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Interaction Effect of Nitrogen Levels on Leaf Area Index, Dry Matter Accumulation, and Nitrogen Uptake of Wheat Crop (*Triticum aestivum* L.)

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Abstract:

Nitrogen is a critical nutrient influencing the growth, development, and productivity of wheat (*Triticum aestivum* L.). This study investigates the interaction effect of varying nitrogen levels on key growth parameters, including Leaf Area Index (LAI), dry matter accumulation, and nitrogen uptake, which are fundamental to optimizing yield. A field experiment was conducted using different nitrogen levels (e.g., 0, 40, 80, 120, 160 and 200 kg N ha⁻¹) to assess their impact on wheat performance. Results indicated that nitrogen levels significantly affected LAI, with higher nitrogen rates leading to an increased leaf area, enhancing photosynthetic capacity. Similarly, dry matter accumulation followed a positive correlation with nitrogen availability, with the highest accumulation observed at 200 kg N ha⁻¹. Nitrogen uptake efficiency 160 kg N ha⁻¹ improved with increasing nitrogen application, although diminishing returns were noted beyond a threshold. The interaction of these factors suggests that optimizing nitrogen levels can improve wheat growth and nitrogen use efficiency, offering insights for more sustainable and productive wheat cultivation practices. This research underscores the importance of precise nitrogen management to balance crop yield and environmental impact.

Keywords: Varieties, nitrogen levels, F-RBD and Wheat crop.

INTRODUCTION

Wheat is a grass of the family Poaceae and is one of the world's principal staple foods, especially for the majority. In India, it ranks second after rice, first as a major crop, and secondly as a diet staple. Wheat is also the main source of supply for about 20% of global calories and is sustaining about 55% of the population of the globe. Crop wise statistics data of **USDA 2014 -15**, wheat cultivation worldwide: 220.88 millions of acres, where approx. 725.47 million tons are being generated with average productivity per-hectare being 3.28 tons. In India, out of 30.47 millions of hectares, an aggregate product of 95.85 million tons is harvested considering the productivity rate 3.15 tons/hectare.

Wheat belongs to the most indispensable and vital cereals being devoured on a large scale across human consumers. In Uttar Pradesh in the 2014-15 season, wheat was cultivated over 9.85 million hectares and produced 22.42 million tons with a yield of 22.77 quintals per hectare. The crop is sown in three primary agro-climatic regions of Uttar Pradesh, such as Western Uttar Pradesh that has 3.29 million hectares, Eastern Uttar Pradesh that has 5.24 million hectares, and Central Uttar Pradesh with 0.68 million hectares (**Annual Report, 2014-15**). Mainly a staple crop in all food cultures, wheat is fundamentally processed into flour for the preparation of breads, manufacturing of pasta and noodles, among many more. Mostly produced from the Fertile Crescent, agriculture of this grain has highly contributed to human development for thousands of years.

Population growths have continued to accelerate the increasing demands of the crop leading to increased yields coupled with efficiency on the nutrients available to be transferred. Nitrogen is a crucial nutrient that affects the yield of wheat, because it supports photosynthesis and protein synthesis by contributing to the production of chlorophyll and amino acids. Its effect is seen on the biomass and grain yield in various types of wheat, especially common wheat for bread and durum wheat for pasta. Wheat is widely farmed in several soils and climates throughout the world, and major producers include China, India, Russia, the United States, and Canada, among others.

Being an easily adaptable nutrient-rich crop, wheat sources good quality carbohydrates, proteins, vitamins, and minerals. A combination of the proper use of the soil, water, and nutrient use for this crop makes for high yields. Still, the crop also easily gets affected by pests and diseases and other climatic conditions. Increased wheat productivity and sustainability can be achieved only with the advances of agronomy, plant breeding, and biotechnology. Uttar Pradesh has registered an increase in the area of late-sown wheat because of reasons like delayed rice transplanting, late monsoons, long-duration rice varieties, and late-season rains besides the time cycle of other crops like sugarcane, potatoes, and toria.

Late-sown wheat, as such, gives lower yield because its growth potential is reduced. Delayed germination often reduces growth and development periods, resulting in premature maturity caused by dehydration in the grain-filling phase as there are high temperatures and dry winds, consequently reducing biomass and yield. Nitrogen is highly essential for growth in wheat and needs careful management so that crop requirement and environmental concerns are at par. Over-application leads to nitrate leaching and greenhouse gas emission; conversely, insufficient

amounts lead to reduced plant growth and yield. It involves the optimization of nitrogen levels with high yield while minimizing the environment impact.

Other factors include the LAI, which is the ratio of the area of the leaves to that of the ground. These are crucial for the interception of solar radiation and photosynthesis. Dry matter accumulation reflects total plant biomass, whereas nitrogen uptake efficiency depicts the ability of crops to uptake and utilizes the available nitrogen which is necessary for effective utilization of the fertilizer. Although application of N increases LAI and biomass, the uptake efficiency will decrease when applied in excess quantities. This calls for a proper fertilization strategy toward optimal growth. However, there is a need to carry further research on the correlation levels of nitrogen with the indicator of growth under changing agro-ecological conditions.

The present study aims at establishing optimal nitrogen management in relation to the effects of varying nitrogen levels on LAI, dry matter accumulation, and nitrogen uptake in wheat for improved crop performance. Such results may increase the nitrogen use efficiency in wheat production toward more sustainable agriculture.

MATERIAL AND METHODS

The field experiment was carried out in the Rabi season during the year 2014-15 at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology located at Narendra Nagar (Kumarganj), Faizabad, Uttar Pradesh. This farm is at a distance of about 42 kilometers from the headquarter of the Faizabad district and falls on the Faizabad-Raibareilly road. The experimental site is located in the subtropical zone of the Indo-Gangetic plains. Its latitude is 26°47' North and longitude is 82°12' East. An elevation of about 113 meters above mean sea level prevails here. The regional characteristics of the experimental site essentially reflect extreme weather patterns common to this region.

Experimental details:

The experiment was conducted on a randomized block design with three wheat varieties: PBW-373, HD-2327 and NW-1014 and with six levels of nitrogen application viz., 0, 40, 80, 120, 160, and 200 kg N ha⁻¹, where replications were three per treatment.

Details of layout:

Design: Randomized Block Design (Factorial), Replication: 3, Varieties: 3, Nitrogen levels: 6, Treatment combinations: 18, Total no. of plots: 54 Gross plot size: 4 x 5 = 20 m², Net plot size: 3.2 x 4 = 12.8 m², Row to row distance: 20 cm, Main irrigation channel : 1.5 m, Sub irrigation channel: 1 m, Replication border (path) : 1 m, Bunds: 0.5 m, Field border : 1 m. The traits measured during the experiment included initial plant population (m⁻²), Plant height (cm), Number of shoots (m⁻²). The data collected on these aspects were analyzed using the analysis of variance (ANOVA) technique as given by **Gomez and Gomez (1984)**. The critical difference at the 5% level of probability was deliberate to test the significance of differences between treatment means wherever the F-test was significant (**Chandel et al., 1998**).

Observations recorded

Leaf area index (LAI):

The leaf area index was determined at 30, 60, and 90 days after sowing. For the measurement, plants from a 0.25 m row segment were chosen, and their green leaves were separated to measure

surface area using an automatic leaf area meter. Leaves were divided into three groups: small, medium, and large. Five leaves from each group were chosen, and their surface area was recorded. the number of leaves of every category was multiplied with the surface area of their leaves, and the summation of all three was done to get the total leaf area, and thus, a leaf area index was calculated as the total leaf area divided by the ground area.

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}$$

Dry matter accumulation:

Second row lengths of 25 cm of plants were taken randomly at 30, 60, and 90 days after sowing as well as at the harvesting period. The above-cut plants were left drying by the sun then taken chopped into small pieces after cutting close to the ground, each sample was taken on separate paper bags. They were left in the electric oven at 65-70°C until they remained with constant dry weight. The dry weight of the plants obtained was expressed in grams per running meter.

Nitrogen uptake by crop:

Samples of both the wheat grain and the straw from each plot were accurately pulverized. The extracts for nitrogen estimation were carried out according to the modified micro-Kjeldahl technique followed by **Jackson (1967)**. These values then get multiplied with the respective grain or straw yield. Calculated results were presented based on the total uptake in kilograms per hectare basis of the crop.

$$\text{Nitrogen uptake by grain (kg ha}^{-1}\text{)} = \frac{\text{N content in grain (\%)} \times \text{Grain yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}\text{)} = \frac{\text{N content in straw (\%)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

RESULTS AND DISCUSSION

Presents the Leaf area index, dry matter accumulation and Nitrogen uptake under different treatments based on Varieties and Nitrogen levels practices for the years 2014-2015 along with.

Leaf area index at 30 DAS

Varieties and Nitrogen levels reported that the above table 1 it has been presented that Leaf Area Index in Variety V₁ was the significantly maximum at a level of 1.38 followed by Variety V₂, the LAI at a value of 1.34 whereas the LAI in variety V₃ is minimum as 1.33. Among the treatments, the highest LAI value was recorded for N₅ (200 kg/ha) at 1.43 followed by N₄ (160 kg/ha) at an LAI of 1.42. The lowest LAI was recorded in control treatment N₀ at an LAI of 1.26, as shown by **Badiyala et al. (2023)** and **Menka Mehra et al. (2007)**.

Leaf area index at 60 DAS

Varieties and Nitrogen Levels of Maximum leaf area index for varieties at 60 days has been taken in (V₃) NW-1014 with LAI as 2.94 whereas in (V₂) HD-2327 it has been 2.87. The lowest

LAI has been recorded in case of (V₃) PBW-373 where it has been 2.65, which goes in well with the report of **Rahman *et.al* (2023)** and **Kumar *et.al.*(2023)**. Among the levels of N, the highest LAI after 60 days was recorded at 3.07 by N₅ at 200 kg/ha, followed by N₄ at 160 kg/ha with an LAI of 3.04. The lowest was that recorded by the control N₀, which was reported by **Tahir *et al.* (1997)** as having an LAI of 2.48.

Leaf area index at 90 DAS

The result indicated that the maximum LAI at 90 days was obtained in Varieties (V₃) NW-1014 with the value of 3.63, whereas the second maximum LAI was found in (V₂) HD-2327 with an LAI of 3.59. The lowest LAI was found in (V₃) PBW-373 with a value of 3.31, as reported by **Kumar *et.al.*, (2020)** and **Khanda *et al.*,(2003)**. Among the N levels, LAI was recorded the maximum at 90 DAS with 3.85 for N₅ followed closely by N₄ (160 kg/ha) which reported at 3.80. Control was observed as the minimum value and noted at 3.10 as reported by **Singh *et al.*, (2007)**.

Dry matter accumulation (g) running meter⁻¹ 30 DAS

The Variety V₁ (NW-1014) at 30 DAS showed the highest accumulation of dry matter with 12.43 m² while the second variety was V₂ (PBW-373) at 12.09 m². The lowest dry matter accumulation was recorded for V₃ (HD-2327) at 11.14 m². The highest dry matter accumulation was recorded for N₅ at 200 kg/ha, 12.85 m² followed by N₄ at 160 kg/ha at 12.80 m². The lowest accumulation was obtained in control with 10.43 m² for the N₀ as reported by **Mishra *et al.*, (2003)**.

Dry matter accumulation (g) running meter⁻¹ 60 DAS

It was showed that at 60 DAS, the maximum dry matter accumulation among the varieties was in the shoot of (V₁) NW-1014 with 89.44 m². Variety (V₂) PBW-373 had 87.84 m² of shoots, while the minimum dry matter accumulation was found to be in (V₃) HD-2327 at 80.84 m². Nitrogen level results indicated maximum dry matter accumulation at 60 DAS as in case of N₅ with an application of 200 kg/ha was 92.72 m² by **Kumar *et.al.*, 2024** Nitrogen levels applied through N₄ were the closest with the application of 160 kg/ha in the form of basal, at a rate of 92.44 m². Accumulation of minimum dry matter in control was at a rate of 75.68 m² by the treatment N₀, agreeing with **Ratanoo *et al.*, (2016)**.

Dry matter accumulation (g) running meter⁻¹ 90 DAS

It was reported that Variety the highest dry matter accumulation at 90 DAS stage in data was for (V₁) NW-1014 with 135.62 m². (V₂) PBW-373 had a dry matter accumulation 133.01 m². The lowest dry matter accumulation was recorded for (V₃) HD-2327 with 122.58 m² **Das *et.al.*, (1998)**.Where as in Nitrogen levels the highest dry matter accumulation at 90 DAS stage data was for N₅ (200kg/ha) with 141.00 m². N₄ (160kg/ha as a basal dose) recorded a dry matter

accumulation of 140.83 m^{-2} . The lowest dry matter accumulation was observed in the control group N_0 with 114.74 m^{-2} similar result reported by **Singh *et.al.*, 2004 and Kumar *et.al.*, 2023**

Dry matter accumulation (g) running meter⁻¹ at harvest stage

It was estimated that the significantly maximum dry matter at the harvesting stage was achieved by variety V_1 NW-1014 at 148.72 m^2 followed by V_2 PBW-373 at 145.86 m^2 and minimum was recorded by variety V_3 HD-2327 at 134.42 m^2 . On the contrary, maximum dry matter accumulation at harvest was recorded for N_5 (200 kg/ha) at 155.10 m^2 , while N_4 followed at 154.44 m^2 as a basal dose. Control N_0 had the least accumulation, at 125.84 m^2 -the similar result reported by **Sardana *et al.* (2002)**.

Nitrogen uptake by grain (kg ha^{-1})

In terms of nitrogen uptake by grain (kg ha^{-1}), the variety NW-1014 (V_1) showed the highest uptake at 62.89 kg ha^{-1} . This was followed by HD-2327 (V_2) with 58.93 kg ha^{-1} , while PBW-373 (V_3) had the lowest nitrogen uptake at 53.35 kg ha^{-1} . The highest uptake of the nitrogen by grain was in 160 kg ha^{-1} (N_4), with a value of 67.36 kg ha^{-1} , followed by 200 kg ha^{-1} (N_5) with an uptake value of 64.31 kg ha^{-1} . Low uptake was recorded in control (N_0) in 47.15 kg ha^{-1} , approximately close to the results in **Singhal *et al.*, (2012)**.

Nitrogen uptake by straw (kg ha^{-1})

It was showed that Variety level highest Nitrogen uptake by straw (kg ha^{-1}) in data was for (V_1) NW-1014 with 23.91 kg ha^{-1} . (V_2) PBW-373 had a Nitrogen uptake by straw of 22.01 kg ha^{-1} . The lowest Nitrogen uptake by straw was recorded for (V_3) HD-2327 with 20.44 kg ha^{-1} . Where as in Nitrogen levels the Nitrogen uptake by straw data was for N_4 (160 kg/ha) with 24.33 kg ha^{-1} . N_5 (200 kg/ha as a basal dose) recorded a Nitrogen uptake by straw of 23.50 kg ha^{-1} . The lowest Nitrogen uptake by straw was observed in the control group, N_0 , with 18.45 kg ha^{-1} similar result reported by **Tahir *et.al.*, .2009**

Interaction Effect

The interaction effects of varieties and nitrogen levels differed significantly on LAI, dry matter accumulation, and N uptake at different stages of growth. Optimal amounts of nitrogen applications (N_4 and N_5) in all instances enhanced LAI and dry matter, especially in variety V_1 that is NW-1014, and results indicate that varietal selection with targeted amount of nitrogen management is more important for maximizing crop production.

Table 1: Effect of different treatments on Leaf area index, Dry matter accumulation and Nitrogen uptake by grain (kg ha⁻¹) and Nitrogen uptake by straw (kg ha⁻¹)

Treatment s	Leaf area index			Dry matter accumulation (g) running meter ⁻¹				Nitrogen uptake by grain (kg ha ⁻¹)	Nitrogen uptake by straw (kg ha ⁻¹)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	At harvest		
Varieties									
PBW-373	1.33	2.65	3.31	11.14	80.84	122.58	134.42	53.35	20.44
HD-2327	1.34	2.87	3.59	12.09	87.84	133.01	145.86	58.93	22.01
NW-1014	1.38	2.94	3.63	12.43	89.44	135.62	148.72	62.89	23.91
SEm±	0.01	0.04	0.04	0.15	1.21	1.79	1.95	0.89	0.30
CD (P=0.05)	0.05	0.11	0.13	0.44	3.48	5.14	5.62	2.55	0.87
Nitrogen levels(kg ha ⁻¹)									
0	1.26	2.48	3.10	10.43	75.68	114.74	125.84	47.15	18.45
40	1.30	2.66	3.21	11.10	81.93	122.58	134.42	52.84	20.44
80	1.34	2.82	3.52	11.85	86.00	130.40	143.00	58.35	22.44
120	1.39	2.93	3.66	12.33	90.44	136.63	149.62	63.38	23.07
160	1.42	3.04	3.80	12.80	92.44	140.83	154.44	67.36	24.33
200	1.43	3.07	3.85	12.85	92.72	141.00	155.10	64.31	23.50
SEm±	0.02	0.05	0.06	0.22	1.71	2.53	2.76	1.25	0.42
CD (P=0.05)	0.07	0.16	0.19	0.63	4.92	7.27	7.95	3.61	1.23

Whereas variety-(V₁,V₂,V₃) and Nitrogen levels- N₀ N₁,N₂,N₃,N₄,N₅

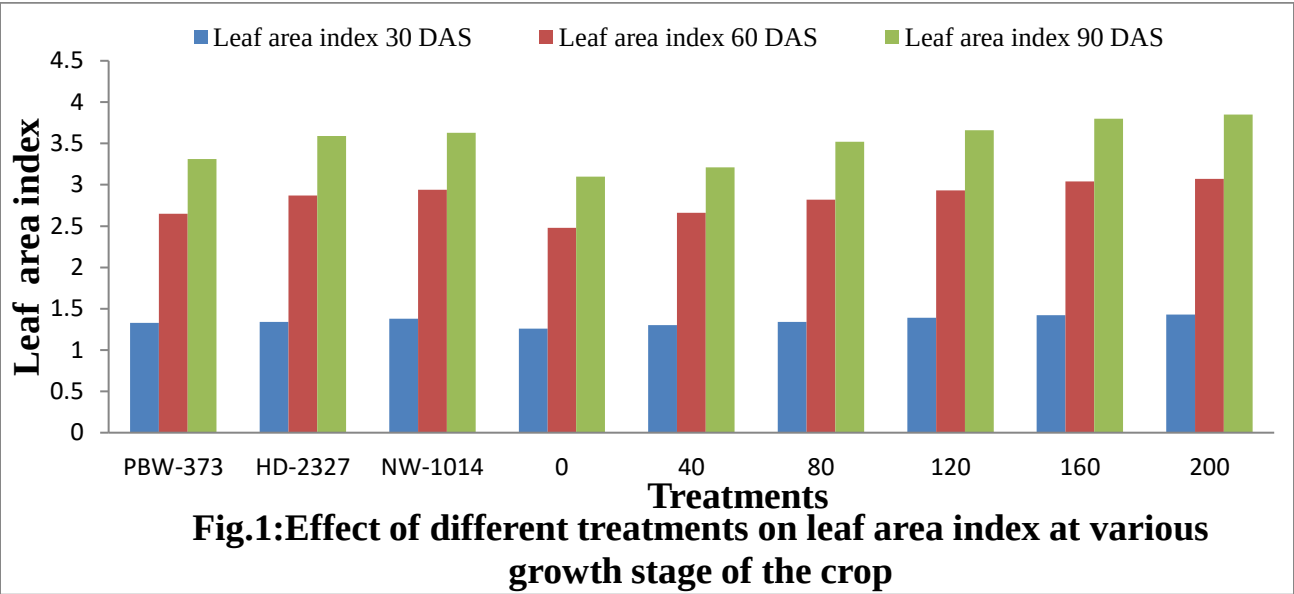
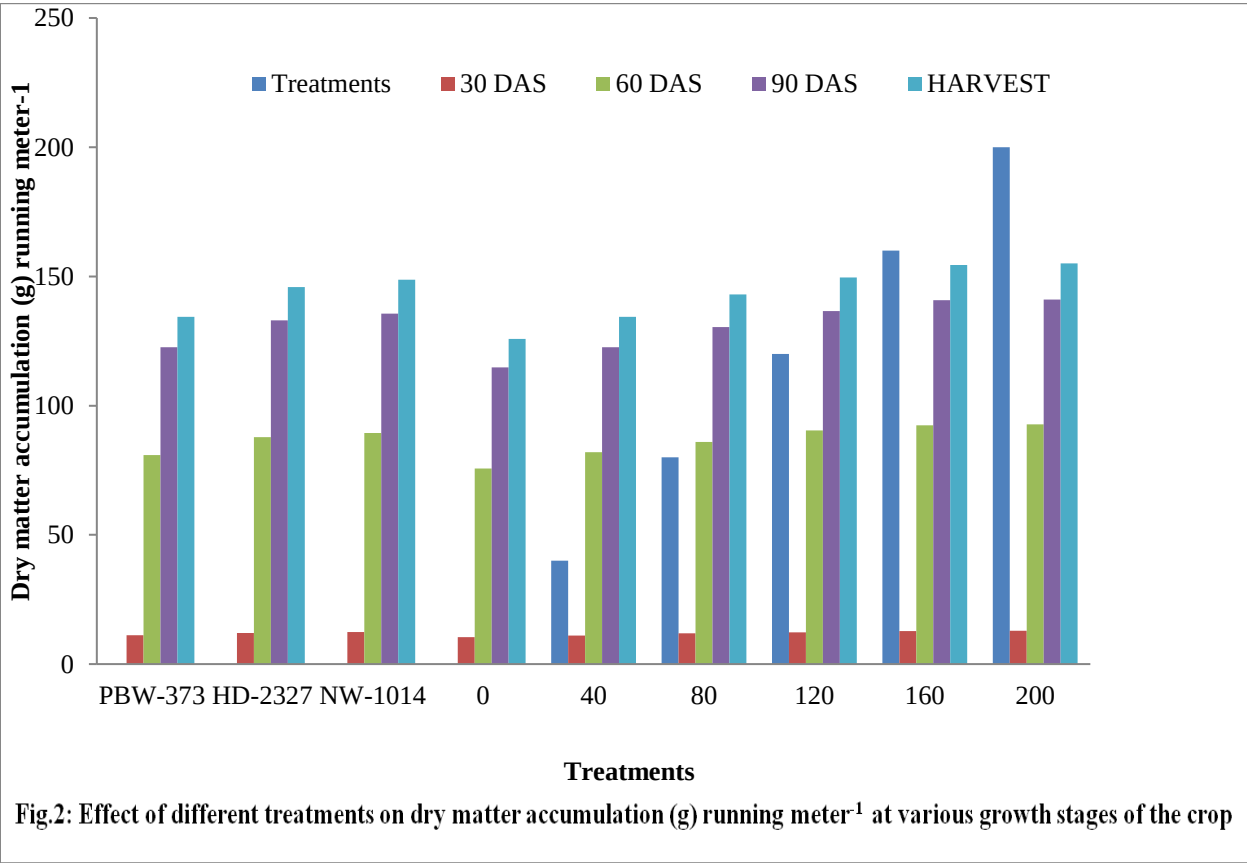
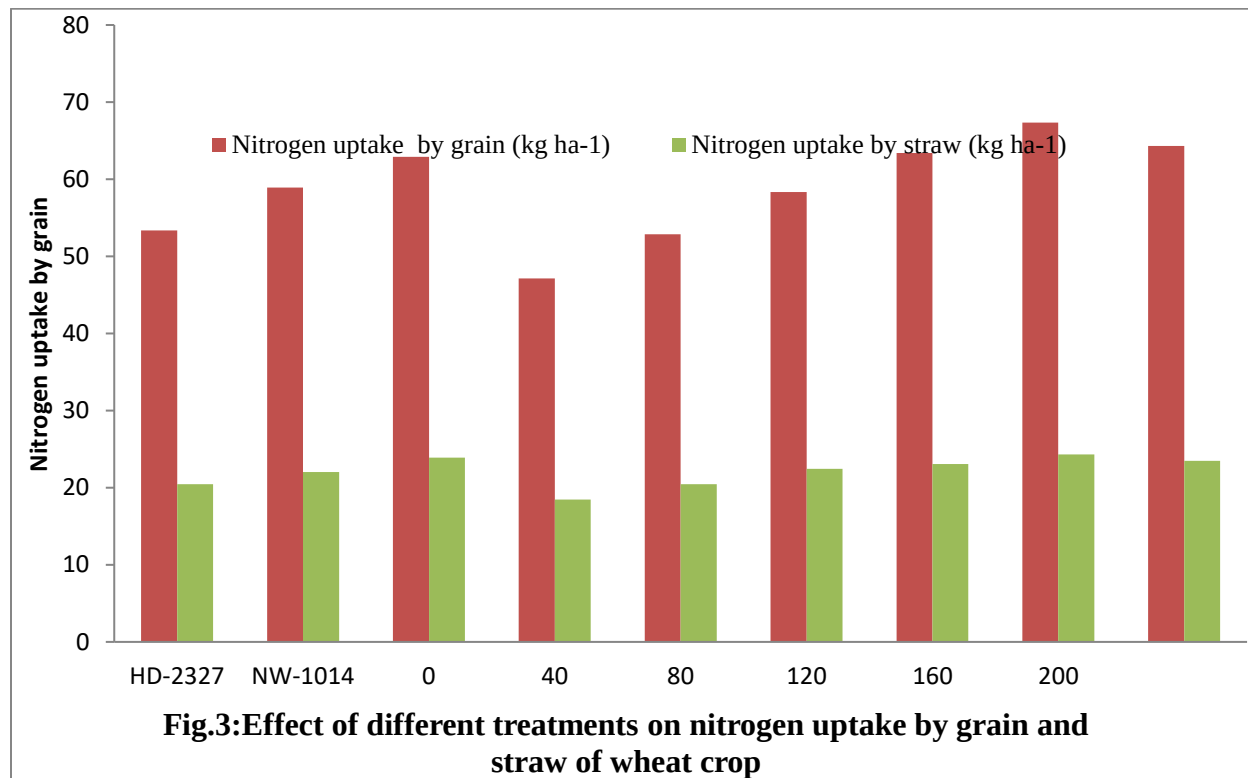


Fig.2: Effect of different treatments on dry matter accumulation (g) running meter⁻¹ at various growth stages of the crop





Conclusion

The most consistent varieties are NW-1014 (V_1) and N_5 nitrogen level (200 kg/ha), as they gave the best results in terms of growth metrics, demonstrating their effectiveness in promoting plant growth and nutrient absorption. The result confirms the requirement for fine-tuning the selection of crop variety as well as the application of nitrogen to increase productivity; it can be a basis for recommendations in agricultural practice. Further research may be conducted on the amount of nitrogen application and its economic feasibility to ensure that the most cost-effective approach is used for higher yields.

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