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Assess impact of different sowing dates and irrigation levels on growth and yield of wheat varieties under tarai region of Uttarakhand

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ABSTRACT

A study was conducted to assess impact of different sowing dates and irrigation levels on growth and yield of wheat varieties under Western Himalayan foothills using field data from wheat varieties HD-2967 and PBW-502 under varied sowing dates (15th November 25th November, and 5th December) and irrigation levels (three, four, and five irrigations). Early sowing on 15th November significantly increased grain yield with HD-2967 yielding 51.4 q/ha and PBW-502 48.4 q/ha, compared to late sowing on 5th December (44.5 and 42.3 q/ha, respectively); SEm± = 0.92, CD (5%) = 2.61. Plant height was also significantly higher under early sowing, with values of 95.8 cm (HD-2967) and 95.0 cm (PBW-502); SEm± = 1.24, CD (5%) = 3.53. A two-way ANOVA showed highly significant effects of sowing date and irrigation level on both grain and biological yield. Under five irrigations, maximum grain yields were recorded: 49.3 q/ha (HD-2967) and 47.4 q/ha (PBW-502); SEm = ±1.05, CD (5%) = 2.98.

Keywords: Wheat, Sowing Date, Irrigation Level, Grain Yield, Biological Yield

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INTRODUCTION

Wheat (Triticum aestivum L.) is a globally significant staple crop, serving as a key source of carbohydrates and protein for a large portion of the world's population. (Gupta et al., 2021). In India, wheat production is significantly influenced by agronomic practices, including sowing dates and irrigation levels, which directly impact crop growth, development, and yield (Chhokar et al., 2023; Khan et al., 2021). The tarai region of Uttarakhand, characterized by its unique agro-climatic conditions, presents both opportunities and challenges for wheat cultivation (Sati, 2024; Kumar and Singh, 2019). The choice of appropriate sowing time and optimal irrigation management is critical for maximizing productivity and ensuring sustainable wheat production (Pareek et al., 2024).

Sowing time plays a crucial role in determining the duration of various phenological stages, crop growth, and final yield (Langangmeilu, et al., 2023). Early and timely sowing allows wheat crops to utilize favorable environmental conditions, including temperature and solar radiation, leading to better vegetative growth and higher yields (Kumar et al., 2023; Patel and Meena, 2019). Conversely, delayed sowing can shorten the crop's life cycle, expose it to higher temperatures during grain filling, and ultimately reduce grain yield (Mishra et al., 2021).

Similarly, irrigation management is a key factor affecting wheat growth and productivity (Choudhary et al., 2020). Adequate irrigation ensures a continuous supply of moisture, which influences plant height, biomass accumulation, and grain yield (Meena et al., 2024). The frequency and timing of irrigation impact various phenological stages, with higher irrigation levels promoting extended crop growth and improved yield attributes (Saha et al., 2020). However, water scarcity or suboptimal irrigation can lead to moisture stress, affecting tillering, flowering, and grain development, thereby reducing overall yield (Rehman et al., 2023).

The present study was undertaken to assess the impact of different sowing dates and irrigation levels on the growth and yield of two wheat varieties, HD-2967 and PBW-502, under the tarai region of Uttarakhand. The findings of this study aim to provide insights into optimizing wheat production by identifying the most suitable sowing time and irrigation regime for this region.

MATERIALS AND METHODS

A field experiment was conducted during the rabi seasons of 2017–18 and 2018–19 in Block C6 of the Norman E. Borlaug Crop Research Center, part of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. This center is located in the Udham Singh Nagar district of Uttarakhand, within the Tarai region at the base of the Shivalik hills in the Himalayas. The research focused on evaluating the effects of varying sowing dates and irrigation schedules on the growth

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and yield of different wheat varieties. The study area is geographically positioned at 29° 00' N latitude, 79° 28' E longitude, and is situated 244 meters above sea level.

The experiment was laid out in a factorial design, incorporating three sowing dates i.e., 15th November, 25th November, and 5th December and three irrigation treatments consisting of three, four, and five irrigations. Weather-related parameters such as daily minimum and maximum temperatures, relative humidity, duration of sunshine, rainfall, and pan evaporation were obtained from the agro-meteorological observatory located at the research centre.

The soil at the experimental site is classified as mollisol (sub-order: Udoll, great group: Hapludoll) and belongs to the Haldi soil series. It is derived from calcareous parent material as described by Deshpande et al. (1971), with a moderate to coarse texture. These soils typically develop under the influence of tall grasses in conditions ranging from poor to well drainage. They originate predominantly from alluvial deposits.

The experiment of this study was structured in a split-plot design considering three replications to assess the effect of different sowing dates and irrigation levels on the growth and yield of wheat. In this setup, the main plot treatments included three sowing dates: 15th November (D1), 25th November (D2), and 5th December (D3), while the sub-plot treatments comprised three irrigation regimes: five irrigations (I1), four irrigations (I2), and three irrigations (I3). Two wheat cultivars, HD-2967 and PBW-502, were chosen for their suitability to the local agro-climatic conditions. The trial was laid out following a randomized complete block design (RCBD).

Before sowing, the field was thoroughly prepared through ploughing and leveling to create a fine seedbed conducive to uniform germination. Sowing was done with a seed drill, maintaining a row spacing of 22.5 cm for optimal plant population. Irrigation was administered as per the treatment schedule, with water quantities adjusted according to the specified irrigation levels. Nutrient management followed the recommended N:P:K ratio, with urea, di-ammonium phosphate (DAP), and muriate of potash (MOP) serving as the fertilizer sources. At sowing, the entire quantities of phosphorus and potassium, along with half of the nitrogen, were applied. The remaining nitrogen was administered in two equal split doses: one during the tillering stage and the other at the jointing stage to support optimal crop development.

Observations Recorded

1. Phenological Development-The number of days taken to reach key phenophases, such as CRI, 75% tillering, jointing, anthesis, and physiological maturity, was recorded for each treatment.
2. Growth Parameters- Plant height was recorded at 30, 60, and 90 days after sowing (DAS), as well as at the time of harvest. To evaluate vegetative growth and overall plant development under different treatments, measurements were taken from five randomly selected plants within each plot.
3. Yield Attributes and Yield
   - Biological Yield (q/ha): The total biomass per plot was harvested and converted into yield per hectare.
   - Grain Yield (q/ha): Grain yield was assessed by threshing and weighing the harvested produce from each plot, serving as the key indicator of crop productivity.
   - Harvest Index (%): This parameter indicates the efficiency of the plant in converting biomass into grain yield. The harvest index was computed using the formula:

$$\text{Harvest Index} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \text{X}100$$

The experimental data were analyzed statistically using Analysis of Variance (ANOVA) to determine the significance of treatment effects. To compare the treatment means, the Least Significant Difference (LSD) test was employed at the 5% level of significance.

RESULTS AND DISCUSSION

Effect of sowing time on growth and development of Wheat varieties

Crop Development

Number of days taken to attain various phenophases

The time taken to reach various phenological stages in the wheat crop under different sowing dates was recorded for CRI, 75% tillering, jointing, anthesis, and physiological maturity. The number of days required to reach these phenological stages is shown in Table 1. A longer duration to reach the CRI stage was observed in the late sowing dates, likely due to lower temperatures that hinder early crop growth. For other stages, such as 75% tillering, jointing, flowering, milking, and physiological maturity, the crop sown on 15th November took longer to reach these stages compared to those sown on 25th November and 5th December. A detailed analysis of the data indicates that the number of days required for different phenophases decreased as sowing was delayed, resulting in a shorter growth period for late-sown crops. Delayed sowing leads to a reduction in the crop's overall life span, resulting the plant to reach various stages earlier than those sown on time. Similar findings were reported by Islam (2017) and Ram et al. (2012) in their field experiments.

Table 1: Effect of sowing date and irrigation on phenophases of HD-2967 and PBW-502 wheat (mean of two years 2017-18 and 2018-19)

Treatments	HD-2967	PBW-502										
Date of Sowing	Phenological Stages	Phenological Stages										
	CRI	75% Tillering	Jointing	Flowering	Milking	Maturity	CRI	75% Tillering	Jointing	Flowering	Milking	Maturity
15-Nov.	20	27	52	85	110	138	20	28	53	87	112	139
25-Nov.	21	29	48	82	104	135	22	29	50	83	108	137
05-Dec.	22	26	46	80	99	133	23	27	47	81	105	135
SE(m) ±	0.2	0.2	0.3	0.4	0.3	0.5	0.4	0.2	0.4	0.4	0.3	0.5
CD (p=0.05)	0.7	0.5	1.0	1.0	0.8	1.4	1.1	0.7	1.3	1.1	0.8	1.3
Level of irrigation												
5-Irrigations	23	29	54	86	112	137	24	29	56	88	115	140
4-Irrigations	22	28	52	84	109	134	23	30	53	87	112	136
3-Irrigations	21	26	48	82	106	131	22	27	49	83	109	134
SE(m) ±	0.2	0.2	0.3	0.4	0.3	0.5	0.4	0.2	0.4	0.4	0.3	0.5
CD (p=0.05)	0.7	0.5	1.0	1.0	0.8	1.4	1.1	0.7	1.3	1.1	0.8	1.3

Crop Growth and Yield Attributes

Plant height

Crop height is largely governed by a variety's genetic characteristics, although environmental conditions and crop management practices also play significant roles (Li et al., 2018; Li et al., 2021; Guo et al., 2020; Mu et al., 2022). Plant height for different sowing date treatments was recorded at 30, 60, and 90 days after sowing (DAS) and at harvest. The plant height data for various sowing dates are summarized in Table 1. For the HD-2967 wheat variety, the plant height at 30 DAS was 32.3 cm, 28.6 cm, and 26.4 cm for the sowing dates of 15th November, 25th November, and 5th December, respectively. Similarly, for the PBW-502 variety, the plant height at 30 DAS was 32.0 cm, 28.1cm, and 25.9 cm for the same sowing dates. At 60 DAS, the HD-2967 variety showed plant heights of 63.9 cm, 61.6 cm, and 58.7 cm for the sowing dates of 15th November, 25th November, and 5th December, respectively. For PBW-502 at 60 DAS, plant height was 63.1 cm, 61.1 cm, and 58.2 cm for the corresponding sowing dates. The tallest plants were recorded at 90 DAS for the 15th November sowing. At harvest, the plant height for HD-2967 was 95.8 cm, 93.0 cm, and 88.7 cm for the sowing dates of 15th November, 25th November, and 5th December, respectively, while for PBW-502, the recorded heights were 95.0 cm, 92.5 cm, and 88.2 cm for the same sowing dates.

Figure 1 (a and b) depicts that plant height is Decreasing with delay in date of sowing. Critical analysis of plant height observations for both the varieties (HD-2967 and PBW-502) indicated that the highest plant height was observed in case of 1st date of sowing i.e. 15th November; the performance of plants sown on 5th December was poorest. The findings align with those of Gora et al. (2017), Whaid et al. (2017) and Chandra and Srivastava (2020), who suggested that earlier sowing is more favorable for producing taller plants compared to later sowing dates. In the case of delayed sowing, the growing period is shorter during the early stages of growth but relatively longer during the subsequent stages, which, combined with higher temperatures, leads to a reduced overall growth period and poorer plant characteristics. Early-sown crops benefit from more favorable environmental conditions, such as optimal temperatures and increased solar radiation, which support better vegetative growth.

Table 2: Temporal variation of plant height in wheat crop as influenced by different dates of sowing and irrigation levels (mean of two years 2017-18 and 2018-19)

Treatment	HD-2967	PBW-502					
	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
Date of Sowing								
15 November	32.3	63.9	83.4	95.8	32.0	63.1	82.7	95.0
25 November	28.6	61.6	80.9	93.0	28.1	61.1	80.4	92.5
5 December	26.4	58.7	76.8	88.7	25.9	58.2	76.3	88.2
SE(m) ±	0.7	0.8	0.6	0.7	0.6	0.8	0.6	0.6
CD (p=0.05)	2.1	2.4	1.8	2.1	1.8	2.4	1.8	1.8
Level of irrigation								
5 Irrigations	32.2	68.7	85.9	98.2	31.4	67.9	85.1	97.4
4 Irrigations	29.3	62.7	80.1	91.9	28.6	61.9	79.3	91.1
3 Irrigations	27.2	56.8	75.1	87.3	26.7	56	74.4	86.5
SE(m) ±	0.7	0.8	0.6	0.7	0.6	0.8	0.6	0.6
CD (p=0.05)	2.1	2.4	1.8	2.1	1.8	2.4	1.8	1.8

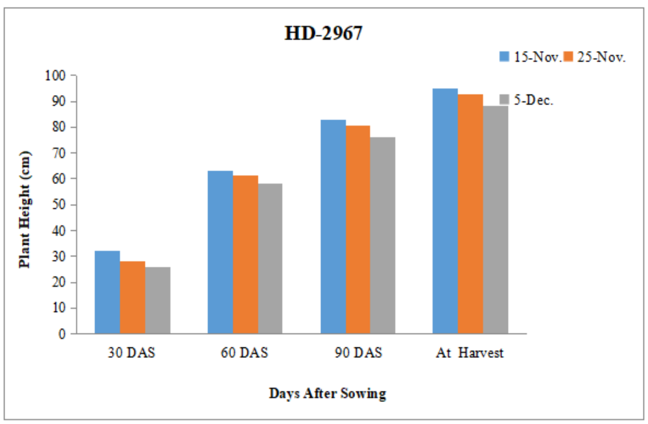


Fig. 1: Temporal variation of plant height (cm) in HD-2967 wheat variety as influenced by different dates of sowing

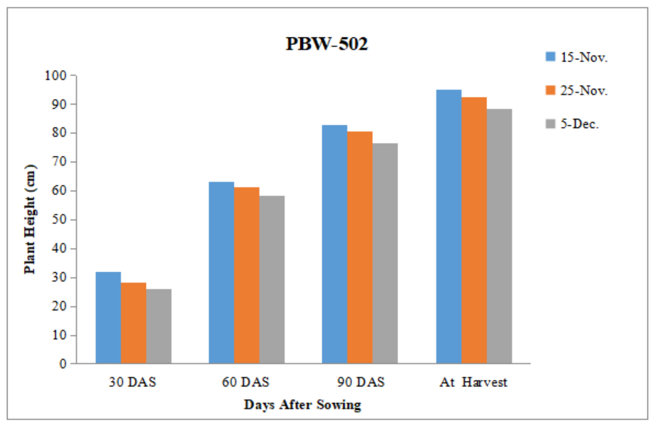


Fig. 2: Temporal variation of plant height (cm) in PBW--502 wheat variety as influenced by different dates of sowing

Biological yield

Table 3 presents the biological yield obtained from different sowing date treatments, which is also illustrated in Figure 2 for both wheat varieties HD-2967 and PBW-502. For wheat variety HD-2967 biological yield was obtained 116.5 q/ha, 111.0q/ha and 102.4 q/ha for the different dates of sowing dates viz., 15th November, 25th November and 05th December respectively. In case of wheat variety PBW-502 biomass was obtained 109.4 q/ha, 105.3 q/ha and 95.8 q/ha for three dates of sowing i.e. 15th November, 25th November and 05th December, respectively. Highest biological yield was recorded for the crop sown on 15th November for both the wheat varieties (HD-2967 biological yield 116.5 q/ha and PBW-502 biological yield 114.3 q/ha). It might be due to more days taken to attain physiological maturity stage for 15th November sowing date. The crop sown on 5th December produced lowest biological yield for these two wheat varieties (HD-2967 biological yield 102.4 q/ha and PBW-502 biological yield 99.8 q/ha). These findings are in conformity with the Ram et al. (2012), Burman (1994) and Dubey et al. (2019). Kumar et al. (2015) also reported that the biological yield was significantly decreased as sowing delayed after second week of November.

Table 3: Impact of sowing date and irrigation levels on the biological yield (q/ha) and grain yield (q/ha) of HD-2967 and PBW-502 wheat varieties (mean of two years 2017-18 and 2018-19)

Treatments	HD-2967		PBW-502	
	Yield (q/ha)		Yield (q/ha)	
Date of Sowing	Biological	Grain	Biological	Grain
15-November	116.5	51.4	109.4	48.4
25-November	111.0	48.7	105.3	46.6
5-December	102.4	44.5	95.8	42.3
SE(m) ±	0.7	0.8	0.6	0.8
CD (p=0.05)	2.1	2.4	1.8	2.4
Level of irrigation				
5 Irrigations	109.9	49.3	107.2	47.4
4 Irrigations	105.7	47.2	102.4	45.4
3 Irrigations	95.2	39.2	93.7	36.7
SE(m) ±	0.7	0.8	0.6	0.8
CD (p=0.05)	2.1	2.4	1.8	2.4

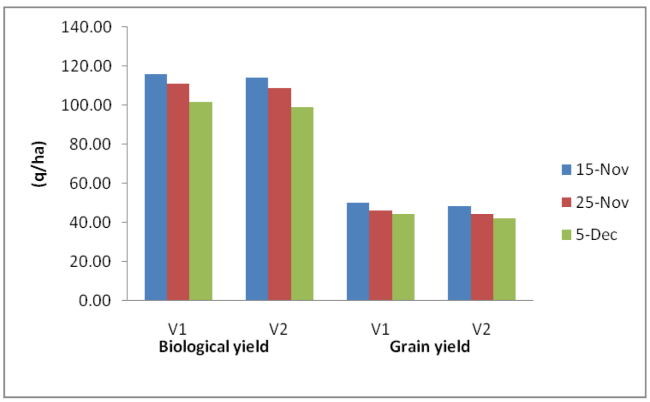


Fig. 3: Effect of sowing dates on biological yield (q/ha) and grain yield of HD-2967 and PBW-502 wheat varieties

Grain yield

The grain yield of wheat, influenced by different sowing dates, is presented in Table 3. Crop sown on 15th November resulted in highest grain yield compare to other two sowing dates (25th November and 05th December). Average Grain yield was recorded with crop sown on 15th November for HD-2967 variety is 51.4 q/ha and for PBW-502 variety grain yield is 48.4 q/ha. The grain yield recorded for 15th November sowing dates was significantly higher than the crop sown on 25th November (HD-2967 grain yield 48.7 q/ha and PBW-502 grain yield 46.6 q/ha) and 05th December (HD-2967 grain yield 44.5 q/ha and PBW-502 grain yield 42.3 q/ha).The later sowings subjected to higher temperatures (6 to 70C), relatively higher evaporative demand (3 mm) and relatively lower humidity (12 to 20%) than those of first sowing during post flowering period till maturity. The negative impact of heat stress during the later stages of crop development and earing in delayed sowing adversely affected grain yield. A reduction in grain yield due to delayed sowing has also been documented by Ram et al. (2012), Burman (1994) and Dubey et al. (2019). The delay in sowing likely led to a decrease in grain yield as the crop was exposed to higher temperatures, shortening the growing period (Ouda et al., 2005). The above normal temperature of the last two weeks of March has an adverse effect on grain yield. This is significant for the wheat crop because the above-normal temperature during this period reduces wheat productivity regardless of the date of sowing.

Effect of irrigation levels on growth and development of Wheat varieties

Crop Development -Number of days taken to attain various phenophases

The time taken to various phenological stages in wheat crop under different irrigation levels was recorded for CRI, 75% tillering, jointing, anthesis and physiological maturity. The number of days required to reach the aforementioned phenological stages is shown in Table 1. The noticeable delay in the development of various phenophases under the four and five irrigation treatments could be attributed to the increased availability of irrigation water and continuous moisture supply to the crop due to more frequent irrigations. Extended crop growth under higher irrigation levels has also been observed by Kumar et al. (2015).

Crop Growth and Yield Attributes

Plant height

Irrigation water is one of the limiting factors in crop production that directly or indirectly affects the phenological development as well as the yield of the crop (Baloch et al., 2010). Effect of different irrigation levels (number of irrigations five, four and three) was analyzed for both the wheat crop varieties (HD-2967 and PBW-502) in the rabi season of 2017-18 and 2018-19 and represented in table 4.2. For wheat variety HD-2967 plant height at 30 DAS was recorded 32.2 cm, 29.3 cm and 27.2 cm for the five, four and three irrigation levels respectively while the plant height for PBW-502 wheat variety at 30 DAS was observed as 31.4 cm, 28.6 cm and 26.7 cm for the five, four and three irrigation levels respectively. Likewise, plant height was recorded at 60 DAS, 90 DAS and at harvest stage for both the wheat varieties. Plant height (mean of 2017-18 and 2018-19) for different treatments was found to be varying significantly. Statistical analysis of the experimental field data revealed that at all the growth stages, effect of levels of irrigation was significant (Figure 4.5 a and b) on plant height. Critical examination of the data reveals that plant height increases with the increase in number of irrigations (five, four and three irrigations) at different phenological stages (Figure 4.5 a and b). Similar findings have been also reported by Bray (1997); Gora et al. (2017) and Mahmud et al. (2016). As the number of irrigations increases, adequate supply of moisture to the plant may have increased succulence in the meristematic cells and maintained turgor which results in to the taller plants (Li et al., 2018).

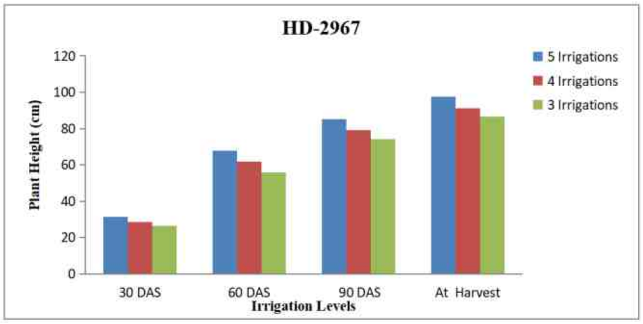


Fig. 4: Temporal variation of plant height (cm) in HD-2967 wheat variety as influenced by different levels of irrigation

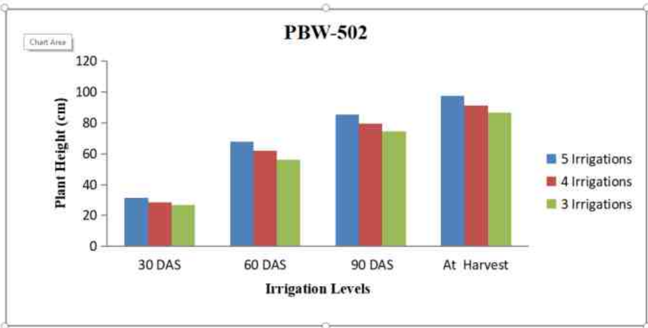
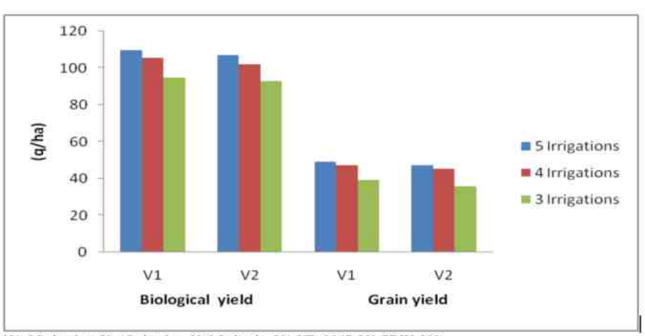


Fig. 5: Temporal variation of plant height (cm) in PBW-502 wheat variety as influenced by different levels of irrigation

Biological yield

Biological yield obtained through different treatments of irrigation levels is presented in table 3 and depicted in figure 3 for both wheat varieties HD-2967 and PBW-502. It can be seen from the table 3 that for wheat variety HD-2967 when five irrigations were applied the biomass recorded as high as 109.9 q/ha compared to 95.2 q/ha when only three irrigations were applied.



*I1-5 Irrigation, I2-4 Irrigation, I3-3 IrrigationV1-HD-2967, V2-PBW-502

Fig. 5: Effect of Irrigation levels on biological yield (q/ha) and grain yield of HD-2967 and PBW-502 wheat varieties

The difference recorded in observed biomass between four and three irrigation levels compared to fifth irrigation level are 4.2 q/ha and 14.7 q/ha, respectively. For wheat variety PBW-502, maximum biomass was obtained 107.2 q/ha when five irrigations were applied as compared to 93.7 q/ha when only three irrigations were applied. Therefore, irrigation frequency has also a significant impact on wheat yield and maximum biomass was produced when five irrigations were applied for these two wheat varieties (HD-2967 yield 109.9 q/ha and PBW-502 yield 107.2 q/ha). Atikullah et al. (2014) also reported the similar findings.

Grain yield

Grain yield of wheat as affected by different levels of irrigation has been presented in Table 3. Highest grain yield was obtained when five irrigations were applied for both the varieties HD-2967 and PBW-502 (HD-2967 grain yield 49.3 q/ha and PBW-502 grain yield 47.4 q/ha). As it is already mentioned that the water is one of the most important factors to determine the yield of crop, therefore water scarcity may lead to different types of stresses in the crop and ultimately yield is reduced due to low water availability (Mahmud et al., 2016).

CONCLUSION

In conclusion, the study highlights the significant impact of sowing dates and irrigation levels on the growth and yield of wheat varieties in the Tarai region of Uttarakhand. Early sowing (15th November) resulted in better crop development, with higher plant height, biological yield, and grain yield compared to later sowing dates. Similarly, higher irrigation levels (5 irrigations) consistently promoted better growth and higher yields, underlining the importance of timely water supply. Overall, the combination of early sowing and adequate irrigation optimized wheat productivity, emphasizing the need for region-specific agronomic practices to improve wheat yield in this agro-climatic zone.

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