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EFFECTS OF GRADED LEVELS OF FERTILIZERS AND IRRIGATION ON YIELD AND YIELD ATTRIBUTES OF WHEAT VARIETY DBW-187 IN RICE-WHEAT CROPPING SYSTEM IN JHARKHAND INDIA

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ABSTRACT

A field experiment entitled "Effects of graded levels of fertilizers and irrigation on yield and yield attributes of wheat variety DBW-187 in rice-wheat cropping system in Jharkhand'' was carried out during rabi season (November-April) in both years 2024-2025 and 2025-2026 at the instructional research farm, Jharkhand Rai University, Ranchi, Jharkhand. The experiment was laid out in randomised block design with three replications, comprising graded level of fertilizers and irrigations, T_1 50% RDF(NPK) with 3 irrigation, T_2 50% RDF(NPK) with 4 irrigation, T_3 50% RDF(NPK) with 5 irrigation,T_4 50% RDF(NPK) with 6 irrigation, T_5 100%RDF (NPK) with 3 irrigation, T_6 100%RDF (NPK) with 4 irrigation, T_7 100%RDF (NPK) with 5 irrigation, T_8 100%RDF (NPK) with 6 irrigation, T_9 150%RDF (NPK) with 3 irrigation, T_{10} 150%RDF (NPK) with 4 irrigation, T_{11} 150%RDF (NPK) with 5 irrigation, T_{12} 150%RDF (NPK) with 6 irrigation, T_{13} soil test fertilizer with 3 irrigation, T_{14} soil test-based fertilizer with 4 irrigation, T_{15} soil test-based fertilizer with 5 irrigation, T_{16} soil test-based fertilizer with 6 irrigation. Results revealed that all yield and yield attributes such as no. of effective tillers m^{-2}, Spike length (cm), No. of grain per spike, 1000 grain weight (g), Grain yield (q/ha), straw yield (q/ha) were found maximum in treatment T_{12} i.e., 150%RDF (NPK) with 6 irrigation and minimum was observed in T_1 i.e., 50%RDF (NPK) with 3 irrigations. 1000 grain weight were found to be non-significant. Result showed that the application of 150% RDF (NPK) with 6 irrigations significantly improved crop performance.

Keywords **:** Graded Levels of Fertilizers**,** Irrigation, Yield and Yield Attributes, Wheat

Introduction

Wheat (*Triticum aestivum* L.) is the chief food crop in the world and also occupies a prominent position in Indian agriculture after rice (Ram *et al.*, 2013). The term 'cereal' has been derived from Roman 'ceres' which refers to the "goddess of grains". Being a C_3 plant and long day plant it belongs to the family Poaceae (Gramineae) and is majorly cultivated in areas situated at higher elevation having tropical climate in winter season. It has a higher protein content, around 12% higher than other cereal and is of particular importance because of the presence of a particular substances 'gluten' which contribute to maintain the good bread making quality. It is also rich in relatively high niacin and thiamine.

Over 80 countries in the world use to grow wheat in over a combined area of 220.7 million hectares producing over 781 million metric tonnes with productivity of 4.5 tonnes/ha (2021-22). India is the second largest wheat producing country in the world. In India, wheat is grown in over 32 million hectares (20% of total arable area) to produce the all-time highest output of 112.18 million tonnes of wheat (14.46% of world production) with a record average productivity of 3.5 tonnes/ha. (Ministry of Agriculture & Farmers Welfares, 2023). In India wheat is grown in the sates of Uttar Pradesh, Punjab, Haryana, Madhya

Pradesh, Rajasthan, Bihar and Gujarat. Uttar Pradesh ranks first in production with over 33.95million tonnes followed by Madhya Pradesh with 22.42 million tonnes as of FY 2021-22 (Agricultural Statistics at a Glance, 2022). In FY 2021-2022, the total wheat produced in Jharkhand state was 2.20 lakh metric tonnes, with an average yield of 2.5 tonnes/ha in an area of 88 thousand ha (Government of Jharkhand, 2022).

The nutrients that are essential for plant growth and development are nitrogen, phosphorus and potassium i.e. N, P, K respectively. Nitrogen helps in the plants growth above ground. Phosphorus enhances plant cell division. It also helps in flower and seed production and development of a strong root system. Potassium enhances plant ability to withstand drought and heat stress ability to fight diseases.

The DBW187 variety of wheat, also known as 'Karan Vandana' developed by ICAR- Indian Institute of Wheat and Barley Research, Karnal which was released for irrigated timely sown conditions of North Eastern Plains Zone comprising of Eastern Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal possesses better resistance against the local diseases like leaf rust and leaf blight.

Material and Methods

A field experiment entitled "Effects of graded levels of fertilizers and irrigations on Bio-fortified wheat (*Triticum aestivum* L.) variety (DBW-187) in Rice-wheat cropping system in Jharkhand" was conducted at the Research Farm, Jharkhand Rai University, Ranchi, during two consecutive rabi season in 2024-25 and 2025-26. The research farm is located at 23.297422 °N latitude and 85.412766 °W longitude and at an altitude of 200 m above the mean sea level. The experimental site is located in Ranchi, receives an average rainfall 1440 mm annually, of which 85 percent falls between June to September and is distributed erratically throughout space and time. The soil is primarily red in colour, falling under the red-yellow-light grey category association group, which corresponds to the main soil order (Alfisols) found in Jharkhand. These soils are typically well-aggregated, offering high permeability but have very poor water holding capacity, a result of the presence of hydrated iron and aluminium oxides. Soil samples from 0-15cm with the help of auger were collected from different locations of the experimental plot area before initiating the field experiment and were mixed thoroughly to make a composite sample. The soil was slightly acidic in reaction (pH 6.38), low in organic carbon (0.17%) and available nitrogen (10.4 kg/ha), medium in available phosphorus (21.57 kg/ha) and potassium (168.3 kg/ha). Fertilizer recommendations for various approaches were developed based on these soil test values. The experiment was laid out in Randomised Block Design consist of 4 doses of fertilizers viz. 50% RDF, 100%RDF, 150%RDF and soil test value and different levels of irrigations viz. 3 irrigation at (CRI, tillering stage, booting stage), 4 irrigation at (CRI, tillering stage, booting stage, milking stage), 5 irrigation at (CRI, tillering stage, booting stage, milking stage, dough stage) and 6 irrigation at (CRI, tillering stage, late jointing stage, booting stage, milking stage, dough stage).The size of the plot were 3 X 2.5 and irrigation channels and path channel were also made in between the plot. Irrigations were applied as per the treatment. Nitrogen was applied in two split doses, with half of the nitrogen and the full dose of phosphorus and potassium applied as a basal dose at sowing in the form of urea, DAP and MOP. The remaining half dose of Nitrogen was applied in two equal splits at the crown root initiation stage (CRI) and at the maximum tillering stage to ensure good growth of the crop. Altogether 6 irrigations were given at 20 days interval during the crop growth stage. Growth and yield attributing characters were recorded at 30, 60, 90 DAS and at maturity. After sowing and harvesting of wheat under various treatments. The height of the plant were measured from each plot at different 5 selected plants. The dry matter accumulation samples plant in each plot were recorded at 30, 60, 90 DAS and at maturity. The dry plant material was first air dried then, chopped and oven dried at 70^{o} C for 72 hr. to a constant weight. Two hand weeding was done at an interval of 25 and 50 DAS. Leaf area index was calculated by dividing the leaf area (cm^2) with the land area occupied (cm^2) by plants. Length of spike was measured by scale. Five ears were randomly selected from the tagged plants in each plot, and their length was measured from the neck node to the tip of the uppermost spikelet. The weight of each selected spike was measured individually, and the average weight of those spikes was then recorded. Ear bearing tillers were counted and recorded as the number of effective tillers per metre row length at maturity from each net plot during harvesting. For the 1000 grain weight, the weight of 1000 grains was measured using an electronic balance to determine the test weight. The crop was manually harvested using a sickle when the grains were nearly mature and the straw had turned yellow. All the data recorded for yield and yield attributes were statistically analysed on the basis of analysis of variance appropriate for randomised block design. The means were compared by treatments using the 5% level of significance and the critical difference value was computed.

Result and Discussion

Yield and Yield attributes

Effective tillers (m^{-2})

The data presented in Table 1 revealed that the number of effective tillers m^{-2} was significantly influenced by different fertilizer and irrigation treatments during both years of experimentation as well as in the pooled analysis. The highest number of effective tillers was consistently recorded under T_{12} (150% RDF (NPK) + 6 irrigations), whereas the lowest value was observed under T_1 (50% RDF (NPK) + 3 irrigations). In the pooled analysis, T_{12} produced the maximum number of effective tillers (410.94 m^{-2}), which was statistically at par with T_{13} (soil test-based fertilizer + 3 irrigations; 357.60 m^{-2}) and T_6 (100% RDF (NPK) + 4 irrigations; 356.53 m^{-2}), while T_1 recorded the minimum value (300.50 m^{-2}). A similar response was also observed at 60 and 90 DAS, indicating the sustained influence of nutrient and moisture availability on tiller development throughout the crop growth period.

The superior tillering under higher fertilizer levels combined with adequate irrigation may be attributed to enhanced nutrient uptake, improved soil moisture availability, and increased photosynthetic efficiency, which collectively promoted cell division, meristematic activity, and the initiation and survival of productive tillers. Adequate nitrogen supply, together with sufficient irrigation, ensures continuous vegetative growth, resulting in greater assimilate production and their efficient translocation towards developing tillers. Conversely, reduced fertilizer application and limited irrigation adversely affected crop growth by restricting nutrient availability and physiological activity, leading to a lower number of effective tillers. These findings are in close agreement with the reports of Singh *et al*. (2021), who also observed a significant improvement in tiller production under higher nutrient levels and optimum irrigation management.

Spike length (cm)

The data presented in Table 1 indicated that spike length was significantly influenced by different fertilizer and irrigation treatments during both years of the study and in the pooled analysis. The longest spike was consistently recorded under T_{12} (150% RDF (NPK) + 6 irrigations), while the shortest spike length was observed under T_1 (50% RDF (NPK) + 3 irrigations). In the pooled analysis, the maximum spike length (12.92 cm) was recorded in T_{12}, followed by T_{11} (12.63 cm) and T_{10} (12.27 cm). The minimum spike length (9.36 cm) was recorded under T_1. Treatment T_{12} remained statistically at par with T_{14} (12.27 cm) and T_8 (11.52 cm), indicating that higher fertilizer application coupled with adequate irrigation significantly improved spike development.

The improvement in spike length under higher fertilizer levels and sufficient irrigation may be attributed to enhanced nutrient availability and improved soil moisture conditions, which promoted vigorous vegetative growth and increased photosynthetic activity. Adequate moisture facilitated greater nutrient absorption, particularly potassium and nitrogen, resulting in higher leaf area index, dry matter accumulation, and efficient translocation of photosynthates towards the developing spikes. These physiological advantages ultimately enhanced spike elongation and reproductive growth. In contrast, reduced fertilizer levels combined with limited irrigation restricted nutrient uptake and assimilate production, leading to shorter spikes. The present findings corroborate those of Khokhar *et al.* (2010), who reported that optimum fertilizer application and adequate irrigation significantly improved spike length through enhanced crop growth and assimilate partitioning.

Number of grains per spike

The data presented in Table 1 revealed that the number of grains per spike was significantly affected by different fertilizer and irrigation treatments during both years of the experiment as well as in the pooled analysis. The maximum number of grains per spike was consistently recorded under T_{12} (150% RDF (NPK) + 6 irrigations), whereas the minimum value was observed under T_1 (50% RDF (NPK) + 3 irrigations). In the pooled analysis, T_{12} produced the highest number of grains per spike (48.27), which was statistically at par with T_{11} (150% RDF (NPK) + 5 irrigations; 45.28) and T_{16} (soil test-based fertilizer + 6 irrigations; 42.80). However, T_{12} remained significantly superior to the remaining treatments.

The higher number of grains per spike under increased fertilizer application and adequate irrigation could be attributed to improved nutrient availability and favourable soil moisture conditions during the reproductive stage. Enhanced nitrogen and potassium nutrition, coupled with optimum water supply, promoted spikelet differentiation, pollen viability, grain setting, and efficient translocation of assimilates from source to sink, thereby increasing the number of grains per spike. Conversely, reduced fertilizer levels and moisture stress adversely affected reproductive development, resulting in fewer grains per spike. These findings are in agreement with those reported by Ali *et al*. (2023) and Das *et al*. (2024), who also observed significant improvements in grain number per spike under optimum nutrient and irrigation management.

1000 grain weight (g)

The data presented in Table 1 indicated that 1000-grain weight was significantly influenced by different fertilizer and irrigation treatments during the experimental period. In the pooled analysis, the highest 1000-grain weight (44.01 g) was recorded under T_{12} (150% RDF (NPK) + 6 irrigations), followed by T_{11} (150% RDF (NPK) + 5 irrigations; 43.71 g). In contrast, the lowest test weight (40.08 g) was observed under T_1 (50% RDF (NPK) + 3 irrigations). The results clearly demonstrated that increasing fertilizer levels along with adequate irrigation significantly improved grain weight.

The increase in 1000-grain weight under higher fertilizer doses and optimum irrigation may be attributed to enhanced nutrient uptake, prolonged photosynthetic activity, and efficient translocation of assimilates to the developing grains during the grain-filling stage. Adequate availability of nitrogen, phosphorus, and potassium, together with sufficient soil moisture, favoured better grain filling, resulting in bolder and heavier grains. Conversely, reduced fertilizer application and limited irrigation restricted assimilate production and grain development, leading to lower test weight. These findings are in conformity with the observations of Ali *et al.* (2023) and Patel *et al.* (2023), who also reported significant improvement in grain weight under optimum nutrient and irrigation management.

Grain yield (q ha^{-1})

The data presented in Table 1 revealed that grain yield was significantly influenced by different fertilizer and irrigation treatments during both years of the study as well as in the pooled analysis. Grain yield increased progressively with increasing fertilizer levels and irrigation frequency. In the pooled analysis, the highest grain yield (48.40 q ha^{-1}) was recorded under T_{12} (150% RDF (NPK) + 6 irrigations), which was statistically at par with T_{11} (150% RDF (NPK) + 5 irrigations; 43.34 q ha^{-1}). The lowest grain yield (22.94 q h^{-}a^{-1}) was recorded under T_1 (50% RDF (NPK) + 3 irrigations) and was significantly inferior to all other treatments.

The higher grain yield under T_{12} may be attributed to the combined effect of optimum nutrient availability and adequate soil moisture throughout the crop growth period, which enhanced vegetative growth, photosynthetic efficiency, dry matter accumulation, and the development of yield-contributing characters such as effective tillers, spike length, grains per spike, and 1000-grain weight. Adequate fertilizer and irrigation also ensured efficient nutrient uptake and assimilate translocation from source to sink during the grain-filling stage, thereby maximizing grain production. In contrast, lower fertilizer application combined with limited irrigation reduced crop growth and yield attributes, resulting in a marked decline in grain yield. These findings highlight the complementary role of balanced fertilization and adequate irrigation in improving crop productivity and are consistent with the results reported by Khan *et al*. (2023).

Straw yield (q ha^{-1})

The data presented in Table 1 revealed that straw yield was significantly influenced by different fertilizer and irrigation treatments during both years of the experiment as well as in the pooled analysis. Similar to grain yield, the highest straw yield (67.47 q ha^{-1}) was recorded under T_{12} (150% RDF (NPK) + 6 irrigations), followed by T_{11} (150% RDF (NPK) + 5 irrigations; 59.33 q ha^{-1}), whereas the lowest straw yield (33.63 q ha^{-1}) was observed under T_1 (50% RDF (NPK) + 3 irrigations).

The marked increase in straw yield under higher fertilizer doses and adequate irrigation may be attributed to enhanced vegetative growth, improved nutrient uptake, and greater photosynthetic efficiency, which promoted higher dry matter accumulation throughout the crop growth period. Adequate moisture availability facilitated efficient nutrient absorption and biomass production, while balanced fertilization supported vigorous stem and leaf development, ultimately increasing straw yield. The improvement in vegetative biomass also contributed to better partitioning of assimilates, resulting in simultaneous enhancement of both grain and straw yield. In contrast, reduced fertilizer application and limited irrigation adversely affected crop growth, leading to lower biomass accumulation and straw production. These findings are consistent with those of Dubey and Sharma (1995) and Behera *et al*. (2015), who reported that optimum fertilizer application and adequate irrigation significantly enhanced wheat straw yield through improved growth and biomass production.

Table 1: Effects of graded levels of fertilizers and irrigation on yield attributes as influenced by different treatments

Treatments	No. of effective tillers/m^2	Spike length (cm)	No. of grain/ spikes	1000 grain weight (g)	grain yield (q/ha)	straw yield (q/ha)
T1 (50% RDF(NPK) with 3 irrigation)	300.5	9.36	25.67	40.08	22.94	33.63
T2 (50% RDF(NPK) with 4 irrigation)	316.9	9.94	32.84	40.53	26.05	37.6
T3 (50% RDF(NPK) with 5 irrigation)	326.26	10.39	35.39	40.64	27.36	39.11
T4 (50% RDF(NPK) with 6 irrigation)	338.83	10.65	38.46	41.49	29.34	42.74
T5 (100%RDF (NPK) with 3 irrigation)	322.22	10.89	28.85	40.62	28.92	38.76
T6(100%RDF (NPK) with 4 irrigation)	356.53	11.29	35.32	41.5	33.6	46.94
T7(100%RDF (NPK) with 5 irrigation)	378.08	11.43	39.54	42.64	37.36	55.03
T8(100%RDF (NPK) with 6 irrigation)	387.61	11.52	41.68	43.02	38.17	56.69
T9(150%RDF (NPK) with 3 irrigation)	311.71	11.48	31.3	41.23	33.6	43.67
T10(150%RDF (NPK) with 4 irrigation)	388.5	12.27	41.48	42.63	38.33	48.72
T11(150%RDF (NPK) with 5 irrigation)	397.61	12.63	45.28	43.71	43.34	59.33
T12(150%RDF (NPK) with 6 irrigation)	410.94	12.92	48.38	44.01	48.04	67.47
T13(Soil test fertilizer with 3 irrigation)	323.98	10.85	31.35	41.28	30.58	44.92
T14(Soil test fertilizer with 4 irrigation)	357.6	11.44	36.22	42.5	36.19	47.49
T15(Soil test fertilizer with 5 irrigation)	382.89	11.71	41.24	43.29	39.56	53
T16(Soil test fertilizer with 6 irrigation)	389.33	11.83	42.8	43.32	41.39	54.47
SEm±	20.57	0.48	1.83	0.46	1.98	2.28
C. D. (P= 0.05)	58.18	1.35	5.17	1.31	5.61	6.44
CV (%)	6.2	4.54	5.27	1.18	6.13	5.07

Conclusion

The present study demonstrated that graded levels of fertilizer and irrigation significantly influenced the growth, yield attributes, and productivity of wheat. Among the evaluated treatments, T_{12} (150% RDF (NPK) + 6 irrigations) consistently recorded the highest number of effective tillers m^{-2}, spike length, grains per spike, 1000-grain weight, grain yield, and straw yield, whereas the lowest values were observed under T_1 (50% RDF (NPK) + 3 irrigations). The results indicate that the application of 150% RDF (NPK) combined with six irrigations is the most effective nutrient and water management strategy for maximizing wheat productivity under the experimental conditions.

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