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Siddharth Saroha
Department of Agronomy, CCS
Haryana Agricultural University,
Hisar, Haryana, India

Anil Kumar Dhaka
Senior Scientist, RDS Seed Farm,
CCS Haryana Agricultural
University, Hisar, Haryana, India

Bhagat Singh
Senior Scientist, Department of
Agronomy, CCS Haryana
Agricultural University, Hisar,
Haryana, India

Swati
Department of Botany and Plant
Physiology (Environmental
Science), CCS Haryana
Agricultural University, Hisar,
Haryana, India

Corresponding Author:
Anil Kumar Dhaka
Senior Scientist, RDS Seed Farm,
CCS Haryana Agricultural
University, Hisar, Haryana, India

Response of different types of wheat genotypes to varying levels of nitrogen in a variety of environments

Siddharth Saroha, Anil Kumar Dhaka, Bhagat Singh and Swati

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Abstract

Problems: Wheat (*Triticum aestivum*) productivity in India is significantly affected by delayed sowing, which exposes the crop to terminal heat stress and temperature extremes, ultimately leading to reduced growth and yield. In addition, suboptimal nitrogen management and genotype selection further limit potential productivity under varying sowing environments.

Experimental Approach: The study was conducted during the 'Rabi' seasons of 2023–24 and 2024–25 at CCS HAU, Hisar, using a split-split plot design with three replications and 45 treatment combinations. Three sowing dates (early, timely and late), three nitrogen levels (125 kg ha⁻¹, 150 kg ha⁻¹ and 175 kg ha⁻¹) and five wheat genotypes (G₁- WH 1105, G₂- WH 1270, G₃- WH 1124, G₄- DBW 222 and G₅- HD 3369) were evaluated for their effects on growth, phenology and yield parameters under field conditions.

Major Findings: Early sowing (1st–10th November) resulted in superior plant height and dry matter accumulation compared to delayed sowing. Increasing nitrogen application improved crop performance, with 175 kg ha⁻¹ showing the best results, closely followed by 150 kg ha⁻¹. Among genotypes, WH 1270 consistently showed superior growth and yield attributes, followed by DBW 222.

Conclusion: The study concludes that timely sowing combined with optimized nitrogen application (150–175 kg ha⁻¹) and the selection of high-performing genotypes such as WH 1270 can effectively reduce yield losses caused by delayed sowing and improve overall wheat productivity under changing climatic conditions

Keywords: Wheat, sowing time, nitrogen levels, genotypes, growth parameters, dry matter accumulation

1. Introduction

Wheat (*Triticum aestivum*) is one of the most important staple food crops globally and plays a central role in ensuring food security. However, its productivity is highly influenced by agronomic practices and environmental conditions, particularly sowing time, varietal selection, and nutrient management. In many wheat-growing regions, especially in North-Western India, delayed sowing due to preceding crop harvests exposes the crop to temperature stress, resulting in reduced tillering, shortened growth duration, and significant yield losses.

Previous studies have consistently reported that late sowing leads to poor crop establishment and lower grain yield due to exposure to terminal heat stress during the reproductive stage (Ortiz-Monasterio *et al.*, 2005; Prasad *et al.*, 2017) ^[1, 14]. In addition, the choice of wheat genotype plays a vital role in determining yield stability under varying sowing environments, as different varieties respond differently to heat stress and growth duration constraints. Nitrogen management further influences crop performance by enhancing vegetative growth and yield attributes when applied at optimal levels. Earlier research has also demonstrated that integrated management practices involving timely sowing, suitable cultivars and balanced nitrogen application can substantially improve wheat productivity under diverse agro-climatic conditions (Coventry *et al.*, 2011; Kesarwani *et al.*, 2018) ^[1, 11].

Therefore, the present investigation is undertaken to evaluate the combined effect of sowing time, nitrogen levels, and wheat genotypes on growth, phenology, and yield performance, with the aim of identifying suitable management strategies for achieving higher and more stable wheat productivity under variable environmental conditions.

2. Objectives

- To study the effect of sowing time and nitrogen levels on growth, phenology, yield attributes, and yield of wheat genotypes.
- To find out the interactive effect of genotypes, nitrogen levels, and sowing times.
- To compute the economics of different treatments.

3. Materials and Methods

1. Experimental Site and Location

The experiment was conducted during the 'Rabi' seasons of 2023-24 and 2024-25 at the Research Farm of the Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (India). It is situated at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level.

2. Climate and Weather

Hisar experiences a semi-arid climate with hot, dry winds in summer, very cold winters, and humid monsoon conditions.

Maximum temperatures reach up to 48°C in May–June, while minimum temperatures can drop below 0°C in December–January. The area receives about 450 mm annual rainfall, 70–80% of which occurs during July–September, with the rest from occasional cyclonic showers. Relative humidity ranges from 75–90% during July–March and declines to 40–50% in summer, with annual averages of about 80% (morning) and 44% (evening).

Vapour pressure varies from 7–12 mm in dry months to 20–22 mm during monsoon, with annual averages around 14.7 mm (morning) and 14.4 mm (evening). Bright sunshine averages 6.9 hours/day, highest in April (9.3 h) and lowest in July (6.1 h), while wind speed averages 5.5 km h⁻¹, being higher in summer and lower in winter. Meteorological data recorded during wheat seasons (2023–24 and 2024–25) at CCS HAU, Hisar showed that maximum temperature ranged from 30.5–31.3 °C in 2023–24 and 34.4–40.3 °C in 2024–25, while minimum temperature ranged from 15.4–20.1 °C and 17.4–22.8 °C, respectively. Overall, the 2024–25 season recorded comparatively higher temperatures than 2023–24.

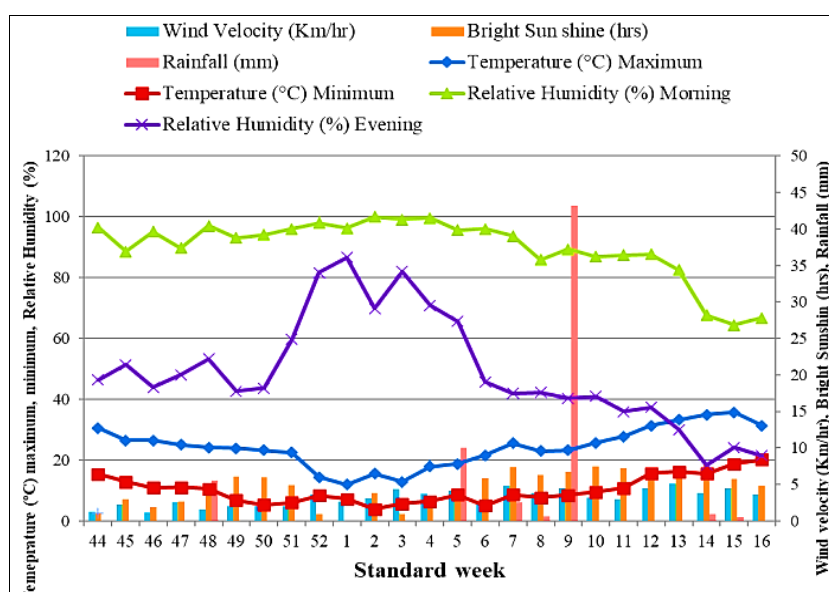


Fig 1: Mean weekly weather data recorded at agricultural meteorology observatory, CCSHAU, Hisar during rabi (2023-2024)

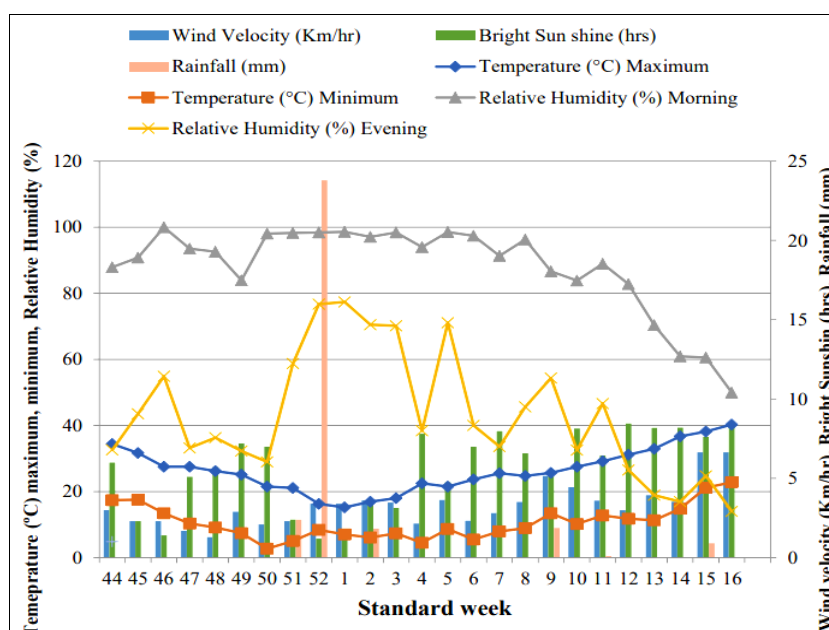


Fig 2: Mean weekly weather data recorded at agricultural meteorology observatory, CCSHAU, Hisar during rabi (2024-2025)

Mean weekly morning and evening relative humidity ranged from 96.6–66.7% and 46.3–21.5% in 2023–24, and 88–50% and 33–14% in 2024–25. Sunshine hours varied from 1.0–4.8 hours (2023–24) and 6.0–8.4 hours (2024–25). Wind speed ranged from 1.3–3.6 km/hr and 3.0–6.6 km/hr, respectively. Total rainfall was 63.2 mm in 2023–24 and 30.9 mm in 2024–25.

3. Physico-chemical Properties of Soil

The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction (pH 8.3), low in organic carbon (0.32%) and available nitrogen (120 kg ha⁻¹), medium in available phosphorus (19.7 kg ha⁻¹), and high in available potassium (253 kg ha⁻¹).

4. Experimental Details

The experiment was conducted in a split-split plot design with 3 replications and 45 treatment combinations. Main plots included

sowing times: S1 (1st–10th November), S2 (20th–30th November) and S3 (15th–25th December). Sub-plots consisted of nitrogen levels: N1 (125 kg ha⁻¹), N2 (150 kg ha⁻¹), and N3 (175 kg ha⁻¹). Sub-sub plots included wheat genotypes: G₁ (WH 1105), G₂ (WH 1270), G₃ (WH 1124), G₄ (DBW 222) and G₅ (HD 3369). Plot size was 2.40 m × 8.00 m (gross 19.20 m²) and 1.60 m × 7.00 m (net 11.20 m²).

5. Cultural Operations

Sowing was done manually by ‘pora’ method at 5 cm depth on different dates. Half N, full P₂O₅, K₂O and ZnSO₄ were applied basally, while remaining N was top-dressed at first irrigation. S₁, S₂ and S₃ received 5, 4 and 3 irrigations respectively. Harvesting was done manually and threshing by mini plot thresher.

4. Results and Discussion

1. Plant height (cm)

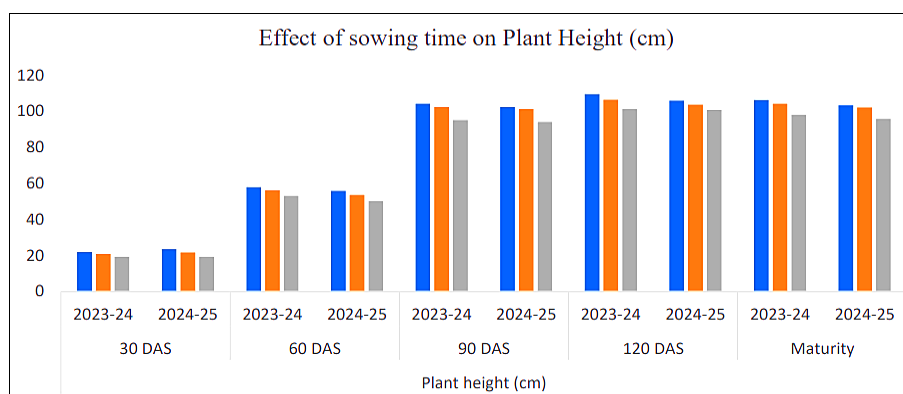


Fig 3: Effect of sowing times, nitrogen levels and genotypes on plant height (cm) at different growth stages in wheat

Plant height data at 30, 60, 90, 120 DAS and maturity showed that early sowing (1st–10th November) recorded the highest plant height in both years (21.9 & 23.4 cm at 30 DAS; 106.2 & 103.2 cm at maturity), followed by 20th–30th November. The lowest

plant height was consistently observed under late sowing (15th–25th December) in both years. Similar trends were recorded at all growth stages.

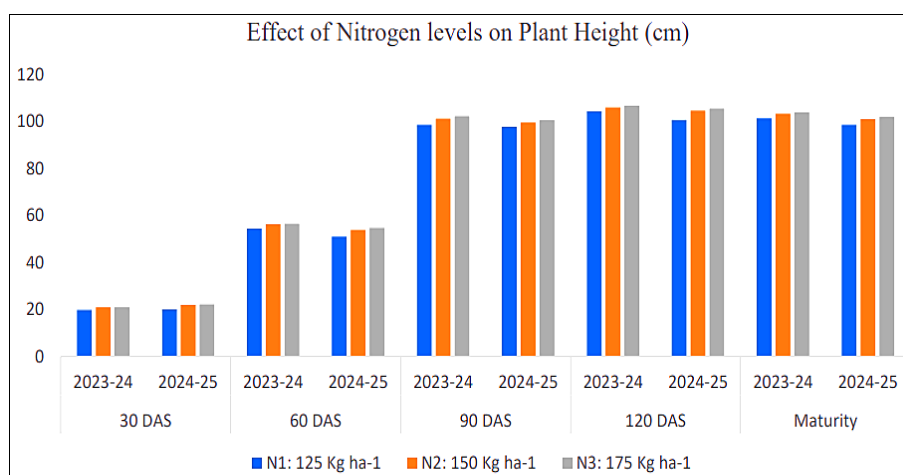


Fig 4: Effect of sowing times, nitrogen levels and genotypes on plant height (cm) at different growth stages in wheat

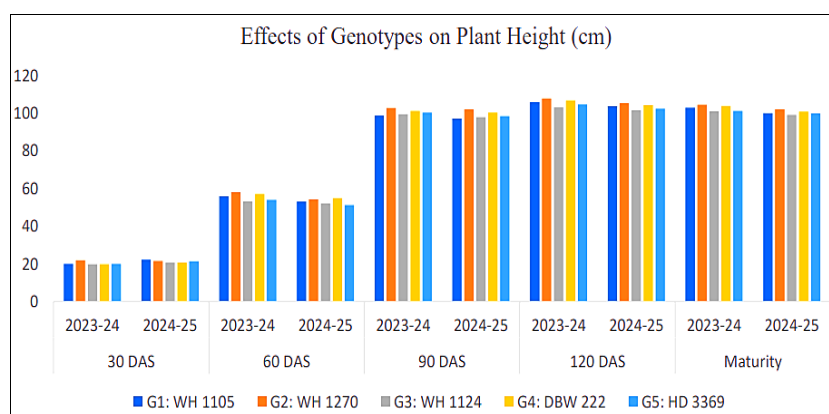
Plant height at 30 DAS was not significantly affected by nitrogen levels. However, from 60 DAS onwards, nitrogen levels significantly influenced plant height. The highest plant height was recorded with 175 kg N ha⁻¹, showing 102.2 and 100.6 cm at 90 DAS in 2023–24 and 2024–25, respectively, which was statistically at par with 150 kg N ha⁻¹ (101.1 and 99.5 cm), while 125 kg N ha⁻¹ showed the lowest values (98.4 and 97.6 cm).

A similar trend was observed at 120 DAS, where 175 kg N ha⁻¹ recorded maximum plant height (106.7 and 105.4 cm), followed closely by 150 kg N ha⁻¹ (105.9 and 104.5 cm). At maturity also, 175 kg N ha⁻¹ gave the highest plant height (103.7 and 101.8 cm), statistically at par with 150 kg N ha⁻¹ (103.2 and 100.9 cm), while the lowest was recorded under 125 kg N ha⁻¹ (101.3 and 98.4 cm).

Table 1: Effect of sowing times, nitrogen levels and genotypes on plant height (cm) at different growth stages in wheat

Treatments	Plant height (cm)									
	30 DAS		60 DAS		90 DAS		120 DAS		Maturity	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
S1: 1st-10th November	21.9	23.4	57.9	55.8	104.1	102.4	109.5	105.9	106.2	103.2
S2: 20th-30th November	20.8	21.6	56.2	53.6	102.4	101.2	106.4	103.7	104.1	102.1
S3: 15th-25th December	19.1	19.3	53.1	50.1	95.1	94.0	101.1	100.8	97.9	95.7
SEm±	0.11	0.16	0.41	0.43	0.39	0.60	0.39	0.37	0.35	0.74
CD at 5%	0.45	0.64	1.61	1.67	1.51	2.35	1.53	1.47	1.37	2.89
Nitrogen Levels										
N1: 125 Kg ha ⁻¹	19.8	20.1	54.5	51.0	98.4	97.6	104.3	100.6	101.3	98.4
N2: 150 Kg ha ⁻¹	20.9	22.0	56.2	53.8	101.1	99.5	105.9	104.5	103.2	100.9
N3: 175 Kg ha ⁻¹	21.0	22.2	56.5	54.7	102.2	100.6	106.7	105.4	103.7	101.8
SEm±	0.10	0.09	0.40	0.36	0.33	0.40	0.43	0.33	0.32	0.34
CD at 5%	NS	NS	1.25	1.11	1.13	1.24	1.34	1.03	1.01	1.04
Genotypes										
G1: WH 1105	20.1	22.3	56.0	53.1	98.7	97.2	105.9	103.7	103.0	100.1
G2: WH 1270	22.0	21.7	58.2	54.4	102.9	102.0	107.8	105.3	104.6	102.0
G3: WH 1124	19.9	20.8	53.3	52.2	99.5	97.9	103.1	101.6	101.0	99.1
G4: DBW 222	20.0	20.9	57.2	55.0	101.2	100.3	106.8	104.3	103.9	100.8
G5: HD 3369	20.1	21.5	54.1	51.3	100.4	98.5	104.7	102.5	101.2	99.9
SEm±	0.15	0.19	0.44	0.40	0.36	0.38	0.48	0.46	0.59	0.41
CD at 5%	NS	NS	1.24	1.14	1.02	1.07	1.36	1.30	1.67	1.18

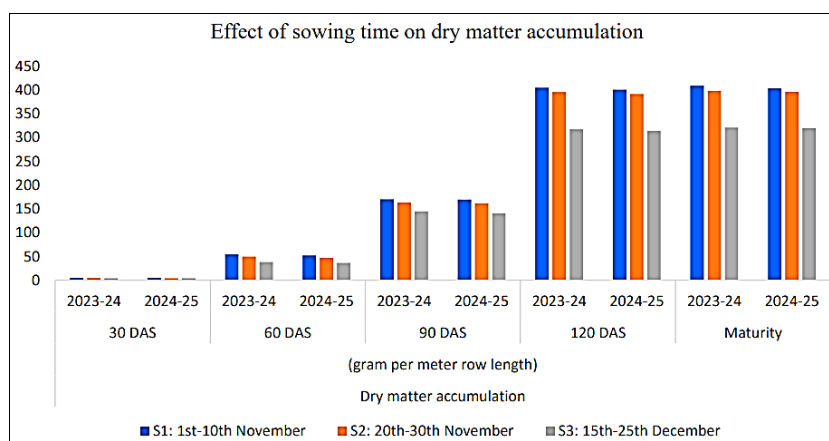
At 30 DAS, genotypes showed no significant difference in plant height; WH 1270 had the highest (22.0 and 21.7 cm) and WH 1124 the lowest (19.9 and 20.8 cm) in both years. From 60 DAS onwards, significant variation was observed, with WH 1270 and DBW 222 recording maximum plant height (58.2 and 55.0 cm, respectively, during 2023–24 and 2024–25).

**Fig 5:** Effect of Genotypes on Plant Height (cm)

WH 1270 showed the highest plant height at all stages, recording 102.9 and 102.0 cm at 90 DAS, 107.8 and 105.3 cm at 120 DAS, and 104.6 and 102.0 cm at maturity during 2023–24 and 2024–25, respectively, and remained statistically at par with DBW 222 at all stages. The lowest plant height at 90 DAS was observed in WH 1105 (98.7 and 97.2 cm), at 120 DAS in WH

1124 (103.1 and 101.6 cm) and at maturity also in WH 1124 (101.0 and 99.1 cm). Earlier, at an initial stage, WH 1124 and HD 3369 recorded the lowest plant height (53.3 and 51.3 cm, respectively).

2. Dry matter accumulation (g m⁻¹ row length)

**Fig 6:** Effect of sowing times, nitrogen levels and genotypes on dry matter accumulation (g/m row length) at different growth stages

Dry matter accumulation at 30, 60, 90, 120 DAS and at maturity was highest under early sowing (1st–10th November) and lowest under late sowing (15th–25th December) during both years. At 30 DAS, early sowing recorded 4.8 and 4.6 g m⁻¹, while late sowing recorded 4.2 and 4.4 g m⁻¹.

At 60 DAS, it was 54.5 and 52.4 g m⁻¹ under early sowing and 38.8 and 36.9 g m⁻¹ under late sowing. At 90 DAS, values were

170.2 and 169.7 g m⁻¹ (early) and 145.2 and 140.6 g m⁻¹ (late). At 120 DAS, early sowing recorded 404.8 and 400.7 g m⁻¹, whereas late sowing recorded 317.3 and 313.5 g m⁻¹. At maturity, dry matter accumulation was highest in early sowing (408.5 and 403.7 g m⁻¹) and lowest in late sowing (320.9 and 319.5 g m⁻¹), with intermediate values in 20th–30th November sowing throughout both years.

Table 2: Effect of sowing times, nitrogen levels and genotypes on dry matter accumulation (g/m row length) at different growth stages

Treatments	Dry matter accumulation (gram per meter row length)									
Sowing times	30 DAS		60 DAS		90 DAS		120 DAS		Maturity	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
S1: 1st-10th November	4.8	4.6	54.5	52.4	170.2	169.7	404.8	400.7	408.5	403.7
S2: 20th-30th November	4.6	4.5	50.1	47.5	163.5	161.8	395.6	391.4	398.1	395.9
S3: 15th-25th December	4.2	4.4	38.8	36.9	145.2	140.6	317.3	313.5	320.9	319.5
SEm±	0.04	0.03	0.37	0.35	0.48	0.57	0.67	0.54	1.21	0.60
CD at 5%	0.16	0.12	1.44	1.42	1.88	2.22	2.63	2.10	4.72	2.34
Nitrogen Levels										
N1: 125 Kg ha ⁻¹	4.5	4.4	46.6	44.6	157.8	155.7	370.4	367.0	372.6	370.4
N2: 150 Kg ha ⁻¹	4.6	4.5	48.2	45.8	160.1	157.6	373.2	368.9	376.5	373.8
N3: 175 Kg ha ⁻¹	4.6	4.6	48.5	46.4	161.0	158.8	374.3	369.7	378.4	374.8
SEm±	0.02	0.03	0.49	0.34	0.59	0.57	0.79	0.66	0.73	1.02
CD at 5%	NS	NS	1.53	1.05	1.82	1.79	2.43	2.05	2.26	3.15
Genotypes										
G1: WH 1105	4.3	4.1	47.2	45.5	159.6	156.7	363.0	360.6	371.0	367.8
G2: WH 1270	4.8	5.0	50.3	48.6	162.9	160.5	381.7	377.3	384.9	380.7
G3: WH 1124	4.3	4.2	45.4	43.7	156.7	154.4	365.3	362.4	368.2	365.9
G4: DBW 222	4.7	4.9	49.8	46.6	161.5	159.7	379.8	373.8	381.0	378.7
G5: HD 3369	4.5	4.2	46.2	43.8	157.3	155.5	373.2	368.5	374.2	372.0
SEm±	0.03	0.04	0.57	0.52	0.64	0.68	0.97	1.24	1.17	1.24
CD at 5%	NS	NS	1.63	1.46	1.81	1.92	2.74	3.51	3.30	3.50

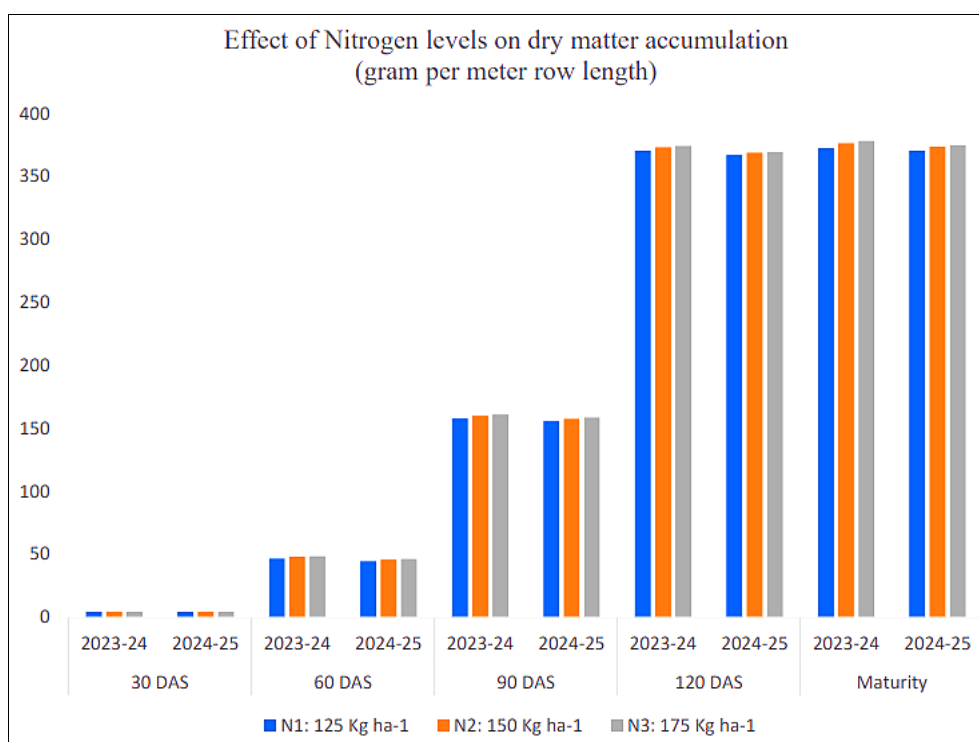


Fig 7: Effect of nitrogen levels on dry matter accumulation (gram per meter row length)

Nitrogen levels did not significantly affect dry matter accumulation at 30 DAS in both years. However, from 60 DAS onwards, significant differences were observed. At 60 DAS, 175 kg N ha⁻¹ recorded the highest dry matter (48.5 and 46.4 g m⁻¹), statistically at par with 150 kg N ha⁻¹, while 125 kg N ha⁻¹

showed the lowest values. A similar trend continued at 90 DAS, 120 DAS, and at maturity, where 175 kg N ha⁻¹ consistently recorded the maximum dry matter accumulation, closely followed by 150 kg N ha⁻¹, whereas 125 kg N ha⁻¹ remained the lowest throughout both years.

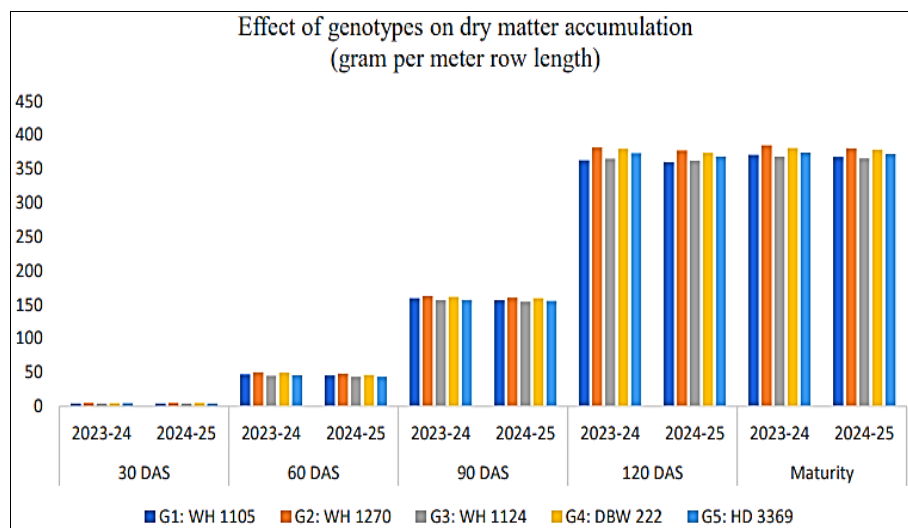


Fig 8: Effect of genotypes on dry matter accumulation (gram per meter row length)

Similar trend was observed among genotypes. At 30 DAS, no significant difference was found, though WH 1270 showed the highest dry matter accumulation (4.8 and 5.0 g m⁻¹). From 60 DAS onwards, significant differences appeared. At 60 DAS, WH 1270 (50.3 and 48.6 g m⁻¹) was highest, followed by DBW 222, while WH 1124 recorded the lowest. At 90 DAS, WH 1270 again showed maximum values (162.9 and 160.5 g m⁻¹), at par with DBW 222. At 120 DAS, WH 1270 recorded the highest dry matter (381.7 and 377.3 g m⁻¹), statistically similar to DBW 222, while WH 1105 was lowest. At maturity also, WH 1270 (384.9 and 380.7 g m⁻¹) remained highest, at par with DBW 222 (381.0 and 378.7 g m⁻¹).

5. Conclusion

The study concludes that sowing time is a critical factor for achieving higher wheat productivity. Early sowing (1st-10th November) resulted in significantly better growth parameters, including plant height and dry matter accumulation compared to late sowing (15th-25th December). Among nitrogen levels, the application of 175 kg N ha⁻¹ was found to be the most effective, although it was often statistically at par with 150 kg N ha⁻¹, suggesting that 150 kg N ha⁻¹ can be an optimal dose for late-sown conditions to balance yield and economics. Regarding genotypes, WH 1270 and DBW 222 consistently outperformed other genotypes under varying sowing environments, indicating their better adaptability and heat tolerance. Therefore, to mitigate yield losses under late-sown conditions, it is recommended to sow wheat by the end of November, apply 150 kg N ha⁻¹, and use genotypes like WH 1270 or DBW 222.

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