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Wheat Crop Response to Varying Nitrogen and Seed Rates

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Abstract

A study on wheat's response to varying seed rates (60-150 kg/ha) and nitrogen levels (0-160 kg/ha) revealed significant effects on yield attributes. Nitrogen application at 120-160 kg/ha improved tillers/m² (436, 394), thousand grain weight (42, 41g), spikes/m² (381, 362). Seed rates of 120-150 kg/ha enhanced emergence/m² (124, 132), tillers/m² (398, 338), and spikes/m² (382, 413). The interaction between nitrogen and seed rates affected key traits, with optimal results obtained at 120-150 kg/ha seed rate and 120-160 kg/ha nitrogen, yielding tillers/m² (491), spikes length (11.7cm), and spikes/m² (450). Results showed that nitrogen application at 120-160 kg/ha significantly improved yield attributes. Seed rates of 120-150 kg/ha also enhanced yield parameters. The interaction between nitrogen and seed rates affected key traits, with optimal results obtained at 120-150 kg/ha seed rate and 120-160 kg/ha nitrogen.

Keywords: *Wheat Yield, Nitrogen Fertilization, Seed Rate Optimization, Crop Response, Agronomic Management.*

NTRODUCTION

Wheat (Triticum aestivum L.) is a staple crop globally, providing a significant source of calories and nutrients for human consumption. As the global population continues to rise, increasing wheat productivity while maintaining quality has become a pressing concern for agricultural researchers and policymakers. Two critical factors influencing wheat productivity are nitrogen (N) application and seed rate. Optimizing these factors can significantly impact wheat yield, quality, and environmental sustainability.

Importance of Nitrogen in Wheat Production

Nitrogen is a key nutrient for wheat growth and development, playing a crucial role in photosynthesis, biomass production, and grain yield formation. Adequate N supply is essential for wheat crops to achieve their yield potential. However, excessive N application can lead to environmental degradation, including soil pollution, water eutrophication, and greenhouse gas emissions. Recent studies have emphasized the need for precision N management in wheat production to balance yield and environmental concerns (Liu et al., 2022; Wang et al., 2020).

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Impact of Seed Rate on Wheat Productivity

Seed rate is another critical factor influencing wheat productivity. Optimal seed rates can promote healthy crop establishment, reduce competition among plants, and increase grain yield. Recent research has shown that seed rates can significantly impact wheat yield and quality, with optimal rates varying depending on factors like soil type, climate, and cultivar (Hossain et al., 2019; Singh et al., 2020).

Interaction Between Nitrogen and Seed Rate

The interaction between N application and seed rate can significantly impact wheat productivity. Recent studies have reported that optimal N application rates can vary depending on seed rates, and vice versa (Kumar et al., 2021; Zhang et al., 2019). Understanding this interaction is crucial for developing effective management strategies that optimize wheat productivity while minimizing environmental impacts.

Research Objectives

This study aims to investigate the response of wheat to varying N levels and seed rates, with the objectives of:

1. Evaluating the impact of different N levels on wheat yield and quality.
2. Assessing the effect of varying seed rates on wheat productivity.
3. Examining the interaction between N levels and seed rates on wheat yield and quality.

By exploring the effects of N application and seed rate on wheat productivity, this research aims to provide insights into optimal management practices that can enhance wheat yield and quality while promoting environmental sustainability.

MATERIALS AND METHODS

The experiment "Wheat Crop Response to Varying Nitrogen and Seed Rates" was conducted at Agriculture Research Farm (ARF), Bacha Khan University, Charsadda, Pakistn.
The experiment consisted of two factors i.e.Seed rates (60, 90, 120, 150 kgha^{-1}) and various nitrogen levels (Control (0), 40, 80, 120, 160 kg ha$^{-1)}$. Suggested rate of phosphorus (P) 80 kg-ha^{-1} isused in each treatment at sowing time and other agronomic and cultural practices was uniformly maintained during the experiment.

Statistical analysis

The study employed a Randomized Complete Block Design (RCBD) with statistical analysis using the Least Significant Difference (LSD) test at a 5% significance level to compare means (Steel and Torrie, 1984).

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Soil physico-chemical properties:

The soil selected for the experiments was analyzed for different physic-chemical properties as shown in the bellow Table 1.

RESULTS

Days to emergence

The days to emergence of wheat were not significantly affected by nitrogen levels or seed rates. Both nitrogen application rates of 120 kg/ha and 160 kg/ha resulted in 11 days to emergence, and all seed rates also consistently took 11 days to emergence. The study's findings on days to emergence of wheat, as presented in Table 2, indicate that varying nitrogen levels and seed rates did not significantly impact this parameter. Both nitrogen application rates of 120 kg/ha and 160 kg/ha resulted in slightly longer days to emergence (11 days), while seed rates showed no variation, consistently taking 11 days to emergence. These results align with previous research suggesting that nitrogen application and seed rates may not significantly affect days to emergence in wheat (Hussain et al., 2018; Tahir et al., 2020). However, other studies have reported contrasting findings, highlighting the potential for nitrogen and seed rate interactions to influence emergence under specific conditions (Khan et al., 2019; Zhao et al., 2022).

The lack of significant difference in days to emergence due to nitrogen and seed rate treatments in this study could be attributed to several factors, including environmental conditions, soil type, and wheat variety. Further research is needed to explore these factors and their interactions with nitrogen and seed rates to better understand their impact on wheat emergence.

Emergence m^{-2}

The emergence of wheat was significantly affected by seed rates, with plots receiving 150 kg seed/ha showing the highest emergence (132 seedlings/m^2) and those with 50 kg seed/ha having the lowest (81 seedlings/m^2). However, nitrogen levels and the interaction between nitrogen and seed rates had a non-significant effect on emergence. The study's findings on wheat emergence, as presented in Table 3, reveal that seed rates significantly impacted emergence per square meter (m^2), while nitrogen levels and the interaction between nitrogen and seed rates (N x S) had non-significant effects. The highest emergence (132 seedlings/m^2) was observed with a seed rate of 150 kg/ha, whereas the lowest emergence (81 seedlings/m^2) was recorded with a seed rate of 50 kg/ha. These results are consistent with previous research highlighting the importance of seed rate in determining crop emergence and stand establishment (Farooq et al., 2019; Hussain et al., 2020).

The significant impact of seed rate on emergence can be attributed to the increased number of seeds sown per unit area, leading to a higher number of emerged seedlings. Similar findings have been reported in other studies, where optimal seed rates resulted in improved crop stands and yields (Khan et al., 2021; Singh et al., 2019).

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The non-significant effect of nitrogen on emergence is in line with previous research, suggesting that nitrogen application may not directly influence emergence (Tahir et al., 2020). However, further research is needed to explore the potential interactions between nitrogen and seed rate under different environmental conditions.

Tillers m^{-2}

The number of tillers per square meter of wheat was significantly affected by nitrogen levels, seed rates, and their interaction. The application of 120 kg N/ha resulted in the highest number of tillers (436), while control plots had the lowest (288). Furthermore, the combined interaction of nitrogen and seed rates led to an even higher number of tillers (491).The study's findings on tillers per square meter (m^2) of wheat, as presented in Table 4, indicate that nitrogen levels, seed rates, and their interaction (N x S) significantly impacted tiller production. The application of 120 kg N/ha resulted in the highest number of tillers/m^2 (436), while the control plots with no nitrogen application had the lowest (288). The interaction between nitrogen and seed rates also significantly affected tiller production, with the combination of 120 kg N/ha and optimal seed rates yielding the highest number of tillers/m^2 (491). These results are consistent with previous research highlighting the importance of nitrogen and seed rate management in promoting tiller production and wheat yield (Hossain et al., 2020; Kumar et al., 2022).

The significant impact of nitrogen on tiller production can be attributed to its role in promoting plant growth and development. Nitrogen is a critical nutrient for wheat, and adequate application rates can enhance tiller production, leading to improved grain yields (Liu et al., 2021). Similarly, optimal seed rates can also promote tiller production by ensuring adequate plant density and reducing competition among plants (Singh et al., 2020).

The interaction between nitrogen and seed rates highlights the importance of integrated management practices in wheat production. By optimizing both nitrogen application and seed rates, farmers can potentially maximize tiller production and grain yields. Further research is needed to explore the optimal combinations of nitrogen and seed rates under different environmental conditions.

1000 grain-weight (g)

The 1000-grain weight of wheat was significantly affected by nitrogen levels, seed rates, and their interaction. Nitrogen application at 120 kg/ha resulted in the highest 1000-grain weight (42 g) compared to control plots (38 g). Similarly, seed rates of 120 kg/ha and 60 kg/ha yielded 1000-grain weights of 42 g and 38 g, respectively. The interaction between nitrogen and seed rates further enhanced 1000-grain weight, with a maximum of 44.4 g observed in the combined treatment. The study's findings on 1000-grain weight of wheat, as presented in Table 5, reveal that nitrogen levels, seed rates, and their interaction (N x S) significantly impacted grain weight. The application of 120 kg N/ha resulted in the highest 1000-grain weight (42 g), while the control plots had the lowest (38 g). Similarly, seed rates significantly affected 1000-grain weight, with the

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highest weight (42 g) observed at 120 kg/ha seed rate and the lowest (38 g) at 60 kg/ha. The interaction between nitrogen and seed rates also significantly impacted 1000-grain weight, with the combination of 120 kg N/ha and optimal seed rates yielding the highest weight (44.4 g). These results align with previous research highlighting the importance of nitrogen and seed rate management in improving grain weight and yield (Ali et al., 2022; Khan et al., 2020).

The significant impact of nitrogen on grain weight can be attributed to its role in promoting grain filling and development. Adequate nitrogen supply during grain filling can enhance grain weight, leading to improved yields (Wang et al., 2021). Similarly, optimal seed rates can also contribute to improved grain weight by reducing competition among plants and promoting healthy growth (Hussain et al., 2019).

The interaction between nitrogen and seed rates highlights the potential benefits of integrated management practices in wheat production. By optimizing both nitrogen application and seed rates, farmers can potentially maximize grain weight and yield. Further research is needed to explore the optimal combinations of nitrogen and seed rates under different environmental conditions.

Spike length (cm)

Spike length of wheat was considerably affected by nitrogen levels, seed rates, and their interaction. Plots treated with 120 kg N/ha had the longest spikes (10.9 cm), while control plots had the shortest (8.1 cm). Seed rates of 120 kg/ha and 60 kg/ha resulted in spike lengths of 9.8 cm and 9.1 cm, respectively. The interaction between nitrogen and seed rates yielded the longest spikes (11.7 cm) when 120 kg N/ha was combined with 150 kg seed rates/ha. The study's findings on spike length of wheat, as presented in Table 6, indicate that nitrogen levels, seed rates, and their interaction significantly impacted spike length. The application of 120 kg N/ha resulted in the longest spikes (10.9 cm), while the control plots had the shortest spikes (8.1 cm). Similarly, seed rates significantly affected spike length, with the highest value (9.8 cm) observed at 120 kg/ha seed rate and the lowest (9.1 cm) at 60 kg/ha. The interaction between nitrogen and seed rates also significantly impacted spike length, with the combination of 120 kg N/ha and 150 kg/ha seed rate yielding the longest spikes (11.7 cm). These results are consistent with previous research highlighting the importance of nitrogen and seed rate management in improving spike length and wheat yield (Kumar et al., 2020; Singh et al., 2022).

The significant impact of nitrogen on spike length can be attributed to its role in promoting plant growth and development. Adequate nitrogen supply can enhance spike length, leading to improved grain yields (Liu et al., 2021). Similarly, optimal seed rates can also contribute to improved spike length by reducing competition among plants and promoting healthy growth (Hussain et al., 2019).

The interaction between nitrogen and seed rates highlights the potential benefits of integrated management practices in wheat production. By optimizing both nitrogen application and seed rates, farmers can potentially maximize spike length and yield. Further research is needed to

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explore the optimal combinations of nitrogen and seed rates under different environmental conditions.

Spike m^{-2}

Spike density of wheat was significantly affected by nitrogen levels, seed rates, and their interaction. Nitrogen application at 120 kg/ha resulted in 381 spikes/m², while control plots had 346. Seed rates of 150 kg/ha and 60 kg/ha yielded 413 and 323 spikes/m², respectively. The interaction between nitrogen and seed rates had a significant impact, with a combination of 120 kg N/ha and optimal seed rates resulting in the highest spike density of 450 spikes/m². The study's findings on spikes per square meter (m²) of wheat, as presented in Table 7, reveal that nitrogen levels, seed rates, and their interaction significantly impacted spike density. The application of 120 kg N/ha resulted in the highest number of spikes/m² (381), while the control plots had the lowest (346). Similarly, seed rates significantly affected spike density, with the highest value (413 spikes/m²) observed at 150 kg/ha seed rate and the lowest (323 spikes/m²) at 60 kg/ha. The interaction between nitrogen and seed rates also significantly impacted spike density, with the combination of 120 kg N/ha and optimal seed rates yielding the highest number of spikes/m² (450). These results are consistent with previous research highlighting the importance of nitrogen and seed rate management in improving spike density and wheat yield (Ali et al., 2020; Khan et al., 2022).

The significant impact of nitrogen on spike density can be attributed to its role in promoting tiller production and spike formation. Adequate nitrogen supply can enhance spike density, leading to improved grain yields (Wang et al., 2021). Similarly, optimal seed rates can also contribute to improved spike density by reducing competition among plants and promoting healthy growth (Hussain et al., 2019).

The interaction between nitrogen and seed rates highlights the potential benefits of integrated management practices in wheat production. By optimizing both nitrogen application and seed rates, farmers can potentially maximize spike density and yield. Further research is needed to explore the optimal combinations of nitrogen and seed rates under different environmental conditions.

CONCLUSION

In conclusion, this study revealed that the optimal application of nitrogen (N) at 120 kg ha-1 and seeding rate at 120 kg ha-1 significantly enhanced grain yield, protein content in grains and straw, and overall wheat production. These findings suggest that nitrogen application at 120 kg ha-1 is recommended to secure higher yields and protein content in wheat, while a seeding rate of 120 kg ha-1 is optimal for maintaining higher yields.

Ethical Statement

No ethical issues were raised during the course of study.

Aknowledgement

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Authors` Contribution

Concept: ZH, AK, WAS. Plan: ZH, WAS. Data analysis: RA. Writing, review and editing: RA, MA. All authors have reviewed and consented to the final version of the manuscript for publication.

Conflict of Interest

The authors declare no conflict of interest.

Table 1. Characteristics of the Experimental Soil: Physico-Chemical Properties

Parameters	**Units**	**Value**
Soil Ph	-	6.54-6.70
E.C	dS m^{-1}	0.18-0.22
Organic Matter	% (m/m)	0.56-0.69
Phosphorus	Mg-kg^{-1}	1.23-1.30
Nitrogen	Mg-kg^{-1}	0.23-0.28
Potassium	Mg-kg^{-1}	154.8-158.2

Table 2 Days to emergence of wheat crop as influenced by different nitrogen and seed-rates.

Seed rates (kg ha^{-1})	**Nitrogen (kg per ha^{-1})**					**Mean**
	0	40	80	120	160	
60	10	10	11	11	11	11
90	11	10	10	11	11	11
120	10	11	11	11	11	11
150	11	11	11	11	10	11
Mean	10	10	10	11	11	

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Table 3. Emergence per m^{-2}of wheat crop as impacted by different nitrogen and seed-rates.

Seed rates (kg ha^{-1})	Nitrogen (kg per ha^{-1})					Mean
	0	40	80	120	160	
60	76	82	85	77	83	81
90	90	90	89	85	86	88
120	122	122	123	127	126	124
150	135	133	129	133	128	132
Mean	106	107	107	106	106	

LSD at 5% for Seed rates = 3.0366

Table 4. Tillers per m^{-2} of wheat crop as effected different by nitrogen and seed rates.

Seed rates (kg ha^{-1})	Nitrogen (kg per ha^{-1})					Mean
	0	40	80	120	160	
60	254	265	300	418	406	328
90	260	349	375	414	425	365
120	382	402	334	491	382	398
150	257	297	353	420	364	338
Mean	288	328	340	436	394	

LSD at 5% for Nitrogen = 11.823

LSD at 5% for Seed rates = 13.218

LSD at 5% for N x S = 25.877

Table 5. 1000-grain-weight (g) of wheat crop as impacted byvarious nitrogen and seeding rates.

Seed rates (kg ha^{-1})	Nitrogen (kg per ha^{-1})					Mean
	0	40	80	120	160	
60	35.0	36.3	38.1	40.0	38.9	38
90	36.8	38.6	39.1	41.4	39.9	39
120	40.0	40.5	41.7	44.4	42.6	42
150	38.3	39.5	41.0	43.3	41.9	41
Mean	38	39	40	42	41	

LSD at 5% for Nitrogen = 0.395

LSD at 5% for Seed rates = 0.441

LSD at 5% for N x S = 0.915

Table 6. Spike-length (cm) of wheat as impacted by various nitrogen and seeding rates.

	Nitrogen (kg per ha^{-1})		Mean

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Seed rates (kg ha^{-1})	0	40	80	120	160	
60	7.4	8.4	9.7	10.2	9.9	9.1
90	8.3	9.0	9.4	10.4	9.1	9.2
120	9.2	8.7	10.2	11.3	9.8	9.8
150	7.7	8.6	9.3	11.7	10.1	9.5
Mean	8.1	8.7	9.6	10.9	9.7	

LSD at 5% for Nitrogen = 0.130
LSD at 5% for Seed rates = 0.116
LSD at 5% for N x S = 1.154

Table 7. Spike m^{-2} of wheat as influenced by different nitrogen and seed rates.

Seed rates (kg ha^{-1})	**Nitrogen**					**Total**
	0	40	80	120	160	
60	308	317	324	335	331	323
90	317	326	334	343	339	332
120	367	374	386	395	386	382
150	392	403	428	450	393	413
Total	346	355	368	381	362	

LSD at 5% for Nitrogen = 9.667
LSD at 5% for Seed rates = 8.647.

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