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Influence of fertility levels on growth and yield attributes of different wheat (*Triticum aestivum* L.) varieties under semi-arid conditions of Rajasthan

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Abstract

A field experiment was conducted during 2024-25 at Agronomy Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan to evaluate the “Effect of Fertility Levels on Growth, Yield and Quality of Different Wheat (*Triticum aestivum* L.) Varieties Under Semi-Arid Conditions of Rajasthan”. The experiment was laid out in split plot design with three replications. The experiment consists four fertility levels viz.; control, 75% RDF, 100% RDF and 125% RDF as main plot and three varieties viz; RAJ 3077, RAJ 3765 and RAJ 4083 as sub plot. The significantly higher growth parameters viz., plant height, dry matter accumulation (DMA), crop growth rate (CGR) and relative growth rate (RGR) and yield attributes and yield i.e. the maximum ear length (10.35 cm), number of grains ear⁻¹ (57.70), 1000-grains weight (48.35 g), grain yield (5643 kg ha⁻¹), straw yield (8233 kg ha⁻¹), biological yield (13877 kg ha⁻¹) and harvest index (40.62%) of wheat were obtained with the application of 125% RDF followed by 100% RDF. However, Among the varieties, the variety RAJ 3077 recorded significantly higher growth parameters viz., plant height, dry matter accumulation (DMA), crop growth rate (CGR) and relative growth rate (RGR) and yield attributes and yield i.e. the maximum ear length (10.23 cm), number of grains ear⁻¹ (57.00), 1000-grains weight (47.77 g), grain yield (5458 kg ha⁻¹), straw yield (8094 kg ha⁻¹), biological yield (13552 kg ha⁻¹) and harvest index (40.31%) of linseed.

Keywords: Wheat, variety, fertility, growth, yield attributes and yield

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops cultivated both in India and across the world. It belongs to the family *Poaceae*. This crop is primarily grown during the spring season and thrives well in tropical, subtropical, and temperate regions. Wheat has the ability to withstand extreme cold and snowfall and resumes its growth when the temperature rises in spring. It can be successfully cultivated from sea level up to an altitude of about 3300 meters. The ideal climatic conditions for wheat cultivation include a cool and moist environment during the vegetative phase, followed by a dry and moderately warm climate for grain maturation and ripening. The optimum temperature for seed germination ranges between 20°C and 25°C. However, hot and dry conditions during the heading and flowering stages are unfavourable, as extreme temperatures and drought can severely affect crop growth. Prolonged cloudy weather, combined with high humidity and low temperatures, often increases the risk of rust infection. During ripening, the crop requires an average temperature of around 25-30°C, while the grain-filling stage is highly sensitive to temperature variations, which significantly influence yield. (Korde *et al.* 2024) ^[1]. Temperatures exceeding 25°C generally reduce the grain weight of wheat. Among cereal crops, wheat is notable for its relatively high protein content, primarily in the form of gluten. Globally, wheat covers an area of about 215.29 million hectares, producing around 730.84 million metric tonnes, with an average productivity of 3390 kg ha⁻¹. In India, wheat is cultivated on approximately 29.55 million hectares, accounting for 13.43% of the world's total wheat area. The country produces about 101.20 million tonnes of wheat, marking a 1.3% increase compared to the previous year, with an average yield of 3424 kg ha⁻¹. In Uttar Pradesh, the crop covers around 9.78 million hectares, ranking first in production with 31.99

million tonnes and a productivity level of 3269 kg ha⁻¹. However, the yield in Uttar Pradesh is comparatively lower than that of Punjab (5030 kg ha⁻¹) and Haryana (4410 kg ha⁻¹) (DES 2023)^[2].

It is a misconception that wheat can grow successfully with little or no nitrogen (N). In fact, wheat is highly sensitive to nitrogen deficiency, and its impact is clearly visible in plant growth and development. Inadequate nitrogen supply often leads to reduced yield, poor grain formation, and inferior grain quality, similar to the effects observed in other crops. Such nutrient deficiencies can ultimately contribute to worsening food insecurity (Jat and Seth 2021)^[3]. Among all the essential nutrients, nitrogen (N) holds a crucial role in the growth and metabolic activities of wheat plants. It forms the fundamental component of proteins and nucleic acids and is vital for various physiological and biochemical processes within the plant. Nitrogen also influences both internal metabolism and external physiological functions that support overall plant development (Dubey *et al.* 2018)^[4]. Phosphorus (P) is a vital nutrient required for plant growth and metabolic functions. After nitrogen, it represents the second most common nutrient deficiency affecting cereal crops globally. Phosphorus also serves as a key structural element in various metabolically active molecules within the plant (Singh *et al.* 2020)^[5]. Potassium is a vital nutrient that contributes significantly to improving grain weight, overall yield, and drought tolerance in cereal crops (Lv *et al.*, 2017)^[6]. Studies have shown that drought-tolerant wheat varieties generally contain higher levels of internal potassium (K) compared to drought-sensitive types. In addition to enhancing drought resistance, potassium also plays a crucial role in helping wheat plants withstand various biotic stresses (Jeer *et al.*, 2017)^[7].

Selecting suitable crop varieties plays a crucial role in enhancing productivity. Over time, several high-yielding wheat varieties have been developed and promoted for cultivation. However, many of these varieties tend to lose their yield potential as soil and environmental conditions change. Hence, the continuous development and selection of high-yielding varieties with a moderate level of adaptability to diverse soil and climatic conditions are essential to sustain and improve yield ha⁻¹ (Patidar and Singh 2021)^[8].

Among the different factors influencing crop production, soil fertility and varietal selection play a vital role and require careful consideration to achieve the maximum yield potential of wheat. With this understanding, the present field experiment was carried out.

Materials and Methods

The field experiment was carried out at the Agronomy Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan during rabi season of 2024-25. The experimental site is situated in semi-arid eastern plains of Rajasthan and lies between 26°92' North latitude, 75°78' East longitude and at an altitude of 430 meters from the mean sea level. The soil of the experimental field was sandy in texture and slightly alkaline in reaction with PH 7.58, organic carbon (OC) (0.43%), available nutrient (nitrogen 217.30 kg ha⁻¹; phosphorus 20.28 kg ha⁻¹ and potassium 219.20 kg ha⁻¹). The experiment was laid out in split plot design with three replications. The field trial consists four fertility levels viz.; control, 75% RDF, 100% RDF and 125% RDF as main plot and three varieties viz; RAJ 3077, RAJ 3765 and RAJ 4083 as sub plot. The wheat varieties were sown @ 125 kg seed ha⁻¹ with spacing of 22.5 cm x 5 cm. The six irrigations are applied. All agricultural practices were kept uniform in all the plots.

Results and Discussion

Growth Parameters

Effect of Fertility Levels

The different fertility levels significantly enhanced the growth parameters viz. plant height (cm) and DMA (g plant⁻¹) at 60, 90 DAS and at harvest, CGR (g plant⁻¹ day⁻¹) and RGR (g g⁻¹ day⁻¹) at 60-90 DAS and 90 DAS-at harvest of the wheat (Table 1). The significantly maximum plant height (84.50 cm at 60 DAS; 88.50 cm at 90 DAS and 92.17 cm at harvest) were recorded with the application of 125% RDF and it was statistically at par with the application of 100% RDF. The observed increase in wheat growth may be attributed to improved nutrient availability throughout the crop's growth stages. Chemical fertilizers provided NPK during the early stages, while additional nutrients were available in later stages of development. Wheat growth at all observation points was enhanced in treatments that received higher doses of NPK through inorganic fertilizers. Comparable findings have also been reported by Chopra *et al.* (2016)^[9] and Yadav *et al.* (2018)^[10]. Likewise, the significant in dry matter accumulation (4.90 g plant⁻¹ at 60 DAS; 12.60 g plant⁻¹ at 90 DAS and 14.95 g plant⁻¹ at harvest) was recorded with the application of 125% RDF and it was statistically at par with the application of 100% RDF (Table 4.1). The increase in dry weight is closely linked to nutrient availability, which promotes vigorous vegetative growth, including greater plant height, ultimately contributing to higher plant dry weight. In the present study, treatments receiving higher amounts of nitrogen and other nutrients—through a combination of organic and inorganic fertilizers showed greater dry matter accumulation. The increased fertilizer application likely enhanced leaf area and overall plant development, leading to an increase in total dry matter production. The result is in agreement with the findings of Gangawar *et al.* (2018)^[11], Singh *et al.* (2019)^[12] and Kumar and Singh (2020)^[13] who observed that dry matter production in wheat increased significantly when the rate of fertilizer application was increased. Moreover, the CGR (0.256 at 60-90 DAS and 0.0783 at 90 DAS- at harvest) and RGR (1.076 at 60-90 DAS and 1.137 at 90 DAS- at harvest) significantly higher with the application of 125% RDF and it was statistically at par with the application of 100% RDF. Similar results were also reported by Akhtar *et al.* (2018)^[14], Kaur *et al.* (2018)^[15] and Kumar *et al.* (2023)^[16].

Effect of Varieties

The different varieties significantly enhanced the growth parameters viz. plant height (cm) and DMA (g plant⁻¹) at 60, 90 DAS and at harvest, CGR (g plant⁻¹ day⁻¹) and RGR (g plant⁻¹ day⁻¹) at 60-90 DAS and 90 DAS-at harvest of the wheat (Table 1). The significantly maximum plant height (83.41 cm at 60 DAS; 87.43 cm at 90 DAS and 91.06 cm at harvest) were recorded with the variety RAJ 3077 and it was followed by the variety RAJ 4083. Likewise, the significant in dry matter accumulation (4.85 g plant⁻¹ at 60 DAS; 12.45 g plant⁻¹ at 90 DAS and 14.77 g plant⁻¹ at harvest) was recorded with the variety RAJ 3077 and it was followed by the variety RAJ 4083 (Table 4.3). Moreover, the CGR (0.253 at 60-90 DAS and 0.0773 at 90 DAS- at harvest) and RGR (1.070 at 60-90 DAS and 1.131 at 90 DAS- at harvest) significantly higher with the variety RAJ 3077 and it was followed by the variety RAJ 4083 (Table 1). The variations in growth traits among different wheat varieties can be attributed to their inherent genetic characteristics and their adaptability to specific soil and climatic conditions. Differences in growth parameters across varieties are primarily due to the genetic inheritance of these traits. Similar

results were also reported by Kumar (2012) ^[17], Kumari *et al.* (2013) ^[18] and Kumar *et al.* (2017) ^[19].

Yield attributes and yield

Effect of fertility Levels

The different fertility levels significantly enhanced the yield attributes viz. ear length (cm), number of grains ear⁻¹, 1000 grains weight (g) and yield viz. grain yield (kg ha⁻¹), straw yield (kg ha⁻¹), biological yield (kg ha⁻¹) and HI (%) of the wheat crop (Table 2). The maximum ear length (10.35), number of grains ear⁻¹ (57.70), 1000 grains weight (48.35) and yield viz. grain yield (5643), straw yield (8233), biological yield (19877) and harvest index (40.62) were recorded with the application of 125% RDF and it was statistically at par with the application of 100% RDF. The improvement in yield attributes and overall yield with higher fertilizer doses can be attributed to the increased availability of essential nutrients to the crop. Supplying nitrogen, phosphorus, and potassium at sowing, along with additional nitrogen as top dressing, enhanced growth during the early vegetative stage, which improved photosynthetic efficiency and ultimately led to higher biological yield. This comprehensive nutrient availability promoted greater leaf area,

enhancing photosynthetic performance and contributing to increased biological yield. Moreover, the integrated application of organic and inorganic fertilizers likely supported the development of a deeper and more vigorous root system, allowing the plant to access nutrients from a larger soil volume, thereby improving growth and boosting overall biological yield in wheat. Similar results were also reported by Marino *et al.* (2011) ^[20], Naz and Akmal (2016) ^[21], Kumar *et al.* (2016) ^[22] and Jat and Seth (2021) ^[3].

Effect of Varieties

The different varieties significantly enhanced the yield attributes viz. ear length (cm), number of grains ear⁻¹, 1000 grains weight (g) and yield viz. grain yield (kg ha⁻¹), straw yield (kg ha⁻¹), biological yield (kg ha⁻¹) and HI (%) of the wheat crop (Table 4.7-4.8). The maximum ear length (10.23), number of grains ear⁻¹ (57.00), 1000 grains weight (47.77) and yield viz. grain yield (5458), straw yield (8094), biological yield (13552) and harvest index (40.31) were recorded with the variety RAJ 3077 and it was followed by the variety RAJ 4083. Similar results were also reported by Hussain *et al.* (2002) ^[23], Singh *et al.* (2018) ^[24] and Raut *et al.* (2023) ^[25].

Table 1: Effect of fertility levels and varieties on growth parameters of wheat at successive stage

Treatments	Plant height (cm)			DMA (g plant ⁻¹)			CGR (g plant ⁻¹ day ⁻¹)		RGR (g g ⁻¹ day ⁻¹)	
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 -90 DAS	90 DAS-at harvest	60 -90 DAS	90 DAS-at harvest
Fertility Levels										
Control	65.26	69.64	72.54	3.86	9.92	11.76	0.202	0.0616	0.976	1.036
75% RDF	79.39	83.49	86.95	4.63	11.89	14.10	0.242	0.0739	1.051	1.112
100% RDF	83.15	87.18	90.79	4.83	12.41	14.73	0.253	0.0771	1.070	1.130
125% RDF	84.50	88.50	92.17	4.90	12.60	14.95	0.256	0.0783	1.076	1.137
SEm±	0.67	0.66	0.69	0.04	0.09	0.11	0.002	0.0006	0.003	0.003
CD (p=0.05)	2.33	2.29	2.38	0.13	0.33	0.39	0.007	0.0020	0.012	0.012
Varieties										
RAJ 3077	83.41	87.43	91.06	4.85	12.45	14.77	0.253	0.0773	1.070	1.131
RAJ 3765	69.08	73.39	76.43	4.07	10.45	12.40	0.213	0.0649	0.997	1.058
RAJ 4083	81.74	85.79	89.35	4.75	12.21	14.49	0.249	0.0759	1.062	1.123
SEm±	0.37	0.36	0.38	0.02	0.05	0.06	0.001	0.0003	0.002	0.002
CD (p=0.05)	1.11	1.09	1.13	0.06	0.15	0.18	0.003	0.0010	0.005	0.005

Table 2: Effect of fertility levels and varieties on yield attributes and yield of wheat

Treatments	Yield attributes			Yield (kg ha ⁻¹)			Harvest Index (%)
	Ear length (cm)	Number of grains ear ⁻¹	1000-grains weight (g)	Grain yield	Straw yield	Biological yield	
Fertility Levels							
Control	8.15	45.41	39.05	3833	6191	10025	38.19
75% RDF	9.77	54.43	45.61	5277	7874	13150	40.10
100% RDF	10.20	56.84	47.63	5547	8135	13682	40.52
125% RDF	10.35	57.70	48.35	5643	8233	13877	40.62
SEm±	0.08	0.43	0.36	48	31	71	0.22
CD (p=0.05)	0.27	1.49	1.25	167	107	245	0.75
Varieties							
RAJ 3077	10.23	57.00	47.77	5458	8094	13552	40.31
RAJ 3765	8.59	47.85	40.84	4430	6864	11294	39.09
RAJ 4083	10.04	55.93	46.87	5338	7867	13205	40.16
SEm±	0.04	0.24	0.20	27	21	42	0.10
CD (p=0.05)	0.13	0.71	0.59	80	63	127	0.31

Conclusion

Based on a one-year field study on wheat, it may be concluded that: The application of 125% RDF with the variety RAJ 3077 was suitable to attain the higher growth parameters, yield attributes of wheat and it was followed by 100% RDF with the variety RAJ 3077.

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