Effect of tillage practices and fertility levels on growth, yield attributes and yield of wheat in rice- wheat cropping system

Abstract

The present investigation entitle "Effect of tillage practices and fertility levels and yield of wheat in rice- wheat cropping system" was conducted at Agronomy Research Farm, CSAUAT, during *rabi* 2021-22 and 2022-23. The experiment was laid out into Split plot design with3 replication. Two levels of tillage *viz.* (1) Conventional tillage Two ploughing followed by sowing), (2) Reduce tillage (one ploughing followed by sowing were randomly allotted to main plot while ten 10 fertility levels The parameters were observed plant viz. plant height (at 30, 60, 90 DAT and harvest), Number of leaves/ Plant (30, 60, 90 and at harvest), Leaf area index (at 30, 60, 90 DAT and harvest), Relative growth rate (mg g day^{-1}), Relative growth rate (mg g day^{-1}), Grain weight ear^{-1}, 1000 grain weight (g), and Grain yield (q ha^{-1}). Study result revealed the maximum plant height (cm), number of leaves / plant, leaf area index, relative growth rate (mg g day^{-1}) Ear length (cm), number of grain ear^{-1}, grain weight ear^{-1}, 1000 grain weight (g) and Grain yield (q/ha) were recorded with conventional tillage with 125% RDF + chloromequate chloride.

Introduction

Being a significant prehistoric crop, wheat (Triticum aestivum L.) forms the foundation of our country's food security system. The expression "Dal roti chalna" acknowledged its importance in our way of life. Its straw is one of the main feedstuffs for many cattle. As a result, wheat is the food grain with the highest protein content; pulses come in first. It's used for things like bread, cakes, biscuits, noodles, petri dishes, and chapattis. Starch (60–68%), protein (8–15%), fat (1.5–2.0%), cellulose (2.0–2.5%), and minerals (1.5–2.0%) are all present in wheat grains.**(Kumar *et al.* 2019).** By providing more than 50% of the calories for those who primarily rely on it, the wheat crop significantly contributes to the food security of the country. Consequently, wheat serves as a significant global source of energy for animal feed and human diets. Approximately 224 million hectares of wheat are grown worldwide, and an average of 775.8 million metric tonnes are produced each year. The United States of America, China, India, and the European Union are the top four global producers of wheat. India is the world's second-largest producer of wheat, thanks to its rich and varied agro-ecological conditions, which have guaranteed food and nutritional security to most of the country's people through production and constant supply, especially in recent years. According to the Directorate of Economics and Statistics, wheat is cultivated on 33.64 million hectares in India, producing 107.59 million tonnes and 3206.30 kg ha^{-1} of productivity in 2019–20. Six main zones have been identified for the nation's wheat-growing region. The North-Western Plain Zone (NEPZ) is the region with the largest wheat cultivation area. All states in India save Kerala cultivate wheat. India's leading wheat-growing state is Uttar Pradesh. 9.85 million hectares of wheat are grown in Uttar Pradesh, producing 35.50 million tonnes of wheat. Madhya Pradesh and Punjab, with respective areas of 6.39 million hectares and 17.17 million tonnes and 3.5 million hectares and 17.14 million tonnes and 17.17 million tonnes, are next in line. By 2050, the world's wheat consumption is expected to reach 900 million tonnes. By 2050, it is predicted that India will require at least 140 million tonnes of wheat, compared to the current anticipated 109.24 million tonnes of production. 216.18 million hectares worldwide are planted to wheat, yielding 763.6 million metric tonnes at an average of 3530 kg ha^{-1}. With an average productivity of 3530 kg ha^{-1}, it covers 29.32 million hectares in India and produces 103.6 million metric tonnes, or one third of the country's total food grain production **(Kar *et al.* 2021).** Accordingly, wheat is likely to continue to be vital in ensuring food security across the globe.

With 9.65 million hectares (36.6 %), 26.87 million tonnes (39.3 %), with a productivity of 2785 kg ha^{-1}, Uttar Pradesh is the largest wheat-growing state in India (Anonymous, 2019).

Approximately 90 % of the world's rice is produced in Asia, where it is farmed on 142 million hectares of land and produces 622 million tonnes of rice **(Rashid *et al.*, 2012).** Approximately 43 % of India's total food grain production is derived from rice, making it one of the biggest contributors to food grain production **(Mondal *et al.*, 2020).** With a 104.31 million tonne yield, rice is grown on 44.38 million hectares of land in India. By 2025, the nation would need to produce over 130 million tonnes of rice in order to feed its expanding population. Roughly 2 billion people in Asia alone rely on rice, which provides 80% carbs, 7-8% protein, 3% fat, and 3% fibre, to meet their energy demands. Middle Eastern nations, Malaysia, Korea, Japan, Australia, the United States, Canada, the United Kingdom, Italy, and Sweden are the export destinations. Aromatic rice is becoming more and more in demand both domestically and internationally **(Ankit *et al.*, 2022).**

In the field, during harvesting, in storage, during milling, cooking, and during consumption, aromatic rice releases a distinct aroma **(Rajeev *et al.*, 2014).** Both environmental and genetic factors play a role in the development of aroma. It is well known that fragrant rice develops its aroma most effectively when it is grown in milder climates throughout flowering and maturity. The majority of India's production of basmati rice is exported. The most popular aromatic fine-quality rice in global trade, basmati rice commands a premium price on the export market. Actually, basmati rice grows solely on the Indo-Gangetic plain and is a gift from "Mother - Nature" to the Indian subcontinent. As of 2015, there were 23 varieties of basmati rice that were recognised by the Seeds Act of 1966. Globally, India is the leading manufacturer and exporter of basmati rice (Shoomro *et al.,* 1999). Over 70 % of the world's basmati rice is produced in India; Pakistan produces the remaining portion. In India, 8.7 million tonnes of basmati rice were produced in 2014–15 from 2.1 million hectares.

Conventional tillage often seeks to break up lumps and level the ground while also reversing and agitating a deep layer of soil, integrating and eliminating plant detritus, and exposing soil pests to sunlight for control. During both the winter and summer production seasons, conventional tillage entails a number of mechanical operations, such as deep ploughing, deep disking, ripping, shallow tyne workings, and fine seedbed preparation following the harvesting of various grain crops. After then, there is a fallow season to allow the crops to absorb moisture until the following crop is planted. After heavy rains, this method leaves the soil surface naked, vulnerable to erosion by wind and water, and highly compacted. This necessitates re-loosening the soil in order to help minimise weed growth and encourage moisture absorption from successive rainfalls. Full-width tillage, or reduced tillage, involves disturbing the whole soil surface and leaves 15 % to 30 % of residue cover in place after planting. In the inland Pacific Northwest, other conservation tillage techniques include sweep tillage systems, chisel, discs, under cutter fallow, and delayed minimum tillage. over primary spring tillage, the under cutter method of fallow management delivers nitrogen to the soil surface while slicing beneath it with wide V blade sweeps. One or two non-inversion rod weeding operations are then conducted over the summer to control weeds **(Pathania *et al.*, 2020).**

Under cutter V-sweep, minimal tillage and delayed minimum tillage are both used as principal tillage techniques. After primary tillage, herbicides can be used to manage weeds; however, secondary tillage techniques like rod weeding are more frequently employed. With the exception of delaying primary spring tillage with an under cutter V-sweep until at least mid-May, delayed minimal tillage is comparable to minimum tillage (**Ali *et al.* 2021).**

It is impossible to apply reduced tillage techniques in a "one size fits all" manner. Your alternatives for reduced tillage may vary depending on factors such crop rotation style, soil type, water availability for cover crops, ability to finance new tool purchases for soil management, and your objectives for lowering tillage. It is best to speak with your cooperative first.

Plants naturally take time to grow and develop. Using plant growth promoters can speed up this process by providing nutrients to soil microorganisms, which in turn increases the activity of microbes in the soil and helps to convert inaccessible plant nutrients into available form. While organic plant growth promoters (PGPS), such as soil fertility and crop productivity, also aid in faster plant growth promotion and prevent grain disease, natural plant growth promoters (Phytohormones) are engaged in pushing and stimulating root and shoot growth. Improved chemistry allows plant growth promoters to work on several sites within treated plants, rather than just the leaf surface. They are absorbed by the leaves as well as other plant components.

Material and Method

The field experiment was conducted during *Rabi* of 2021-22 and 2022-23 at Agronomy Research Farm, CSAUAT, Kanpur. The experiment was laid out into Split plot design with 3 replication. Two levels of tillage *viz.* (1) Conventional tillage Two ploughing followed by sowing), (2) Reduce tillage (one ploughing followed by sowing were randomly allotted to main plot while ten 10 fertility levels *viz.* (1) Absolute Control. (2) RDF (150.60.40 NPK kg/ha), 3) 75 % RDF (112.5; 15 30 NPK kg/ha + 10 t FYM/ha) (4) 125 % RDF (187.5; 75; 50 NPK kg/ha) (5) RDF (150; 60; 40 NPK kg/ha) + Two spray of chloromequate chloride (Lihocine 0.2 % at first node (45 Days) and flag leaf stage (80 DAS). (6) RDF (150; 60; 40 NPK kg/ha) + Two Spray of tebunconzole (Folicur 430 SC @ 0.1 %) at first node and flag leaf stage (80 DAS). (7) 75 % RDF (112.5:45:30 NPK kg/ha + 10t FYM/ha + Two Spray of Chloromequate chloride (Lihocine 0.2 % at first node (45 DAS) and flag leaf stage (80 DAS) (8) 75 % RDF (112.5:45:30 NPK kg/ha + 10 t FYM/ha + Two Spray to tebunconzole (Folicur 430SC @0.1 % at first node and flag leaf stage (80 DAS) (9) 125 % RDF (187.5:75:50 NPK kg/ha+ Two Spray of Chloromequate chloride (Lihocine 0.2 % at first node (45 DAS) and flag leaf stage (80 DAS) (10) 125 % RDF (187.5:75:50 NPK kg/ha + Two Spray of tebunconzole Folicur 430 SC @ 0.1 % (Folicur 430 SC @ 0.1 % at first node and flag Leaf (80 DAS) were randomly allocated to sub plots. Standard culture practices recommended for Wheat was followed uniformly in all experimental plots.

Result and Discussion

1. Plant Height

Early stages of 30 DAS of growth revealed non-significant differences in tillage techniques throughout the investigational years 2021–22 and 2022–23. The plant height, however, was positively impacted by tillage techniques at the 60 DAS, 90 DAS, and harvest stages in subsequent crop growth phases. The maximum plant height was recorded with conventional tillage (45.62, 88.30, 93.27 cm and 46.89, 86.22, 91.20 cm) overall growth stages followed by reduce tillage (43.45, 86.38, 91.70 cm and 44.54, 84.62, 90.04 cm). Among various fertility levels, early growth stage of (30 DAS) of growth showed non-significant fertility levels during 2021-22 and 2022-23 of study. At 60, 90 DAS and harvest, the plant height was significantly increased by fertility levels. The maximum height of plant was recorded with 125 % RDF + tebunconzole (48.12, 96.08, 101.94 and 49.34, 94.15, 100.08 cm) at 60, 90 DAS and harvest of wheat which were par with 125 % RDF + chloromequate chloride (47.36, 93.88, 99.55 and 48.54, 91.95, 97.69 cm) and also superior to 75 % RDF + 10 t FYM/ha + tebunconzole (46.22, 91.88, 96.89 & 47.40, 89.95, 95.03 cm) at 60, 90 DAS and at harvest. The minimum height of wheat plant was recorded with absolute control (40.09, 78.33, 82.29 & 41.27, 76.40, 80.42 cm) and it was at par with RDF (41.96, 81.28, 85.21 & 43.14, 79.35, 83.35 cm) during the study of both year 2021-22 and 2022-23. (Table 1). Similar findings were reported by **Timalsina *et al.*, 2021 and Ram *et al.*, 2018.**

2. Number of leaves / plant

The number of leaves grows as the wheat plant grows. When crop growth reached later stages, tillage practices at 60 DAS, 90 DAS, and harvest stage had a significant impact on plant height. At stage of 30 DAS, number of leaves revealed non-significant difference in tillage practices between 2021-22 and 2022-23 of study. Number of leaves were recorded in conventional tillage (16.53, 19.86, 19.88 and 16.50, 14.98, 20.48) at all growth stages followed by reduce tillage (12.05, 15.95, 18.66 and 12.76, 14.98, 19.07).Among various fertility levels, early growth stage of (30 DAS) of number of leaves showed non-significant fertility levels during 2021-22 and 2022-23 of study. The number of leaves were significantly increased by fertility levels at 60, 90 DAS and harvest stages. (Table 2). The consequences of the current investigation are additionally in concurrence with the investigation of **Husnain *et al.* (2011), and Singh *et al.* (2020),**

3. Leaf Area Index

The leaf area index of wheat was lowest at the starting stage of 30 days and increased with plant growth over the course of the two years of the experiment. The highest values of LAI at 30, 60, 90 DAS and at harvest stage were obtained with conventional tillage (0.53, 3.25, 4.56, 5.23 and 0.57, 3.08, 4.29, 4.82) and it was on par with reduce tillage practice (0.49, 3.04, 4.32, 4.94 and 0.51, 2.81, 4.10, 4.61). Among the fertility levels, 125 % RDF+ tebunconzole (0.559, 3.68, 5.03, 5.37 and 0.59, 3.44, 4.78, 5.33) had highest LAI followed by the 125 % RDF + chloromequate chloride (0.551, 3.67, 4.90, 5.55 and 5.58, 3.37, 4.66, 5.21) and was on par with 75 % RDF + 10 t FYM/ha + tebunconzole (0.544, 3.51, 4.79, 5.44 and 0.576, 3.27, 4.55, 5.10), 75 % RDF + 10 t FYM/ha + Chloromequate chloride (0.531, 3.38, 4.68, 5.34 and 0.562, 3.14, 4.45, 5.00) during 2021-22 and 2022-23, respectively. The minimum leaf area index was recorded in the control (0.44, 2.46, 3.74, 4.38 and 0.48, 2.22, 3.49, 4.04) followed by RDF (0.47, 2.69, 3.95, 4.59 and 0.50, 2.45, 3.70, 4.25) and 75 % RDF + 10t FYM/ha (0.48, 2.80, 4.08, 4.72 and 0.52, 2.56, 3.83, 4.38) respectively during 2021-22 and 2022-23 of study. During both years of the experiment, there was no discernible relationship between tillage practices and fertility levels. (Table 3**).** These results also confirms the findings of **Singh *et al.* (2001), Kakraliya *et al.* (2018),**

4. Relative growth rate (mg g day^{-1})

The relative growth rate was typically at its maximum during the 30 to 60 DAS of the crop and began to decline from 60 DAS till harvest. Fertility levels and relative growth rates under tillage methods were not considerably impacted. The highest growth rate was observed in conventional tillage practice (24.56, 14.62, 2.82 and 24.11, 14.34, 2.80) followed by the reduce tillage practice (23.77, 14.10, 2.72 and 23.35, 13.91, 2.69) during the both year 2021-22 and 2022-23. Among fertility levels, higher growth rate was notices in 125 % RDF+ tebunconzole (25.13, 15.37, 3.05 and 24.70, 15.14, 3.02) which is at par on 125 % RDF + chloromequate chloride (24.93, 15.13, 2.97 and 24.50, 14.90, 2.96) and 75 % RDF + 10t FYM/ha + tebunconzole (24.73, 14.90, 2.96 and 24.29, 14.66, 2.89) respectively during both year 2021-22 and 2022-23. The lowest relative growth rate was notices in the control treatment which is at par with the 75 % RDF + 10 t FYM/ha. The consequences of the current investigation are additionally in concurrence with the investigation of **Saharawat *et al.* (2010), and Kumar *et al.* (2019).**

5. Ear length (cm)

Spike length found remarkable variation in the tillage practice. The highest ear length was observed with conventional tillage (10.59 and 11.55 cm) which is at par with reduce tillage (9.95 and 10.54 cm) during 2021-22 and 2022-23 of study. The minimum ear length was observed in reduce tillage (9.95 and 10.54 cm). Among fertility levels, the highest ear length was recorded in 125% RDF+ tebunconzole (12.00 and 12.87 cm) followed by 125 % RDF + chloromequate chloride (11.65 and 12.52 cm) and 75 % RDF + 10t FYM/ha + tebunconzole (11.15 and 12.02 cm) respectively. The lowest ear length was led in the control treatment (8.20 and 9.07 cm) which was at par with RDF (8.85 and 9.72 cm) and 75 % RDF + 10t FYM/ha (9.25 and 10.12 cm). There was no significant interaction effect of tillage practice and fertility levels on ear length during both year of study. These results also confirms the findings of **Toyota *et al.* (2010), and Shri *et al.* (2021)**

6. Number of grain ear^{-1}

Number of grain per ear found remarkable variation in the tillage practice. The maximum number of grain per ear were observed with conventional tillage (39.89 and 42.27) which is at par with reduce tillage during (38.81 and 40.80) 2021-22 and 2022-23 of study. Among fertility levels, the maximum number of grain per ear were recorded in 125 % RDF+ tebunconzole (42.67 and 44.43) followed by 125 % RDF + chloromequate chloride (42.24 and 44.83) and 75 % RDF + 10 t FYM/ha + tebunconzole (41.16 and

43.33) respectively. The minimum grain per ear were counted in the control treatment (43.90 and 37,08) which was at par with RDF (37.05 and 39.23) and 75 % RDF + 10t FYM/ha (38.0 and 40.18). There was no significant interaction effect of tillage practice and fertility levels on ear length during both year of study**.** Similar findings were reported by **Mitra *et al.*, 2014 and Gupta *et al.*, 2006;**

7. Grain weight ear^{-1}

Significant differences in the tillage practices were identified in the grain weight per ear. The maximum grain weight per ear were observed with conventional tillage (1.50 and 1.59 g) which is at par with reduce tillage (1.34 and 1.41 g) during 2021-22 and 2022-23 of study. Among fertility levels, the maximum grain weight per ear were recorded in 125 % RDF+ tebunconzole (1.73 and 1.82 g) followed by 125 % RDF + chloromequate chloride (1.72 and 1.80 g) and 75 % RDF + 10 t FYM/ha + tebunconzole (1.61 and 1.69 g) respectively. The minimum grain weight per ear was weighted in the control treatment (1.02 and 1.09 g) which was at par with RDF (1.20 and 1.27 g) and 75 % RDF + 10 t FYM/ha (1.26 and 1.33 g). During the two years of the experiment, there was no discernible interaction impact between tillage practices and fertility levels on grain weight per ear. Similar findings were reported by **Ghazanfar *et al.* (2010), Zang *et al.* (2017)**

8. 1000 grain weight (g)

There was an apparent variance in the tillage technique for 1000 grain weight. The maximum weight of 1000 grain was observed with conventional tillage (36.34 and 37.51 g) which is at par with reduce tillage (33.36 and 34.50 g) during 2021-22 and 2022-23 of experimentation. Among fertility levels, the maximum weight of 1000 grains was recorded in 125 % RDF+ tebunconzole (39.87 and 42.03 g) followed by 125 % RDF + chloromequate chloride (39.21 and 40.36 g) and 75 % RDF + 10t FYM/ha + tebunconzole (38.00 and 39.15 g) respectively. The minimum weight of 1000 grains was weighted in the control treatment (28.19 and 29.35 g) which was at par with RDF (31.26 and 32.42 g) and 75 % RDF + 10 t FYM/ha (32.06 and 33.22 g). There was no significant interaction effect of tillage practice and fertility levels on 1000 grain weight during 2021-22 and 2022-23 year of study. Similar findings were reported by **Woźniak & Rachoń (2020).**

9. Grain yield (q ha^{-1})

The tillage practices caused a striking variance in grain yield. The maximum grain yield (51.68 and 50.86 q ha^{-1}), straw yield (67.85 and 66.51 q ha^{-1}), biological yield (119.53 and 117.38 q ha^{-1}) and harvest index (43.22 and 43.22 %) were recorded with conventional tillage which is at par with reduce tillage during 2021- 22 and 2022-23 of study. Among fertility levels, the maximum grain yield (55.02 and 54.32 q ha^{-1}), straw yield (71.68 and 70.47 q ha^{-1}), biological yield (126.67 and 124.66 q ha^{-1}) and harvest index (43.40 and 43.39 %) were recorded in 125 % RDF + tebunconzole followed by 125 % RDF + chloromequate chloride and 75 % RDF + 10 t FYM/ha + tebunconzole respectively. The minimum grain yield (45.44 and 44.69 q ha^{-1}), straw yield (62.79 and 61.48 q ha^{-1}), biological yield (108.11 and 106.05 q ha^{-1}) and harvest index (42.08 and 42.19 %) were observed in the control treatment. There was significant interaction effect of tillage practice and fertility levels on grain yield during 2021-22 and 2022-23 year of study. The consequences of the current investigation are additionally in concurrence with the investigation of **Gholami *et al.* (2014) and Kumar *et al.* 2019.**

Table-1: Effect of tillage practices and fertility levels on plant height of wheat

Treatment	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	25.63	26.87	26.25	45.62	46.89	46.29	88.30	86.22	87.43	93.27	91.20	92.38
Reduce tillage	24.54	25.65	25.05	43.45	44.54	43.91	86.38	84.62	85.40	91.70	90.04	90.79
SE(m)	0.048	0.59	0.092	0.069	0.068	0.155	0.123	0.111	0.339	0.112	0.121	0.220
C.D.	NS	NS	NS	0.455	0.446	1.015	0.804	0.725	1.728	0.733	0.789	1.441
Fertility Level												
F_1 (Control)	24.05	25.32	24.62	40.09	41.27	40.55	78.33	76.40	77.24	82.29	80.42	81.23
F_2- RDF (150.60.40 NPK kg/ha)	24.40	25.64	24.97	41.96	43.14	42.40	81.28	79.35	80.17	85.21	83.35	84.13
F_3-75% RDF + 10t FYM/ha	25.55	25.68	25.12	42.53	43.71	43.17	82.18	80.25	81.27	87.33	85.46	86.44
F_4-125% RDF	24.80	26.01	25.37	43.68	44.86	44.20	84.39	82.46	83.6	89.85	87.98	88.84
F_5- RDF + chloromequate chloride	25.05	26.05	25.62	44.25	45.43	44.98	86.39	84.46	85.56	91.73	89.86	90.93
F_6- RDF + tebunconzole	25.20	26.33	25.77	45.23	46.41	45.83	88.46	86.53	87.51	94.15	91.28	93.22
F_7- 75% RDF + 10t FYM/ha + Chloromequate chloride	25.40	26.57	25.97	45.90	47.08	46.46	90.52	88.59	89.53	95.95	94.09	94.99
F_8-75% RDF + 10t FYM/ha + tebunconzole	25.60	26.79	26.17	46.22	47.40	46.89	91.88	89.95	91.65	96.89	95.03	96.57
F_9-125% RDF + chloromequate chloride	25.80	26.96	26.37	47.36	48.54	47.92	93.88	91.95	92.89	99.55	97.69	98.59
F_{10}-125% RDF+ tebunconzole	26.00	27.27	26.57	48.12	49.34	48.62	96.08	94.15	94.98	101.94	100.08	100.88
SE(m)	0.237	0.85	0.288	0.089	0.088	0.370	0.162	0.153	0.906	0.136	0.134	1.018
C.D.	NS	NS	NS	0.256	0.254	1.066	0.459	0.439	2.610	0.392	0.388	2.931

Table-2: Effect of tillage practices and fertility levels on Number of leaves per plant of wheat

Treatment	Number of leaves per plant											
	30 DAS			60 DAS			90 DAS			At harvest		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	5.67	5.27	5.47	16.53	16.50	16.51	19.86	18.82	19.34	19.88	20.48	20.18
Reduce tillage	5.12	4.82	4.97	12.05	12.76	12.40	15.95	14.98	15.46	18.66	19.07	18.86
SE(m)	0.025	0.015	0.032	0.129	0.036	0.039	0.010	0.126	0.084	0.070	0.160	0.087
C.D.	NS	NS	NS	0.848	0.236	0.256	0.064	0.825	0.548	0.459	1.049	0.568
Fertility Level												
F_1 (Control)	4.40	4.05	4.22	9.90	9.79	9.84	13.25	12.24	12.74	15.45	15.95	15.70
F_2- RDF (150.60.40 NPK kg/ha)	4.75	4.40	4.57	11.50	11.39	11.44	15.35	14.34	14.84	16.95	17.45	17.20
F_3-75% RDF + 10t FYM/ ha	4.95	4.60	4.77	12.10	11.99	12.04	16.55	15.54	16.03	17.60	18.10	17.85
F_4-125% RDF	5.15	4.80	4.97	13.20	13.09	13.14	17.30	16.29	16.79	18.20	18.70	18.45
F_5- RDF + chloromequate chloride	5.30	4.95	5.12	13.90	13.79	13.84	18.15	17.14	17.64	19.05	19.55	19.30
F_6- RDF + tebunconzole	5.5	5.15	5.32	14.50	15.74	15.12	18.50	17.49	17.99	19.65	20.15	19.90
F_7- 75% RDF + 10t FYM/ ha + Chloromequate chloride	5.70	5.35	5.52	15.90	16.58	16.24	19.15	18.14	18.62	20.5	21.0	20.75
F_8-75% RDF + 10t FYM/ ha + tebunconzole	5.85	5.50	5.67	16.60	17.28	16.94	19.65	18.64	19.14	21.25	21.75	21.50
F_9-125% RDF + chloromequate chloride	6.05	5.70	5.87	17.40	18.08	17.74	20.30	19.29	79.78	21.7	2 2.20	21.95
F_{10}-125% RDF+ tebunconzole	6.30	5.95	6.25	17.90	18.57	18.23	20.85	19.84	20.34	22.35	22.85	220.60
SE(m)	0.057	0.054	0.053	0.157	0.153	0.156	0.196	0.158	0.174	0.189	0.208	0.167
C.D.	NS	NS	NS	0.451	0.440	0.450	0.565	0.454	0.501	0.545	0.600	0.480

Table-3: Effect of tillage practices and fertility levels on leaf area index of wheat

Treatment	**Leaf Area Index (LAI)**											
	30 DAS			**60 DAS**			**90 DAS**			**At harvest**		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	0.535	0.571	0.553	3.258	3.08	3.13	4.56	4.29	4.48	5.23	4.82	5.05
Reduce tillage	0.490	0.518	0.504	3.042	2.81	2.92	4.32	4.10	4.21	4.94	4.61	4.78
SE(m)	0.012	0.003	0.002	0.007	0.017	0.028	0.013	0.008	0.014	0.049	0.014	0.009
C.D.	0.038	0.018	0.016	0.047	0.111	0.186	0.083	0.050	0.091	0.152	0.089	0.061
Fertility Level												
F_1 (Control)	0.449	0.481	0.465	2.46	2.22	2.34	3.74	3.49	3.61	4.38	4.04	4.21
F_2- RDF (150.60.40 NPK kg/ha)	0.473	0.505	0.489	2.69	2.45	2.57	3.95	3.70	3.82	4.59	4.25	4.42
F_3-75% RDF + 10t FYM/ha	0.488	0.520	0.504	2.80	2.56	2.68	4.08	3.83	3.95	4.72	4.38	4.55
F_4-125% RDF	0.499	0.531	0.515	2.98	2.74	2.65	4.26	4.02	4.14	4.91	4.57	4.74
F_5- RDF + chloromequate chloride	0.511	0.543	0.527	3.12	2.88	3.00	4.44	4.20	4.32	5.09	4.75	4.92
F_6- RDF + tebunconzole	0.522	0.554	0.538	3.25	3.01	3.13	4.53	4.29	4.41	5.18	4.84	5.01
F_7- 75% RDF + 10t FYM/ha + Chloromequate chloride	0.53	0.562	0.546	3.38	3.14	3.26	4.69	4.45	4.57	5.34	5.00	5.17
F_8-75% RDF + 10t FYM/ha + tebunconzole	0.544	0.576	0.560	3.51	3.27	3.39	4.79	4.55	4.67	5.44	5.10	5.27
F_9-125% RDF + chloromequate chloride	0.551	0.582	0.567	3.61	3.37	3.49	4.90	4.66	4.78	5.55	5.21	5.38
F_{10}-125% RDF+ tebunconzole	0.559	0.591	0.575	3.68	3.44	3.65	5.03	4.78	4.90	5.67	5.33	5.50
SE(m)	0.006	0.007	0.005	0.034	0.029	0.032	0.053	0.039	0.042	0.042	0.055	0.045
C.D.	0.016	0.017	0.015	0.099	0.083	0.091	0.151	0.113	0.091	0.122	0.158	0.129

Table-4: Effect of tillage practices and fertility levels on Relative Growth Rate (day g^{-1}) of wheat

Treatments	Relative Growth Rate (day g^{-1})								
	30 DAS			60 DAS			90 DAS		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	24.56	24.11	24.33	14.62	14.34	14.48	2.82	2.80	3.82
Reduce tillage	23.77	23.35	23.56	14.10	13.91	14.01	2.72	2.69	3.01
SE(m)	0.124	0.168	0.123	0.072	0.051	0.050	0.011	0.012	0.010
C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertility Level									
F_1 (Control)	23.13	22.70	22.91	13.33	13.09	13.21	2.26	2.23	2.24
F_2- RDF (150.60.40 NPK kg/ha)	23.44	23.00	23.22	13.63	13.39	13.52	2.62	2.59	2.47
F_3-75% RDF + 10t FYM/ha	23.63	23.20	23.41	13.79	13.55	13.67	2.68	2.64	2.66
F_4-125% RDF	23.85	23.41	23.63	14.02	13.78	13.90	2.76	2.72	2.74
F_5- RDF + chloromequate chloride	24.05	23.61	23.83	14.26	14.02	14.14	2.80	2.77	2.78
F_6- RDF + tebunconzole	24.26	23.83	24.04	14.49	14.25	14.37	2.86	2.82	2.84
F_7- 75% RDF + 10t FYM/ha + Chloromequate chloride	24.49	24.06	24.27	14.71	14.48	14.59	2.89	2.86	2.87
F_8-75% RDF + 10t FYM/ha + tebunconzole	24.73	24.29	24.51	14.90	14.66	14.78	2.96	2.89	2.91
F_9-125% RDF + chloromequate chloride	24.93	24.50	24.71	15.13	14.90	15.01	2.97	2.96	2.95
F_{10}-125% RDF+ tebunconzole	25.13	24.70	24.92	15.37	15.14	15.25	3.05	3.02	3.03
SE(m)	0.261	0.293	0.227	0.165	0.146	0.137	0.011	0.031	0.028
C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-5: Effect of tillage practices and fertility levels on yield attributes of wheat

Treatments	Ear length (cm)			No. of grain ear^{-1}			Grain weight ear^{-1}			1000 grain weight (g)		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	10.59	11.55	11.07	39.89	42.27	41.08	1.50	1.59	1.54	36.34	37.51	36.93
Reduce tillage	9.95	10.54	10.14	38.81	40.80	39.80	1.34	1.41	1.38	33.36	34.50	33.91
SE(m)	0.028	0.085	0.052	0.044	0.129	0.212	0.005	0.008	0.005	0.036	0.086	0.076
C.D.	0.183	0.557	0.344	0.288	0.848	0.986	0.032	0.053	0.035	0.233	0.566	0.501
Fertility Level												
F_1 (Control)	8.20	9.07	8.63	34.90	37.08	35.99	1.02	1.09	1.05	28.19	29.35	28.77
F_2- RDF (150.60.40 NPK kg/ha)	8.85	9.72	9.28	37.05	39.23	38.14	1.20	1.27	1.23	31.26	32.42	31.84
F_3-75% RDF + 10t FYM/ ha	9.25	10.12	9.68	38.0	40.18	39.09	1.26	1.33	1.30	32.06	33.22	32.63
F_4-125% RDF	9.65	10..52	10.09	38.65	40.83	39.74	1.33	1.41	1.37	33.32	34.48	33.90
F_5- RDF + chloromequate chloride	10.0	10.87	10.43	39.01	41.18	40.09	1.39	1.47	1.43	34.50	35.65	35.07
F_6- RDF + tebunconzole	10.30	11.17	10.74	39.42	41.58	40.48	1.44	1.52	1.48	35.48	36.64	36.06
F_7- 75% RDF + 10t FYM/ ha + Chloromequate chloride	10.65	11.52	11.07	40.45	42.63	41.54	1.53	1.61	1.57	36.65	37.80	37.22
F_8-75% RDF + 10t FYM/ ha + tebunconzole	11.15	12.02	11.59	41.16	43.33	42.25	1.61	1.69	1.65	38.00	39.15	38.57
F_9-125% RDF + chloromequate chloride	11.65	12.52	12.08	42.24	44.83	43.73	1.72	1.80	1.76	39.21	40.36	39.77
F_{10}-125% RDF+ tebunconzole	12.00	12.87	12.42	42.67	44.42	43.34	1.73	1.82	1.78	39.87	41.03	40.45
SE(m)	0.028	0.111	0.112	0.458	0.399	0.047	0.012	0.017	0.017	0.413	0.323	0.360
C.D.	0.183	0.319	0.324	1.319	1.149	1.353	0.036	0.050	0.049	1.190	0.929	1.038

Table-6: Effect of tillage practices and fertility levels on yield of wheat

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Biological yield (q ha^{-1})			Harvest Index		
Tillage Practices	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Conventional tillage	51.68	50.86	51.31	67.85	66.51	67.21	119.537	117.382	118.52	43.22	43.22	43.28
Reduce tillage	49.92	49.30	49.62	66.83	65.55	65.24	116.779	114.869	115.84	42.72	42.73	43.81
SE(m)	0.070	0.081	0.245	0.076	0.088	0.256	0.093	0.078	0.051	0.072	0.074	0.165
C.D.	0.457	0.528	1.607	0.497	0.573	0.169	0.607	0.572	0.334	0.472	0.478	1.008
Fertility Level												
F_1 (Control)	45.44	44.69	44.94	62.79	61.48	62.01	108.112	106.05	106.95	42.08	42.19	42.01
F_2- RDF (150.60.40 NPK kg/ha)	47.75	47.0	47.23	64.13	62.82	63.33	111.74	109.68	110.56	42.79	42.46	42.71
F_3-75% RDF + 10t FYM/ ha	48.57	47.82	48.24	64.78	63.47	64.17	113.40	111.34	112.42	42.80	42.85	42.91
F_4-125% RDF	49.64	48.89	49.20	65.93	64.62	65.20	115.50	113.44	114.40	43.01	42.97	43.03
F_5- RDF + chloromequate chloride	50.43	49.68	50.19	66.86	65.55	66.34	117.43	115.73	116.53	42.88	43.06	43.07
F_6- RDF + tebunconzole	41.42	50.73	51.08	68.04	66.73	67.39	119.47	117.47	118.48	43.03	43.18	43.11
F_7- 75% RDF + 10t FYM/ ha + Chloromequate chloride	52.22	51.52	52.35	68.56	67.25	68.38	121.26	119.25	120.73	42.81	43.23	43.35
F_8-75% RDF + 10t FYM/ ha + tebunconzole	53.32	52.62	53.09	69.73	68.42	69.14	122.97	120.96	122.23	43.37	43.35	43.43
F_9-125% RDF + chloromequate chloride	54.20	53.51	53.83	70.82	69.51	70.14	125.00	122.99	123.97	43.40	43.39	43.44
F_{10}-125% RDF+ tebunconzole	55.02	54.32	54.53	71.78	70.47	70.99	126.67	124.66	125.53	43.51	43.47	43.47
SE(m)	0.172	0.179	0.520	0.171	0.168	0.634	0.178	0.173	12.7	0.170	0.164	0.435
C.D.	0.496	0.513	1.497	0.493	0.482	1.827	0.514	0.511	3.505	0.489	0.481	1.213

Conclusion

Plant height, number of tillers and dry matter accumulation was significantly due to rice residue management practices at all stage except 30th day after sowing during both the years. The highest Plant height, number of tillers and dry matter accumulation was recorded with treatment Bio-decomposer Treated Residue at all stage which at par with treatment Residue Burning and Urea Treated Residue (5% urea) during both the year, minimum Plant height, number of tillers and dry matter accumulation was recorded with the treatment residue removal during both the years respectively. Growth parameter such as Leaf area index CGR influence by rice residue management. The highest LAI and CGR was recorded with treatment Bio-decomposer Treated Residue and minimum was recorded with treatment residue removal at all stage during both the year. RGR statically not influence by rice residue management during both the years.

All the Nutrient management option, 125% RDF+ Growth Regulator (Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1%) were found significantly superior respect of growth attributes viz plant height (cm), tillers (m-41) dry matter accumulation (g/m2), LAI, CGR and RGR, yield attributes as effective tillers, length of spike, spikelet's/spike number of grain per spike, test weight (g) and yields and nutrient content and uptake by crop during both the years. However, 75% RDF +10 t FYM minimum was recorded respect of growth attributes viz plant height (cm), tillers (m-2r1) dry matter accumulation (gm^{-2}), LAI, CGR and RGR, yield attributes as effective tillers, length of spike, spikelet's/spike number of grain per spike, test weight (g) and yields and nutrient content and uptake by crop during both the years. Protein content in grain was not influenced significantly due to rice residue management practices and nutrient management during both the years. The highest value of protein content was recorded with Bio-decomposer Treated Residue in residue management and 125% RDF+ Growth Regulator (Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1%) in Nutrient management. However, Protein yield was significantly influence by rice residue and nutrient management the Bio-decomposer Treated Residue in residue management and 125% RDF+ Growth Regulator (Chlormequat chloride @ 0.2% + Tebuconazole @ 0.1%) in Nutrient management during both the years respectively.

References

Ali, I., Khan, A., Ali, A., Ullah, Z., Dai, D. Q., Khan, N., and Sher, H. (2021). Iron and zinc micronutrients and soil inoculation of Trichoderma harzianum enhance wheat grain quality and yield. *Frontiers in Plant Science*, **13**: 960948.

Ankit, Bana, R. S., Rana, K. S., Singh, R., Godara, S., Grover, M., ... & Yogi, A. K. (2022). No-tillage with residue retention and foliar sulphur nutrition enhances productivity, mineral biofortification and crude protein in rainfed pearl millet under Typic Haplustepts: Elucidating the responses imposed on an eight-year long-term experiment. *Plants*, *11*(7), 943.

Ghazanfar, M., Asoodar, M. A., & Alami Saeed, K. H. (2010). The effect of conservation tillage, planting and irrigation methods on water use efficiency and wheat grain yield in north of Ahwaz. *J. Eng. Appl. Sci*, *5*(2), 101-105.

Gholami, A., Asgari, H. R., and Zeinali, E. (2014). Effect of different tillage systems on soil physical properties and yield of wheat (Case study: Agricultural lands of Hakim Abad village, Chenaran township, Khorasan Razavi province).

Gupta, D. K., Bhatia, A., Kumar, A., Das, T. K., Jain, N., Tomer, R and Pathak, H. (2016). Mitigation of greenhouse gas emission from rice–wheat system of the Indo-Gangeticplains: Through tillage, irrigation and fertilizer management. *Agriculture, Ecosystems and Environment*, **230**: 1-9.

Husnain, M., Bukhsh, M. A. H. A., Iqbal, J., Khaliq, T., & Zamir, S. I. (2011). Agro-economic response of two wheat varieties under different tillage practices. *Crop & Environment*, *2*, 1-7.

Kakraliya, S. K., Singh, I., Dadarwal, R. S., Singh, L. K., Jat, R. D., Jat, H. S., & Jat, M. L. (2018). Impact of climate-smart agricultural practices on growth and crop yields of rice (Oryza sativa)-wheat (Triticum aestivum) system in north-western Indo-Gangetic Plains. *Indian J. Agric. Sci*, *88*, 1543-1551.

Kumar S, Pandey ID, Rather SA, Rewasia H. (2019). Genetic variability and inter-trait association for cooking and micronutrient (Fe and Zn) traits in advance lines of kalanamak aromatic rice (*Oryza sativa* L.). Journal of Animal and Plant Sciences. **29**(2): 1232 1239

Mitra, B., Mookherjee, S., & Das, S. (2014). Performances of wheat (Triticum aestivum) under various tillage and nitrogen management in sub-Himalayan plains of West Bengal. *Journal of Wheat Research*, *6*(2), 150-153.

Pathania, P., Rajta, A., Singh, P. C., & Bhatia, R. (2020). Role of plant growth-promoting bacteria in sustainable agriculture. *Biocatalysis and Agricultural Biotechnology*, *30*, 101842.

Ram, H., Singh, R. K., Pal, G., Agarwal, D. K., & Kumar, R. (2018). Effect of tillage practices and genotypes on growth, seed yield and nutrient uptake in wheat (Triticum aestivum). *Indian Journal of Agricultural Sciences*, *88*(11), 1765-69.

Rashid, M. H., Alam, M. M., Rao, A. N., & Ladha, J. K. (2012). Comparative efficacy of pretilachlor and hand weeding in managing weeds and improving the productivity and net income of wet-seeded rice in Bangladesh. *Field Crops Research*, *128*, 17-26.

Saharawat, Y. S., Singh, B., Malik, R. K., Ladha, J. K., Gathala, M., Jat, M. L., and Kumar, V. (2010). Evaluation of alternative tillage and crop establishment methods in a rice–wheat rotation in North Western IGP. *Field Crops Research*, **116**(3): 260- 267.

Shoomro, A. S., Soomro, A. S., and Mazari, S. N. (1999). Impact of plant growth regulators on yield and yield components in rice (*Oryza sativa* L.) under field conditions. *International Journal of Applied Sciences and Biotechnology*, **8**(3): 318- 322.

Shri, A., Kumari, P., Kumari, C., Kumar, D., and Choudhury, S. R. (2021). Effect of different levels of nitrogen and plant growth regulators on yield and nutrient uptake of wheat (*Triticum aestivum* L.). *Journal of food science*, **83**(1): 237-245

Singh, S., Sharma, S. N., & Prasad, R. (2001). The effect of seeding and tillage methods on productivity of rice–wheat cropping system. *Soil and Tillage Research*, *61*(3-4), 125-131.

Singh, Y. P., Singh, S., Singh, A. K., & Panwar, B. (2020). Influence of wheat establishment techniques and previous kharif season crops on productivity, profitability, water use efficiency, energy indices and soil properties in Central India. *Agricultural research*, *9*(2), 203-212.

Timalsina, H. P., Marahatta, S., Sah, S. K., & Gautam, A. K. (2021). Effect of tillage method, crop residue and nutrient management on growth and yield of wheat in rice-wheat cropping system at Bhairahawa condition.

Toyota, A. N., Tanveer, M., Rehman, A. U., Anjum, S. A., Iqbal, J., and Ahmad, R. (2010). Lodging stress in cereal—effects and management: an overview. *Environmental Science and Pollution Research*, **24**: 5222-5237.

Woźniak, A., & Rachoń, L. (2020). Effect of tillage systems on the yield and quality of winter wheat grain and soil properties. *Agriculture*, *10*(9), 405.

Zang, D. K., Bhatia, A., Kumar, A., Das, T. K., and Jain, N. (2017). Mitigation of greenhouse gas emission from rice–wheat system of the Indo-Gangetic plains: Through tillage, irrigation and fertilizer management. *Agriculture, Ecosystems and Environment*, **230**: 1-9.