost of the total wheat production cost in rice–wheat cropping system of South Asia (Pathak et al., 2011), leading to lower benefit: cost ratios. Potential decline in productivity of wheat (4 - 38 %) in this region, is reported through simulation studies under future climate scenarios with increased greenhouse gas emissions, resulting in increase in mean temperature during grain filling thereby decline in productivity on account of extensive tillage system (Haris et al., 2013). Delayed sowing of wheat faces the heat stress at reproductive stage, resulting in lower grain yield and quality.

Conservation agriculture (CA) technologies involve minimum soil disturbance, permanent need based soil cover through crop residues or cover crops, and sensible diversification/crop rotations for higher productivity and better resource use efficiency (Singh *et al*., 2009). The technologies of CA provide opportunities to reduce the cost of production, save water and nutrients, improve yields, crop diversification, efficient resource use and benefit the environment. Farmers often apply fertilizer inefficiently, unaware about the concept and benefit of site specific nutrient management (SSNM). It results in lower yield and poor soil quality /health. SSNM based application ensure better nutrient management in rain fed as well as irrigated condition. The original concept of SSNM to manage among farm nutrient variability was developed in Asia for the rice crop (Dobermann and White 1999). They defined SSNM as a dynamic, farm-specific management of nutrients in a particular crop or cropping system to optimize the supply and demand of nutrients according to their differences in cycling through soil-plant systems. Rice–Wheat Crop Manager (RWCM) is a decision support system tool developed by International Rice Research Institute (IRRI) for SSNM. It is an information and communication technique (ICT) based web tool for decision making aims to sustain the productivity of rice-wheat cropping system, optimize the nutrients and increase the net income of rice and wheat farmers.

MATERIALS AND METHOD

The experiment was place at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, which is roughly 10 km south-east of Varanasi train station. The farm is located at 25^{0}15'N latitude, 82^{0}59'E longitude, and 75.7 metres above mean sea level in the Northern Gangetic Alluvial plains of Uttar Pradesh. The same area was used during the two years of research. The experimental field was fertile and consistent in topography and texture, and it was well-connected with tube wells for timely and systematic watering. The drainage canal was designed to remove surplus water from the experimental field.

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., CE1: Conventional till rice (puddled transplanted) — Conventional till wheat { farmers practice} [CT rice–CT wheat], CE2: Conventional till direct seeded rice — Conventional till wheat[CTDSR–CT wheat], CE3: Conventional till direct seeded rice — Zero-till wheat +rice residue retained [CTDSR–ZT wheat + R R], CE4: 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., N1: Farmers Practices (FP), N2: Recommended fertilizer dose (RFD), N3: Rice - Wheat Crop Manager recommendation (RWCM) in sub plots during both the years. The crop was planted in ZT wheat plots without any prior tillage. To eradicate the existing weeds, glyphosate (1.5%) was spot-applied as needed in all ZT wheat treatments before to sowing. The field was tilled twice for conventional till wheat (CT wheat), then planked and finally seeded using a zero tillage seed drill machine. 164 kg N, 67 kg P2O5, 33 kg K2O ha-1, and 2 kg Zn ha-1 were administered to each treatment in the FFP for wheat crop. At the time of sowing, half of the entire nitrogen dosage was applied as basal along with the full doses of phosphate and potash. The remaining half of the nitrogen dose, in the form of urea, was top dressed in two equal splits following the first and second irrigation. Wheat was treated with 150 kg N, 60 kg P2O5, 40 kg K2O ha-1, and 5 kg Zn ha-1 in all RFDs. At the time of sowing, half of the entire nitrogen dosage was applied as basal along with the full doses of phosphate and potash. The remaining half of the nitrogen dose, in the form of urea, was top dressed in two equal splits following the first and second irrigation. In N_3 fertilizer were applied on the basis of rice-wheat crop manager recommendation (RWCM). 120-55-60-8.2 kg $N\text{-}P_2O_5\text{-}K_2O$-Zn kg hai^{-1} during first year and 122-54.5-60 $N\text{-}P_2O_5\text{-}K_2O$ kg hai^{-1} during the second year was aaplied.

RESULTS:

Plant height (cm)

The data on plant height of wheat were recorded on 30, 60, 90 DAS and at harvest presented in [Tables 1]. Significant differences were observed among various conservation agriculture-based crop establishment methods at 30, 60, and 90 DAS and at harvest in both the year of study. Highest plant height (cm) was recorded in ZT rice-ZT Wheat (CE_4) treatment at 90 DAS during second year of experimentation. In nutrient management practices plant height of wheat was recorded significant under different sub plot levels at all the stages. Maximum plant height was recorded with RWCM (N_3) at 90 DAS.

Table 1: Effect of crop establishment and nutrient management on plant height (cm) of wheat at various crop growth stages

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2019	2020	2019	2020	2019	2020	2019	2020
Crop establishment (CE)								
CE_1: CT rice – CT wheat	22.77	22.93	51.67	51.78	91.28	93.21	89.45	91.12
CE_2: CTDSR – CT wheat	23.62	23.94	52.61	52.87	94.86	97.05	92.47	95.12
CE_3: CTDSR – ZT wheat	24.77	25.01	54.23	54.75	97.93	100.22	95.29	98.31
CE_4: ZT rice – ZT wheat	25.57	25.85	56.76	57.61	101.89	104.34	99.83	101.97
Sem ±	0.50	0.49	0.69	0.66	1.06	1.01	0.95	0.91
CD (P=0.05)	1.52	1.46	2.24	2.13	3.22	3.11	3.05	2.92
Nutrient management (N)								
N_1: Farmers Practices	23.81	24.03	52.06	52.98	94.16	96.24	92.36	93.97

N_2: Recommendation Fertilizer Dose	24.16	24.41	53.57	54.02	96.27	98.48	93.59	96.36
N_3: RWCM Recommendation	24.59	24.85	55.84	55.75	99.03	101.39	96.82	99.56
Sem ±	0.38	0.36	0.59	0.55	0.94	0.89	0.84	0.79
CD (P=0.05)	1.16	1.09	1.88	1.74	2.76	2.65	2.57	2.43
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Number of tillers m^{-1}

In conservation agriculture-based crop establishment methods, significantly highest number of tillers were recorded at 60 DAS with CE_4 during second year of the study [Tables 2]. Among different nutrient management treatments significant variation was recorded in number of tillers of wheat except at 30 DAS during both the experimental years. Significantly highest number of tillers of wheat was recorded by nutrient applied based on RWCM (N_3) recommendation, and followed by RDF (N_2) at 60, 90 DAS and at harvest stages.

Table 2: Effect of crop establishment and nutrient management on tiller count (number m^{-1} row length) of wheat at various crop growth stages

Treatments	30 DAS		60 DAS		90 DAS		At harvest	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Crop establishment (CE)								
CE_1: CT rice – CT wheat	34.43	35.75	71.68	73.52	70.25	71.78	67.14	69.13
CE_2: CTDSR – CT wheat	35.67	36.91	74.39	76.56	72.90	74.79	69.72	72.05
CE_3: CTDSR – ZT wheat	37.58	38.84	76.15	78.65	74.83	76.86	71.59	74.06
CE_4: ZT rice – ZT wheat	38.72	39.98	79.73	82.01	77.17	80.19	73.85	77.28
Sem ±	0.47	0.46	0.98	0.96	0.93	0.92	0.90	0.88
CD (P=0.05)	1.43	1.38	3.04	2.96	2.91	2.86	2.83	2.79
Nutrient management (N)								
N_1: Farmers Practices	35.78	36.93	72.11	74.23	70.48	72.49	67.36	69.81
N_2: Recommendation Fertilizer Dose	36.63	37.88	75.41	77.73	73.71	75.95	70.50	73.17
N_3: RWCM Recommendation	37.39	38.79	78.94	81.11	77.17	79.30	73.86	76.42
Sem ±	0.41	0.39	0.90	0.89	0.86	0.84	0.82	0.81
CD (P=0.05)	NS	NS	2.83	2.76	2.70	2.66	2.63	2.59

Interaction	NS	NS	NS	NS	NS	NS	NS	NS

SPAD reading

Observed data related to SPAD values [Table 3] indicated that crop establishment methods showed significant differences at 30, 60 and 90 DAS. Maximum value for SPAD reading was recorded in ZT rice-ZT Wheat (CE_4) treatment. Significant differences were observed at 60 and 90 DAS among nutrient management levels. Maximum SPAD reading was recorded in RWCM treatment during both the experimental years.

Table 3: Effect of crop establishment and nutrient management on chlorophyll content in leaves (SPAD value) of wheat at various crop growth stages

Treatments	30 DAS		60 DAS		90 DAS	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**
Crop establishment (CE)						
CE_1: CT rice – CT wheat	38.59	38.67	38.98	39.02	37.05	37.08
CE_2: CTDSR – CT wheat	39.14	39.29	39.53	39.64	37.57	37.68
CE_3: CTDSR – ZT wheat	40.06	40.14	40.42	40.50	38.46	38.49
CE_4: ZT rice – ZT wheat	40.89	40.98	41.30	41.35	39.25	39.30
Sem ±	0.30	0.28	0.31	0.29	0.26	0.24
CD (P=0.05)	0.98	0.92	1.03	0.96	0.87	0.82
Nutrient management (N)						
N_1: Farmers Practices	39.37	39.49	39.63	39.75	37.80	37.87
N_2: Recommendation Fertilizer Dose	39.65	39.73	40.05	40.09	38.06	38.10
N_3: RWCM Recommendation	39.98	40.09	40.51	40.55	38.38	38.45
Sem ±	0.27	0.26	0.27	0.25	0.24	0.23
CD (P=0.05)	NS	NS	0.83	0.78	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

LAI

Recorded data of LAI of wheat at 30, 60 and 90 DAS [Tables 4] showed that crop establishment methods had significant difference amongst treatments. ZT rice-ZT Wheat (CE_4) recorded maximum value at all the observed stages of crop during both the experimental years. LAI of wheat among different nutrient management practices showed significant difference at different stages of observation except at 30 DAS. Highest LAI was recorded in RWCM treatment (N_3).

Table 4: Effect of crop establishment and nutrient management on leaf area index of wheat at various crop growth stages

Treatments	30 DAS		60 DAS		90 DAS	
	2019	2020	2019	2020	2019	2020
Crop establishment (CE)						
CE_1: CT rice – CT wheat	0.65	0.66	2.53	2.56	3.19	3.30
CE_2: CTDSR – CT wheat	0.67	0.68	2.61	2.65	3.31	3.42
CE_3: CTDSR – ZT wheat	0.70	0.71	2.72	2.77	3.48	3.57
CE_4: ZT rice – ZT wheat	0.73	0.74	2.84	2.88	3.66	3.71
Sem ±	0.02	0.02	0.06	0.06	0.09	0.08
CD (P=0.05)	0.07	0.06	0.21	0.19	0.31	0.27
Nutrient management (N)						
N_1: Farmers Practices	0.67	0.68	2.60	2.64	3.31	3.39
N_2: Recommendation Fertilizer Dose	0.69	0.70	2.67	2.71	3.30	3.48
N_3: RWCM Recommendation	0.71	0.72	2.75	2.81	3.53	3.61
Sem ±	0.02	0.02	0.04	0.04	0.07	0.06
CD (P=0.05)	NS	NS	0.14	0.13	0.21	0.20
Interaction	NS	NS	NS	NS	NS	NS

DISCUSSION:

Wheat crop growth in ZT-based treatments are higher than in CT wheat due to early planting and the cumulative effects of better light interception, lower soil and canopy temperature, and increased soil moisture availability. This is due to accurate input placement in the limited space formed by the zero-seed drill (ZSD), early emergence and rapid development of wheat, and increased soil moisture availability, all of which allowed the crops to perform better than crops seeded according to farmer practice. These results are consistent with those reported by [Bera et al., 2017]. Studies show that shallow hard pans caused by repeated wet tillage or puddling lead to reduced root development, less tillering, and lower grain production [Sahrawat et al., 2010, Gathala et al., 2011]. Previous investigations done by Nandan R et al. (2018), Sapkal S et al. (2018), and Singh M et al. (2020) observed similar results.

The increased growth and dry matter buildup can be ascribed to the efficient/optimal utilisation of nutrients by synchronising the crop's nutrient demand with the nutrient supply from the soil and fertilisers. This method guarantees that the crop obtains the necessary nutrients at the proper time and in the right proportions, hence optimising its growth and development. Previous investigations have corroborated the conclusions given in the statement. Shrestha et al. (2016) showed substantial improvements in rice growth parameters when site-specific nutrient management strategies were used.

CONCLUSION:

The rice-wheat system contributes significantly to India's food security. The system's significance is properly handled from time to time, but excessive resource consumption, yield stagnation, environmental deterioration including erosion, and nutrient mining pose the greatest challenges. To address these issues in wheat crop conservation agriculture based crop establishment and precision nutrient management based on rice-wheat crop manager can be utilized as a potential option. ZTDSR-ZTW crop establishment with RWCM based nutrient recommendation resulted in higher growth of wheat as discussed in result part. It can be concluded that ZTDSR-ZTW with residue retention of both the crops in accordance with nutrient recommendation based on RWCM can be used for better growth of wheat under eastern IGP.

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