Agronomic Performance of Wheat Varieties in Relation to Sowing Dates in Shiwalik Range of Uttarakhand

Abstract

Wheat (Triticum aestivum L.) plays a vital role in global agriculture, particularly in India, the world's second-largest producer. Despite its adaptability, wheat cultivation in regions like Uttarakhand faces challenges due to population growth, limited arable land and climate change threats. This study evaluated four wheat varieties (RR-21, SY-255, PBW-550, PBW-292) across three sowing dates (10th, 20th, and 30th December) using a Randomized Block Design during the 2023–2024 Rabi season at Dev. Bhoomi Uttarakhand University's agronomy research farm in Naugaon. The study measured key agronomic parameters including plant height, Leaf Area Index (LAI), Net Assimilation Rate (NAR), Crop Growth Rate (CGR), Relative Growth Rate (RGR), and yield components. Statistical analysis using ANOVA highlighted significant differences in growth and yield attributes among sowing dates and varieties. Sowing on December 20th exhibited superior performance, notably with variety RR-21 showing higher plant height, dry weight, CGR, LAI, RGR, and NAR. Variations in yield attributes such as grains per spike, effective tillers, spike length, 1000-grain weight, grain yield, stover yield, biological yield, and harvest index were also observed. Late sowing negatively affected germination rates, leading to increased weed competition and reduced growth parameters.

Keywords: Late sown, wheat, climate change and yield

Introduction

Wheat (*Triticum aestivum* L.) is the cereal crop that is farmed on the largest scale in the world. India is the world's second-largest producer of wheat. The introduction of high yielding cultivars is primarily responsible for this extraordinary rise in productivity. Due to its extreme adaptability, which enables it to be cultivated in non-traditional rice-growing regions of northern

India as well as late-sown, challenging locations that are resistant to technological innovation, wheat makes up the majority of the crop.Wheat continues to be better in terms of area, productivity, and adaptability to a broad variety of agro-climatic conditions. However, we shouldn't be satisfied with the country's development because there are still many obstacles to overcome, such as population increase combined with dwindling arable land, diminishing water supplies, and climate change **(Reynolds *et al*. 2008).** Wheat is planted in Uttarakhand as a rabi crops. There is now a significant yield gap between the state's potential and realised wheat output. About 2,38, 000 hectares of wheat are farmed in Uttarakhand, yielding 632000 metric tonnes of productivity per hectare at 2,657 kg. Sowing time and wheat variety are the two most important production parameters that determine productivity. Wheat cultivation requires specific temperature conditions at various stages of its growth and development, which can vary slightly among different varieties. Ideally, wheat thrives in temperatures between 20°C to 25°C, with an upper limit of 35°C. Temperatures exceeding 30°C during the maturity phase can induce forced maturity, leading to a reduction in yield. The optimal temperature range for wheat anthesis and grain filling is between 12°C to 22°C. . In Uttarakhand, wheat is typically sown in November and concludes in late December, depending on the weather, topography, and harvesting of the preceding crop. Early in the growing season, when wheat is planted in late spring or early summer, temperatures are cool, and later in the growing season, they are hot. Optimal moisture levels are also necessary for its proper growth and development. Exposure to temperatures above this range can markedly diminish grain yield, as demonstrated by **(Tewolde *et al*. 2006) and (Fisher 2007).** Post-anthesis heat stress adversely affects wheat by causing several physiological changes, ultimately resulting in smaller grain weight due to a shortened grain filling period and reduced starch synthesis duration, or a combination of both effects **(Hasan and Ahmed, 2005).**
Thus, identifying wheat varieties that thrive under heat stress and optimizing sowing times to address climate change will significantly enhance wheat production in the state of Uttarakhand**.**

Materials and methods

The experiment was carried out in the Rabi season of 2023–2024 at the Crop Research Farm, Dev Bhoomi Uttarakhand University in Naugaon, Dehradun, Uttarakhand, India. The site featured outstanding soil characteristics and was located within a subtropical climate zone, with geographical coordinates around 77.92˚E longitude and 30.38˚N latitude. The altitude above mean sea level was 638.96 meters (Fig.1). A Randomized Block Design (RBD) was applied in three replications, with four wheat varieties (RR-21, SY-255, PBW-550, and PBW-292) grown under three different planting dates (10, 20, and 30 December) included. Twelve treatments replicated thrice generated 36 plots and the plot size 2m x 2m = $4m^2$. During the reproductive stage, the mean high and low temperatures were, respectively, 30.7 and 15.12 degrees Celsius. The growth, yield component and yield statistics were recorded in accordance with standard procedure.

Plant Height

For each plot, five plants were selected at random and marked for measuring their height at 90 DAS. Height was measured using a meter scale from the ground to the ear head.

Dry weight at 90 DAS

Dry weight of plants is the total mass of plant tissues left after water removal, giving information about the plant's physiological condition, nutrient absorption, and general growth progress. The formula to calculate dry weight is:

Dry weight (g) = *Fresh weight* (g) - *Water weight* (g)

In this context, the fresh weight refers to the total weight of the plant including water content, whereas the water weight represents the weight of water present in the plant tissues.

Leaf Area

The formula for Leaf area is as follows:

$A = L \times W$

• Using a ruler or calliper, determine the leafs length (L) and width (W).

• Utilising the formula for the area of a rectangle, get the leaf area (A)

Leaf Area Index

The Leaf Area Index (LAI) is calculated using the following formula:

LAI= Leaf area / Ground area

Ground area refers to the area on the ground surface covered by the crop canopy. The LAI is expressed as a unitless value, typically ranging from 0 to 5 or higher, depending on the crop and growth stage.

CGR

The formula used to calculate Crop Growth Rate (CGR) is:

$$CGR = \frac{W_2 - W_1}{(t_2 - t_1)\, S}$$

- W_2 is the final dry weight (g) of the crop at a specific time point (e.g., at 60 DAS or at harvest).
- W_1 is the initial dry weight (g) of the crop at the previous time point (e.g., at 30 DAS or at 60 DAS).
- t_2 and t_1 is the time interval (in days) between the two time points.
- S is land area (m^2) over which dry matter was recorded.

  Relative Growth Rate (RGR)

The formula used to calculate Relative Growth Rate (RGR) is:

$$RGR \ (g \ g^{-1} week^{-1}) = \frac{\ln W_2 - \ln W_1}{t_2 - t_1},$$

Where:

- W_2 and the final dry weight (g) of the crop at a specific time point (e.g., at 60 DAS or at harvest).
- W_1 is the initial dry weight (g) of the crop at the previous time point (e.g., at 30 DAS or at 60 DAS).

- T_2 and T_1 the time interval (in days) between the two time points.

Net Assimilation Rate (NAR)

The formula used to calculate Net Assimilation Rate (NAR) is:

$$NAR = \frac{(W_2 - W_1) \times (\ln L_2 - \ln L_1)}{(t_2 - t_1) \times (L_2 - L_1)}$$

Where:

- W_2 is the final dry weight (g) of the crop at a specific time point (e.g., at 60 DAS or at harvest).
- W_1 is the initial dry weight (g) of the crop at the previous time point (e.g., at 30 DAS or at 60 DAS).
- L_2 is the final leaf area (cm^2) of the crop at the same specific time point as W_2.
- L_1 is the initial leaf area (cm^2) of the crop at the same specific time point as $W_{1.}$
- T_2 and T_1 the time interval (in days) between the two time points.

Effective tillers/m²

The number of productive tillers (tillers bearing spikes) in a 1 m^2 area of each experimental plot are counted.

Grains /Spikes

Select a random sample of spikes, count the total grains in each spike, and calculate the average.

Spike length

The length of spikes from the base to the tip (excluding awns) using a ruler is measured, and the average length is calculated.

1000 GW (g)

A sample of 1000 grains from the selected plants was weighed.

Grain Yield

Harvest the grains from each plot, thresh, clean, and weigh them to record the grain yield per unit area (e.g., t /ha).

Stover Yield

After removing the grains, the remaining plant biomass (stover) weigh to record the stover yield.

Biological Yield

Combine the grain yield and stover yield to calculate the total biological yield per unit area.

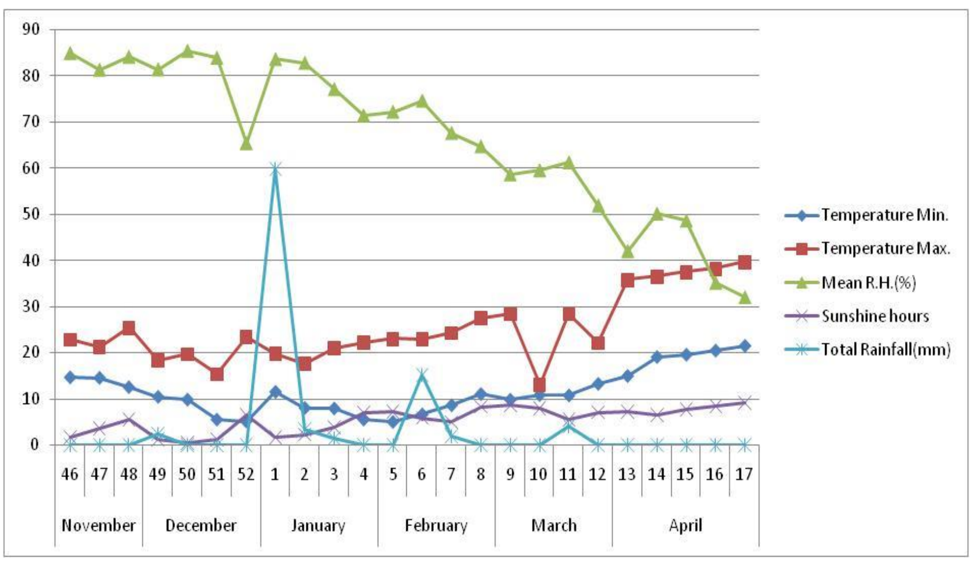
Harvest Index

Use the formula:

(Grain yield / Biological yield) × 100

Collected data were statistically analyzed by the ANOVA using the MS-Excel version. The line sowing method was used to seed the wheat, spacing the rows 15 cm apart. The crop received the full dosages of P (60 kg ha-1) and K (40 kg ha-1) as well as half of the nitrogen (60 kg ha-1) as a basal treatment. The residual nitrogen was used as a top dressing for the boot and tillering phases. The sources of nutrients for N, P, and K were urea, DAP, and nutrients of potash, in that order. In 2023, the crop was picked on April 25, April 30, and May 5.

Fig 1. Experimental site location



Source: Meteorological observatory, Selaqui, Dehradun, Uttarakhand

Fig 2. Mean monthly maximum, minimum temperature and in-crop rainfall during wheat growing period (2023–2024)

Results and discussion

Analysis of variance revealed that there was a significant influence of sowing dates and varieties on the growth and yield of wheat crops.

Effect of sowing dates and varieties on pre-harvest observation of wheat

Plant height at 90 DAS was recorded highest on 20th December (69.23) followed by 30th December (66.52) and minimum on 10th December (66.04). Among the varieties, RR-21 (69.95) showed the highest plant height while the lowest plant height was recorded in PBW-292 (64.25). The Dry weight of the wheat variety was recorded as maximum on 20th December (86.14 cm) and minimum on 10th December. Amongst all, variety RR-21 has shown a higher dry weight at 90 DAS, and a lower dry weight was observed by variety PBW 292. CGR was registered highest by RR21(115.89) and lowest by PBW292 (105.68). Crop sown on 20th December has recorded highest CGR (103.09), whereas lowest was recorded for crop sown on 10th December (79.62). Similarly, performance of variety RR-21 was significantly highest for LAI (3.17), RGR (12.83) and NAR (34.54). Among the sowing dates, crop sown on 20th December was found significantly highest for the traits i.e. LAI (3.06), RGR(12.80), NAR (24.25).

Table 1. Pre -Harvest observation of wheat (*Triticum aestivum* L.)

	Treatments	**Pre - Harvest observation 90 DAS**					
		Plant Height (cm)	**Dry Weight (g)**	**C.G.R gm^{-2}day^{-1}**	**L.A.I** (%)	**R.G.R gm^{-1}day^{-1}**	**N.A.R gm^{-2} day^{-1}**
	Varieties						
V_1	RR-21	69.95	88.53	115.89	3.17	12.83	34.54

V_2	SY-255	68.14	86.44	113.65	3.13	12.80	7.76
V_3	PBW-550	66.72	84.01	108.13	2.94	12.62	3.98
V_4	PBW-292	64.25	78.66	105.68	2.66	12.42	2.94
	F test	S	S	S	S	S	S
	SEd (±)	0.91	0.96	2.54	0.07	0.08	6.12
	CD (P= 0.05)	1.88	2.00	4.95	0.15	0.16	12.68
	Sowing Date						
S_1	10 Dec.	66.04	82.44	79.62	2.86	12.50	7.51
S_2	20 Dec.	69.23	86.14	103.09	3.06	12.80	24.25
S_3	30 Dec.	66.52	84.65	101.27	3.00	12.73	5.16
	F test	S	S	S	S	S	S
	SEd (±)	0.79	0.83	2.15	0.06	0.07	5.30
	CD (P= 0.05)	1.63	1.73	4.35	0.13	0.14	10.99

Effect of sowing dates and varieties on yield attributes

All yield attributes were significantly affected by the date of sowing along with the different varieties used for research study. Delayed sowing decreased grains per spike, effective tillers, spike length, 1000-grain weight, grain yield, Stover yield, biological yeild and harvest index.

Sowing on December 20th significantly influenced entire attributing characters and significantly superior than the 10th and 30th December sowing (Table 2). A comparison of the sowings revealed that crop sown on December 20th had on average higher grains per spike (25.42) than crop sown on 30th December (22.61). Grains per spike were registered significantly highest by RR21 whereas PBW 292 has observed the lowest no. grains per spike. Results of the analysis indicated that the spike length was lengthier for the sowing on December 20th than it was for the sowing on December 10th and December 30th. Likewise, crop sown on 20th of December had a greater number of effective tillers compared to the sowing that took place on 10th and 30th

December. Characters like 1000 GW, Grain yield, biological yield and harvest index showed the similar pattern, maximum values were achieved by crop on sowing date 20th December compared to the sowing dates 10th December and 30th December.

Low germination in late-sown wheat is caused due to temperature variations. With delayed sowing, the temperature decreases and fails to meet the necessary conditions for seedling germination. Late sown crops also encountered a lower number of tillers due to reduced germination rate, caused by lower temperatures. Differences among varieties may be due to their genetic diversity **(Tahir *et al.*, 2009)**. The decrease in plant height, LAI, NAR, biological yield and stover yield in late sowing was due to shorter growing periods. Additionally, low germination of crop, causes weed emergence was more than usual, which resulted into crop weed competition which resulted into lesser plant height, dry weight, CGR and RGR. In contrast to this Early sown crop may have enjoyed better growing environment conditions especially solar radiation and rise in temperature, resulted into increased plant height.

These outcomes are consistent with the findings of **(Shehzad *et al*. 2002).** The reduction in growing time and shriveling of grain due to high temperatures that occurred throughout the milk and grain filling stages were the major causes of the test weight decrease on December 30th as a result of the delayed seeding. Additionally, **(Ram *et al*. 2012)** showed increased growth degree days, photo-thermal units, and yield characteristics in wheat that was planted immediately, which resulted in superior grain yields.

Comparing variety RR-21 to the other three, it has been shown to have a greater test weight (44.68 g), biological yield (95.46 t/ha), number of effective tillers (530.99), grain per spike (25.42), and spike length (13.76) (Table 2.). The favorable temperature that RR-21 wheat crop variety needs to accumulate more photosynthetic activity, which raises production, may be the cause of the crop variety's greater yield features. Researchers **(Akhtar *et al*. 2002), (Kumar *et al*. 2005), and (Patel *et al*. 1999)** have noted a similar pattern across the many types. RR-21 is the cultivar with the highest grain yield *i.e.*, 42.47 t/ha. With a weight of 52.99 t/ha the cultivar RR-21 has produced the largest Stover and has the greatest harvest index (44.49%), according to the data. When seeds were planted on time, the harvest index was much greater than when seeds were sown later. Furthermore, there was no noticeable difference in the varieties' effects on the harvest index. Furthermore, **(Ram *et al*. 2012).** reported notable genotype heterogeneity in yield and harvest index.

Table 2. Post -Harvest observation of wheat (*Triticum aestivum* L.)

	Treatments	Post - Harvest observation							
		1000 GW (g)	Grain Yield (q/ha)	Stover Yield (q/ha)	Biological Yield (q/ha)	Harvest Index	Effective tillers (No.)	Grain /spike (No.)	Spike length (cm)
	Varieties								
V_1	RR-21	44.68	42.47	52.99	95.46	44.49	530.99	25.42	13.76
V_2	SY-255	42.42	41.89	52.53	94.28	44.40	523.81	24.07	13.17
V_3	PBW-550	42.07	39.29	52.39	90.01	43.76	505.33	21.77	13.09
V_4	PBW-292	40.22	35.82	52.02	88.35	40.51	493.82	19.50	12.62
	F test	S	S	S	NS	S	S	S	S
	SEd (±)	0.98	0.54	0.50	1.12	0.73	10.31	0.39	0.22
	CD(P=0.05)	2.03	1.12	1.03	2.31	1.51	21.37	0.82	0.46
	Sowing Date								
S_1	10 Dec.	41.28	39.11	51.79	91.17	91.17	42.19	22.27	13.00
S_2	20 Dec.	43.52	40.35	53.10	92.70	92.70	44.32	23.19	13.29
S_3	30 Dec.	42.25	40.14	52.56	91.55	91.55	43.17	22.61	13.18
	F test	S	S	NS	S	S	S	S	S

SEd (±)	0.85	0.47	0.43	0.97	0.97	0.63	0.34	0.19
CD(P=0.05)	1.76	0.97	0.89	2.00	2.00	1.31	0.71	0.39

Conclusion :

This study underscores the importance of optimizing sowing dates and selecting appropriate wheat varieties to improve wheat production, directly benefiting the livelihood of farmers in Uttarakhand. Sowing on December 20th resulted in the highest plant height, dry weight, Crop Growth Rate (CGR), Leaf Area Index (LAI), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR). This date provided optimal growing conditions, leading to superior growth and yield attributes compared to December 10th and 30th sowings. Delayed sowing dates negatively affected germination rates, plant height, tiller numbers, and overall yield due to lower temperatures and reduced growing periods. Among the varieties tested, RR-21 consistently showed the best performance. Selecting high-yielding varieties like RR-21 can significantly enhance wheat productivity, providing a stable and higher income for farmers. Improved wheat yields directly contribute to food security and economic stability for farming communities in Uttarakhand, enhancing their livelihoods.

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