E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(9): 17-24
Received: 17-06-2024
Accepted: 26-07-2024

Rohit Kumar
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Kartikeya Choudhary
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Ranjeet Singh Bochalya
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Diksha Sharma
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Samriti Chandel
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Corresponding Author:
Rohit Kumar
Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh, India

Effect of different sowing dates on growth and yield of wheat varieties

Rohit Kumar, Kartikeya Choudhary, Ranjeet Singh Bochalya, Diksha Sharma and Samriti Chandel

DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sa.1414

Abstract
The present experiment was conducted at Shoolini University, Solan during *rabi* season of 2023-24 to study the effect of different sowing dates on growth and yield of wheat varieties. The soil of experimental field was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and higher in available phosphorus. The experiment was laid out in Split Plot Design assigning four varieties in main plot comprising of (V_1) HPW-368, (V_2) HPW-349, (V_3) HPW-373 and (V_4) HPW-360 and sowing dates in sub-plot *viz.* (D_1) 5th November, (D_2) 20th November and (D_3) 5th December. Thus, a total of 12 treatment combinations were tested in the study and were replicated thrice. Recommended dose of nitrogen, phosphorus and potassium (120:60:30 Kg ha^{-1}) were applied through urea, SSP and MOP, respectively. Full dose of phosphorus and potassium and half dose of nitrogen were applied at the time of sowing as basal and remaining dose of nitrogen was applied into two split doses at CRI and tillering stage. The total rainfall experienced during the crop growing season was 209 mm. Result indicated that variety (V_2) HPW-349 sown on (D_1) 5th November exerted significantly higher growth, yield attributes and yield of wheat under mid hills of Himachal Pradesh.

Keywords: Sowing dates, wheat varieties, growth performance, yield attributes, phenological stages

Introduction
The most significant staple food crop in the world, wheat (*Triticum aestivum* L.), has emerged as the foundation of India's food security. Due to its wide range of adaptability and great nutritional value, it is grown all over the world. It is a significant winter cereal that contributing about 38% of India's entire crop of food grains. It secures second position as a source of staple food after rice crop, in India. It has good nutrition profile with 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugars, 6.7% pentose's sugar and provides 314 Kcal/100 g of food. Wheat is also a good source of minerals and vitamins *viz.* calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), riboflavin (0.13 mg/100 g) and nicotinic acid (5.4 mg/100 mg) (Singh *et al.*, 2021) [29].
The countries leading in wheat cultivation are China, India, Russia and U.S.A. Globally, it is cultivated on an area of 217.89 million ha with the production and productivity of 756.95 million tonnes and 3.47 tonnes ha^{-1}, respectively (MoA & FW, 2021-22) [4]. Wheat is the second most important staple food crop of India after rice, cultivated in about 30.47 million hectares with the production and average yield of 106.84 million tonnes and 3507 Kg ha^{-1}, respectively (MoA & FW, 2021-22) [4]. The major growing districts in Himachal Pradesh are Kangra, Mandi, Una, Sirmaur and Bilaspur. However, in Solan district, the total wheat area and production is 23022 hectares and 46552 metric tonnes with average yield 2020 Kg ha^{-1} (Statistical abstract of Himachal Pradesh, 2022-23) [5].
Optimum sowing time helps plant to attain favourable environment. Timely sowing of wheat increases number of tillers (m^{-2}), number of spikes, grains spike^{-1} and grain weight, which ultimately increases the grain yield (Qasim *et al.*, 2008) [25]. The unfavourable conditions brought about by high temperatures, particularly during the grain filling stage, can be reduced by varying the sowing time to a time that works best for various varieties that are suited for early, normal and late sowing environmental conditions for guaranteed higher yield (Gupta *et al.*,

2020; Gupta *et al*., 2022) [15, 14].

The time of sowing is important because it allows wheat to flower when environmental pressures like heat and frost are at their lowest. Sowing time is a very important zero cost management strategy responsible for the good productivity of crops. When wheat is sown late, it experiences low temperatures early in the growing season and high temperatures later. It also needs optimal moisture levels for optimal growth and development (Alam *et al.*, 2013) [3]. Under late sown condition wheat crop exposed to low temperature at the germination, which delayed the crop emergence and higher temperature at the reproductive phase leads to force maturity and resulted in reduction of the yield and yield attributes (Gupta *et al*., 2017) [12].

Variety is another important factor playing a crucial role in producing high yield of wheat. Different varieties respond differently for their genotypic characters, input requirement, growth process and the prevailing environment during growing season (Sultana *et al*., 2012) [32]. Crop productivity is also impacted by improper variety selection because a variety's performance varies according to its genetic potential and adapted environment. Cultivating climate-resistant wheat varieties can therefore increase wheat yield (Hussain *et al*., 2012) [16].

Materials and Methods

The experiment was conducted during *rabi* season of 2023-24 at Chamelti Agriculture Farm at the elevation of 1,270 meters above mean sea level lying between latitude 30°85'67.30 N and longitude 77°13'20.38 E, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan (H.P.) which is situated 30 km away from Solan city.

The experiment was arranged in Split Plot Design and replicated thrice. There were 12 treatment combinations assigning four varieties in main plot comprising of (V_1) HPW-368, (V_2) HPW-349, (V_3) HPW-373 and (V_4) HPW-360 and sowing dates in sub-plot *viz*. (D_1) 5th November, (D_2) 20th November and (D_3) 5th December. Recommended dose of nitrogen, phosphorus and potassium (120:60:30 Kg ha^{-1}) were applied through urea, SSP and MOP, respectively. Full dose of phosphorus and potassium and half dose of nitrogen were applied at time of sowing as basal and remaining dose of nitrogen was applied into two splits at CRI and tillering stage. The soil of experimental field was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and higher in available phosphorus. The crop was sown as per treatments with row spacing of 20 cm. The total rainfall received during the crop season (November to May, 2023-24) was 209 mm. Observations were taken as per standard procedure. In order to test the significance of result, standard statistical method based on the analysis of variance technique as suggested by (Panse and Sukhatme, 1967) [24] was employed. The treatment differences were compared with the critical difference (CD) at 5% level of significance to ascertain their significance.

Results and Discussion

Effect on crop growth parameters

The data presented in (Table 1-4) revealed that sowing dates and varieties had significant effect on crop growth parameters. The data revealed that significantly higher crop growth parameters *viz.* plant height, number of tillers, chlorophyll content (SPAD value) and dry matter accumulation were recorded with variety (V_2) HPW-349 which was statistically at par with (V_1) HPW-368. While, among the sowing dates, (D_1) 5th November recorded significantly higher crop growth parameters over rest of the sowing dates.

This increase in plant height might be due to wheat took proper time and favourable condition to attain its growth and development. According to Mukherjee (2012) [20] and Tahir *et al.* (2009) [33] timely sowing wheat observed maximum plant height over rest of sowing dates due to wheat that was sown on time had a more favourable temperature than wheat that was sown later, which showed up as increased crop growth. Shahzad *et al.* (2007) [28] revealed that the genetic diversity of a genotype mostly determines the crop's height, while environmental conditions can also have an impact.

According to Nizamuddin *et al.* (2014) [21] and Dubey *et al.* (2019) [10] increased number of tillers might be a result of improved environmental factors, such as ideal temperature and solar radiation, which directly affected the crop's ability to absorb nutrients and which in turn, produced more green photosynthetic area (source), which is responsible for the formation of carbohydrates and ultimately enhanced the crop's capacity for tillering. The observed variations in the number of tillers among genotypes can be related to the genetic factor of tillering potential exhibited by different genotypes. Similar results were reported by Bachhao *et al.* (2018) [6] and Madhu *et al.* (2018) [19].

According to Ahmed and Hassan (2015) [2] Increased chlorophyll SPAD values in timely-sown crops might be a result of the crop achieving suitable environmental conditions to meet its needs. The observed variation in chlorophyll content of varieties might be due to genetic variability of the genotypes.

Table 1: Effect of sowing dates on periodic plant height (cm) of wheat varieties

Treatments	Plant height (cm)					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
Main plot (Varieties)						
V_1: HPW-368	12.72	21.96	40.08	82.58	85.77	83.39
V_2: HPW-349	13.69	23.06	43.22	87.05	91.45	87.25
V_3: HPW-373	11.19	18.04	36.39	77.20	79.39	77.18
V_4: HPW-360	8.77	14.19	30.36	70.43	72.65	71.67
S.Em±	0.30	0.50	0.93	2.11	2.26	2.14
LSD (p=0.05)	1.03	1.72	3.20	7.31	7.82	7.39
Sub plot (Sowing dates)						
D_1: 5th November	12.90	22.85	41.98	85.58	88.52	87.09
D_2: 20th November	11.69	19.25	37.65	79.71	82.67	79.82
D_3: 5th December	10.20	15.84	32.91	72.66	75.75	72.71
S.Em±	0.21	0.33	0.71	1.38	1.57	1.39
LSD (p=0.05)	0.64	1.00	2.13	4.15	4.70	4.17
Interaction (V × D)	S	S	S	S	S	S

Table 1.1: Interaction effect of sowing dates on plant height of wheat varieties at 30 DAS

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	13.04	16.78	11.77	9.99	12.90
20th November	12.77	13.93	11.49	8.55	11.69
5th December	12.35	10.37	10.30	7.76	10.20
Mean	12.72	13.69	11.19	8.77	
S.Em±	0.43		LSD (p=0.05)	1.28	

Table 1.2: Interaction effect of sowing dates on plant height of wheat varieties at 60 DAS

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	25.13	27.60	21.19	17.50	22.85
20th November	22.56	21.09	18.71	14.63	19.25
5th December	18.20	20.49	14.22	10.45	15.84
Mean	21.96	23.06	18.04	14.19	
S.Em±	0.67		LSD (p=0.05)	2.00	

Table 1.3: Interaction effect of sowing dates on plant height of wheat varieties at 90 DAS

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	47.94	48.04	36.38	35.54	41.98
20th November	38.34	42.35	39.19	30.71	37.65
5th December	33.96	39.26	33.60	24.83	32.91
Mean	40.08	43.22	36.39	30.36	
S.Em±	1.42		LSD (p=0.05)	4.27	

Table 1.4: Interaction effect of sowing dates on plant height of wheat varieties at 120 DAS

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	85.61	90.08	89.92	76.71	85.58
20th November	86.30	84.92	77.20	70.42	79.71
5th December	75.83	86.16	64.49	64.15	72.66
Mean	82.58	87.05	77.20	70.43	
S.Em±	2.77		LSD (p=0.05)	8.29	

Table 1.5: Interaction effect of sowing dates on plant height of wheat varieties at 150 DAS

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	88.80	93.28	92.90	79.13	88.52
20th November	89.49	89.92	78.70	72.56	82.67
5th December	79.02	91.16	66.57	66.27	75.75
Mean	85.77	91.45	79.39	72.65	
S.Em±	3.14		LSD (p=0.05)	9.40	

Table 1.6: Interaction effect of sowing dates on plant height of wheat varieties at harvest

Sowing Dates	Varieties				
	HPW-368	**HPW-349**	**HPW-373**	**HPW-360**	**Mean**
5th November	87.38	91.35	90.73	78.90	87.09
20th November	86.49	85.71	76.62	70.45	79.82
5th December	76.29	84.70	64.20	65.67	72.71
Mean	83.39	87.25	77.18	71.67	
S.Em±	2.78		LSD (p=0.05)	8.34	

Table 2: Effect of sowing dates on periodic number of tillers (m^{-2}) of wheat varieties

Treatments	Number of tillers (m^{-2})				
	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
Main plot (Varieties)					
V_1: HPW-368	143.35	200.69	262.90	244.84	236.81
V_2: HPW-349	145.13	205.18	273.13	254.88	244.75
V_3: HPW-373	131.68	183.36	243.77	233.46	227.04
V_4: HPW-360	111.79	156.51	211.46	202.94	199.68
S.Em±	3.52	4.92	6.40	6.01	5.07
LSD (p=0.05)	12.17	17.04	22.15	20.79	17.53
Sub plot (Sowing dates)					
D_1: 5th November	146.32	205.10	272.08	256.80	249.10
D_2: 20th November	129.32	181.30	241.14	227.77	221.02
D_3: 5th December	123.32	172.90	230.22	217.52	211.10
S.Em±	2.31	3.24	4.21	3.95	3.55
LSD (p=0.05)	6.94	9.71	12.62	11.85	10.63
Interaction (V × D)	NS	NS	NS	NS	NS

Table 3: Effect of sowing dates on periodic chlorophyll content (SPAD value) of wheat varieties

Treatments	Chlorophyll content (SPAD value)				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
Main plot (Varieties)					
V_1: HPW-368	39.87	43.12	52.81	54.69	52.92
V_2: HPW-349	42.15	45.13	55.15	59.54	56.35
V_3: HPW-373	37.18	39.06	50.09	53.32	51.17
V_4: HPW-360	36.07	37.57	49.18	50.81	50.07
S.Em±	0.96	1.07	1.21	1.52	1.17
LSD (p=0.05)	3.32	3.70	4.19	5.27	4.04
Sub plot (Sowing dates)					
D_1: 5th November	40.70	42.92	54.80	57.17	54.52
D_2: 20th November	37.99	40.59	51.47	53.61	52.05
D_3: 5th December	37.76	40.16	49.15	52.99	51.31
S.Em±	0.72	0.76	0.89	1.13	0.83
LSD (p=0.05)	2.16	2.26	2.65	3.40	2.49
Interaction (V x D)	NS	NS	NS	NS	NS

Table 4: Effect of sowing dates on dry matter accumulation (g m^{-2}) of wheat varieties

Treatments	Dry matter accumulation (g m^{-2})					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
Main plot (Varieties)						
V_1: HPW-368	12.91	46.54	89.55	247.42	384.69	493.71
V_2: HPW-349	13.74	50.11	94.29	259.62	403.82	524.34
V_3: HPW-373	11.45	42.90	81.34	231.29	346.36	434.77
V_4: HPW-360	8.89	38.60	73.47	188.59	278.09	338.95
S.Em±	0.26	1.06	1.98	5.83	9.41	12.18
LSD (p=0.05)	0.91	3.68	6.87	20.18	32.55	42.15
Sub plot (Sowing dates)						
D_1: 5th November	13.16	47.19	89.44	245.83	393.57	517.38
D_2: 20th November	11.89	44.19	83.79	228.37	354.61	457.71
D_3: 5th December	10.19	42.24	80.77	220.99	311.55	368.74
S.Em±	0.18	0.71	1.36	3.88	5.77	9.09
LSD (p=0.05)	0.54	2.13	4.08	11.62	17.29	27.25
Interaction (V × D)	S	S	S	S	S	S

Table 4.1: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at 30 DAS

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	14.34	15.96	12.88	9.48	13.16
20th November	13.96	13.61	11.10	8.90	11.89
5th December	10.42	11.65	10.38	8.31	10.19
Mean	12.91	13.74	11.45	8.89	
S.Em±	0.36		LSD (p=0.05)	1.08	

Table 4.2: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at 60 DAS

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	49.29	54.71	45.31	39.44	47.19
20th November	44.83	47.07	45.23	39.65	44.19
5th December	45.51	48.56	38.15	36.72	42.24
Mean	46.54	50.11	42.90	38.60	
S.Em±	1.42		LSD (p=0.05)	4.26	

Table 4.3: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at 90 DAS

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	90.67	100.82	90.25	76.01	89.44
20th November	86.54	90.89	81.19	76.53	83.79
5th December	91.46	91.16	72.59	67.87	80.77
Mean	89.55	94.29	81.34	73.47	
S.Em±	2.72		LSD (p=0.05)	8.16	

Table 4.4: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at 120 DAS

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	252.41	271.92	233.90	225.08	245.83
20th November	251.36	255.43	225.85	180.84	228.37
5th December	238.50	251.51	234.11	159.85	220.99
Mean	247.42	259.62	231.29	188.59	
S.Em±	7.75		LSD (p=0.05)	23.24	

Table 4.5: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at 150 DAS

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	386.57	439.17	374.09	374.46	393.57
20th November	387.48	421.44	351.41	258.10	354.61
5th December	380.02	350.85	313.60	201.71	311.55
Mean	384.69	403.82	346.36	278.09	
S.Em±	11.54		LSD (p=0.05)	34.58	

Table 4.6: Interaction effect of sowing dates on dry matter accumulation of wheat varieties at harvest

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	533.65	587.63	459.79	488.44	517.38
20th November	509.68	555.36	449.59	316.22	457.71
5th December	437.79	430.04	394.94	212.19	368.74
Mean	493.71	524.34	434.77	338.95	
S.Em±	18.18		LSD (p=0.05)	54.50	

The increase in dry matter accumulation were also reported by Singh *et al.* (2022) [30] and Kaur (2020) [18], A timely sown crop may have taken longer than expected to reach the required growth and development which could account for the higher dry matter accumulation. On the other hand, a crop that was sown later may have had a shorter growth season, which led to shorter plant heights and fewer tillers, both of which would have decreased the amount of dry matter that accumulated in the wheat. The variety's higher dry matter accumulation might have resulted from faster initial growth, more tillering and larger leaf area, all of which increased photosynthetic efficiency and dry matter accumulation. Similar results were reported by Bachhao *et al.* (2018) [6].

Interaction effect of sowing dates and varieties on crop growth parameters: Interaction effect of sowing dates and varieties was found to be significant on plant height and dry matter accumulation at all the growth stages. The data revealed that variety (V_2) HPW-349 recorded significantly higher plant height and dry matter accumulation when sown on (D_1) 5th November over rest of the treatments.

Effect on yield attributes and yield

The data presented in Table 5 and Table 6 revealed that variety (V_2) HPW-349 recorded significantly higher yield attributes *viz.* number of effective tillers, number of grains spike^{-1}, spike length, test weight and yield *viz.* grain, straw and biological yield and harvest index which was statistically at par with (V_1) HPW-368. However, among the sowing dates, (D_1) 15th November recorded significantly higher yield attributes and yield i.e., number of effective tillers, number of grains spike^{-1}, grain, straw and biological yield over rest of the sowing dates. While, sowing dates had no significant effect on spike length, test weight and harvest index.

Mukherjee (2012) [20] and Kamrozzaman *et al.* (2016) [17] also reported that crop that was sown on time had a noticeably increased number of productive tillers. The yield of the wheat crop is directly correlated with the number of efficient tillers.

The ear density and crop output will both increase with the number of effective tillers. Timing of sowing may have contributed to a higher number of effective tillers because of favourable weather conditions that extended the vegetative period and increased solar radiation absorption. This in turn positively impacted the total number of tillers. More the spike density, more will be number of effective tillers. Differences in number of effective tillers among varieties might be attributed to their genetic diversity (Shah *et al.* 2006) [27].

Agrawal *et al.* (2001) [1] and Kaur *et al.* (2020) [18] also observed significantly higher number of grains spike^{-1} under timely sown conditions. This could be as a result of the anthesis stage having a proper temperature which produced viable pollen and a longer grain filling time, both of which led to an increase in the number of grains produced per spike.

The increase in spike length might be due to maximum growing degree days and favourable weather conditions which led to increase in spike length. According to Baloch *et al.* (2010) [7] and Tomar *et al.* (2014) [34] Reduction in spike length in late sown condition might be due to crop may have been forced to finish its life cycle earlier than intended which accelerated the senescence of leaves and the flag leaf which intercepts solar radiation. This resulted in insufficient assimilate absorption and translocation through the source for the development of reproductive organs, and might have contributed to the reduction in spike length.

Kaur *et al.* (2020) [18] reported that the higher 1000 grain weight in early and timely sowing may be due to higher number of grains spike^{-1}. Deshmukh *et al.* (2015) [8] also reported that earlier sowing of the crop resulted in higher 1000 grain weight than that the crop sown late in the season. According to Shahzad *et al.* (2002) [28] and Pandey *et al.* (2010) [23] Delayed sowing decreased the test weight. This was mostly because the high temperatures that prevailed during the milk and grain filling stage caused the grain to shrivel.

Ram *et al.* (2012) [26] and Gupta *et al.* (2021) [13] also revealed that the possible reason behind the significant higher yield values in early sowing might be the availability of optimum environmental conditions for growth and development of crop which could have enhanced accumulation of photosynthates from source to sink and thus resulted in higher yield values. Subhan *et al.* (2003) [31] and Qasim *et al.* (2008) [25] concluded that crop planted on 15th November, produced higher grain yield as compared to late and early planting. Differences of grain yield among the varieties might be due to the inherent quality of varieties. Similar results were also confirmed with Tyagi *et al.* (2004) [35].

Madhu *et al.* (2018) [19] also found that highest performance of yield component was recorded with timely sown crop. The increased straw yield observed in variety HPW-349 can be attributed to its genotype's enhanced tillering capacity, which facilitates more efficient utilization of available resources such as radiation and nutrients. Consequently, this genotype exhibits heightened photosynthetic activity, ultimately leading to a greater straw yield. This is in contrary to findings of Fayed *et al.* (2015) [11] who also found significant variation in straw yield of different varieties.

Table 5: Effect of sowing dates on yield attributes of wheat varieties

Treatments	Yield attributes			
	No. of effective tillers (m^{-2})	No. of grains spike^{-1}	Spike length (cm)	Test weight (g)
Main plot (Varieties)				
V_1: HPW-368	224.22	47.70	12.25	41.82
V_2: HPW-349	235.00	48.65	13.21	44.87
V_3: HPW-373	211.55	43.48	11.34	40.41
V_4: HPW-360	178.74	42.41	10.99	40.05
S.Em±	5.57	1.32	0.36	1.00
LSD (p=0.05)	19.28	4.57	1.25	3.44
Sub plot (Sowing dates)				
D_1: 5th November	225.69	48.26	12.48	42.51
D_2: 20th November	208.68	45.30	11.95	41.57
D_3: 5th December	202.76	43.12	11.42	41.28
S.Em±	3.74	0.83	0.30	0.70
LSD (p=0.05)	11.21	2.48	NS	NS
Interaction (V x D)	NS	NS	NS	NS

Table 6: Effect of sowing dates on yield (kg ha^{-1}) and harvest index (%) of wheat varieties

Treatments	Yield (Kg ha^{-1})			Harvest index (%)
	Grain yield	Straw yield	Biological yield	
Main plot (Varieties)				
V_1: HPW-368	2315	3515	5830	39.59
V_2: HPW-349	2491	3670	6161	40.65
V_3: HPW-373	1956	3120	5076	38.54
V_4: HPW-360	1466	2365	3831	37.98
S.Em±	58	90	146	0.54
LSD (p=0.05)	202	311	506	1.87
Sub plot (Sowing dates)				
D_1: 5th November	2695	4124	6819	39.44
D_2: 20th November	1861	2874	4735	39.11
D_3: 5th December	1615	2504	4119	39.02
S.Em±	39	73	108	0.31
LSD (p=0.05)	116	217	324	NS
Interaction (V x D)	S	S	S	NS

Table 6.1: Interaction effect of sowing dates on grain yield of wheat varieties at harvest

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	3114	3365	2067	2232	2695
20th November	2039	2285	1868	1251	1861
5th December	1792	1824	1931	913	1615
Mean	2315	2491	1956	1466	
S.Em±	78		LSD (p=0.05)	232	

Table 6.2: Interaction effect of sowing dates on straw yield of wheat varieties at harvest

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	4611	5031	3342	3514	4124
20th November	3169	3379	2950	1998	2874
5th December	2766	2600	3068	1583	2504
Mean	3515	3670	3120	2365	
S.Em±	145		LSD (p=0.05)	435	

Table 6.3: Interaction effect of sowing dates on biological yield of wheat varieties at harvest

Sowing Dates	Varieties				
	HPW-368	HPW-349	HPW-373	HPW-360	Mean
5th November	7725	8396	5409	5746	6819
20th November	5208	5663	4819	3250	4735
5th December	4558	4424	4999	2496	4120
Mean	5831	6161	5076	3831	
S.Em±	216		LSD (p=0.05)	647	

The increase in biological yield might be due to higher grain and straw yield which led to increase in biological yield. The increased biological yield of variety HPW-349 can be ascribed to its capacity for generating a greater quantity of tillers, hence resulting in an expanded leaf area. This expansion of leaf area then boosts photosynthetic activity, ultimately leading to elevated yields. The genetic make-up of varieties affects the yield of crop. Similar results were reported by Alam *et al.*, (2013) [3] and Pal *et al.*, (2013) [22].

Dhyani *et al.* (2010) [9] reported that decline in harvest index in late sowing as compared to early sowing might be due to higher temperature during reproductive stages in normal and late sowings.

Interaction effect of sowing dates and varieties on yield

Interaction effect of sowing dates and varieties on yield was found to be significant. The data revealed that variety (V_2) HPW-349 sown on (D_1) 5th November recorded significantly higher grain yield, straw yield and biological yield (kg ha^{-1}) over rest of the treatments.

Conclusion

The data concluded that variety (V_2) HPW-349 sown on (D_1) 5th November recorded significantly higher crop growth, yield attributes and yield of wheat under mid hills of Himachal Pradesh.

References

1. Agrawal KK, Upadhyay AP, Upendra S, Gupta VK. Phenological behaviour and thermal requirements of wheat genotypes under different dates of sowing. Ann Plant Soil Res. 2001;3(1):12-16.
2. Ahmed M, Hassan F. Response of spring wheat (*Triticum aestivum* L.) quality traits and yield to sowing date. PLoS One. 2015;13(7):1-16.
3. Alam MP, Kumar S, Ali N, Manjhi RP, Kumari N, Lakra KR, et al. Performance of wheat varieties under different sowing dates in Jharkhand. Soc Adv Wheat Res. 2013;5(2):61-64.
4. Anonymous. Ministry of Agriculture and Farmers Welfare data, New Delhi; c2021-22.
5. Anonymous. Statistical abstract of Himachal Pradesh. Department of Economic and Statistics, Government of Himachal Pradesh, Shimla; c2022-23.
6. Bachhao KS, Kolekar PT, Nawale SS, Kadlag AD. Response of different wheat varieties to different sowing dates. J Pharmacogn Phytochem. 2018;7(1):2178-2180.
7. Baloch MS, Shah ITH, Nadim MA, Khan MI, Khakwani AA. Effect of seeding density and planting time on growth and yield attributes of wheat. J Anim Plant Sci. 2010;20(4):239-240.
8. Deshmukh KM, Nayak SK, Damdar, Rupali, Wanjiri SS. Response of different wheat genotypes to different sowing time in relation to GDD accumulation. Adv Res J Crop Improv. 2015;6(1):66-72.
9. Dhyani KK. Physiological evaluation of terminal heat tolerance in different genotypes of wheat (*Triticum aestivum* L.). Ph.D. Thesis, GBPUA&T, Pantnagar, Uttaranchal; c2010.
10. Dubey R, Pathak H, Singh S, Chakravarti B, Thakur AK, Fagodia RK. Impact of sowing dates on terminal heat tolerance of different wheat (*Triticum aestivum* L.) cultivars. Nat Acad Sci Lett. 2019;42:445-449.
11. Fayed TB, Eman IES, Mosaad KH, Ahmed M. Evaluation and prediction of some wheat cultivars productivity in relation to different sowing dates under North Sinai region conditions. Ann Agric Sci. 2015;60(1):11-20.
12. Gupta S, Singh RK, Sinha NK, Singh A, Shahi UP. Effect of different sowing dates on growth and yield attributes of wheat in Udham Singh Nagar District of Uttarakhand, India. Plant Arch. 2017;17(1):232-236.
13. Gupta V, Gupta M, Bharat R, Singh M, Kour S, Sharma BC. Effect of sowing environments and N-levels on wheat varieties under irrigated region of Jammu. Indian J Agric

Sci. 2021;91(4):515-520.
14. Gupta V, Gupta M, Sandhu SS, Singh M, Kour S, Bharat R, et al. Evaluation of wheat varieties and their validation through CERES-Wheat model under lower foothills of Shivalik range of N-W Himalayas. AMA Agric Mech Asia Africa Latin Am. 2022;53(2):6051-6065.
15. Gupta V, Gupta M, Singh M, Sharma BC. Thermal requirement for phenophases and yield of wheat varieties under various sowing environments and nitrogen levels in sub-tropical region of Jammu. J Agrometeorol. 2020;22(Special Issue):170-177.
16. Hussain M, Mehmood Z, Khan MB, Farooq S, Dong-Jin L. Narrow row spacing ensures higher productivity of low tillering wheat cultivars. Int J Agric Biol. 2012;14:413-418.
17. Kamrozzaman MM, Khan MAH, Ahmed S, Sultana N, Ruhul Quddus AFM. Evaluation of five wheat varieties on arsenic contaminated soils of Bangladesh. Int J Appl Sci Biotechnol. 2016;4(3).
18. Kaur A, Akarsh SG, Prasad R. Effect of date of sowing and varieties on growth and yield of wheat in mid hill conditions of Himachal Pradesh. Int J Chem Stud. 2020;8(4):1490-1493.
19. Madhu U, Begum M, Salam A, Sarkar SK. Influence of sowing date on the growth and yield performance of wheat (*Triticum aestivum* L.) varieties. Arch Agric Environ Sci. 2018;3(1):89-94.
20. Mukherjee D. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) cultivars under mid hill situation of West Bengal. Indian J Agronomy. 2012;57(2):152-156.
21. Nizamuddin, Kabir R, Hussain M, Tajudin, Jan R, Gurman ZA. Effect of sowing dates on growth and yield of wheat (*Triticum aestivum* L.). Life Sci Int J. 2014;8(30):67-70.
22. Pal RK, Rao MNN, Murty NS. Agrometeorological indices to predict plant stages and yield of wheat for foot hills of western Himalayas. Int J Agric Food Sci Technol. 2013;4:909-914.
23. Pandey B, Pandey RK, Dwivedi DK, Singh RS. Phenology, heat unit requirement and yield of wheat (*Triticum aestivum*) varieties under different crop growing environment. Indian J Agric Sci. 2010;80(2):136-140.
24. Panse VG, Sukhatme RV. Statistical methods for agricultural workers. 4th ed. New Delhi: ICAR; c1985.
25. Qasim M, Qamer M, Faridullah M, Alam M. Sowing dates effect on yield and yield components of different wheat cultivars. J Agric Res. 2008;46(2):135-140.
26. Ram H, Singh G, Mavi GS, Sohu VS. Accumulated heat unit requirement and yield of irrigated wheat (*Triticum aestivum* L.) varieties under different crop growing environment in central Punjab. J Agrometeorol. 2012;14:147-153.
27. Shah WA, Bakht J, Ullah T, Khan AW. Effect of sowing dates on the yield and yield components of different wheat varieties. J Agron. 2006;5(1):106-10.
28. Shahzad MA, Din WU, Sahi ST, Khan Ehsanullah MM, Ahmad M. Effect of sowing dates and seed treatment on grain yield and quality of wheat. Pak J Agric Sci. 2007;44(4):581-583.
29. Singh G, Pandey SN, Kumar R, Maurya SC, Prajapati SK. Effect of weather parameters, date of sowing on performance of wheat varieties (*Triticum aestivum* L.). Int J Res Agron. 2021;4(2):97-99.
30. Singh G, Pandey SN, Prajapati SK, Yadav S. Effect of weather parameters, date of sowing on performance of wheat varieties (*Triticum aestivum* L.). Int J Sci Res. 2022;11(8):1449-1451.
31. Subhan F, Khan M, Jamro GH. Weed management through planting date, seeding rate and weed control method in wheat. Pak J Weed Sci Res. 2003;9(1-2):49-57.
32. Sultana MR, Alim MA, Hossain MB, Karmaker S, Islam MS. Effect of variety and weed management practices on yield and yield attributes of wheat. J Environ Sci Nat Resour. 2012;5(2):91-96.
33. Tahir M, Ali A, Nadeem MA, Hussain A, Khalid F. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) varieties in district Jhang, Pakistan. Pak J Life Soc Sci. 2009;7(1):66-69.
34. Tomar SPS, Tomar S, Srivastava SC. Yield and yield component response of wheat (*Triticum aestivum* L.) genotypes to different sowing dates in Gird region of Madhya Pradesh. Int J Farm Sci. 2014;4(2):1-6.
35. Tyagi PK, Pannu RK, Sharma KD, Chaudhary BD, Singh DP. Post-anthesis dry matter accumulation and its portioning in different wheat (*Triticum aestivum*) genotypes under varying growing environment. Indian J Agronomy. 2004;49(3):163-167.