



Effect of Sowing Dates and Varieties of Wheat Crop (*Triticum aestivum* L.) on Growth and Productivity under Changing Climate

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted at Crop Research Station Masodha, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P) during Rabi season November, 2017-April, 2018. In the field environment, the growth of wheat was greatly influenced by temperature changes associated with sowing dates. The productivity of wheat is highly vulnerable to climate change. The experiment laid out in Split plot design (SPD) with 3 replication and four different dates of sowing (05th November, 25th November, 15th December, 05th January) in a main plot against six varieties of the Wheat crop (HD-3086, HS-562, HI-1544, WR-544, MACS-6222 and HD-2967) in sub plot.. Growth parameters were higher in early sown crops as compared with late sown wheat crops. Among varieties HD-3086 sown on 25th November obtained the highest growth parameter as compared to HS-562, HD-2967, HI-1544, MACS-6222 and WR-544. Growth and yield potential of crop or variety are the outcomes of genomic, environmental and agronomic interactions. Due to the reduction in tillering period and increased risk of hot weather during grain filling, late planting results in a linear reduction in wheat grain yield. It may be concluded that optimum sowing time of wheat crop is 25th November as compared to late sown wheat. Among the variety HD-3086 is the most promising variety.

Keywords: *Productivity; sowing dates; varieties; wheat.*

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is very important from the food security point of view and is the second main source of the world's food energy and nutrition. Wheat being a cool season crop is generally sown from the last week of October to the last week of November in this part of India. Significant reduction in grain yield and yield components is mainly due to delay in sowing of crops, up to mid-December which exposes the crop to high temperature during the grain filling period. Wheat maintains superiority in area, production and versatility in adopting a wide range of agro climates. Delayed sowing exposes crops to adverse conditions such as low temperatures during vegetative growth, resulting in a low germination rate, poor tillering ability, and low plant population [1,2]. Late sowing delays flowering and exposes crops to high temperatures during the grain-filling stage, thus accelerating reproductive development and reducing grain-filling [3, 4]. The sowing date is crucial to allow wheat to flower during the period with minimum stresses, such as frost and heat. Sowing time is a very important zero cost management strategy responsible for the good productivity of crops. Under late sown conditions, wheat face low temperature in the earlier part and high temperature in the later part of the growing season and require favorable moisture for better growth and development. The wheat sown on the normal date of sowing (25th November) attained 15 days late physiological maturity as compared to late sown condition [5]. Eyshi et al. [6] conclude that it is essential to account for interactions between climate and crop management in climate change impact analysis and assessment studies and that difference among crops need to be considered. Liu et al., [7] results showed that grain yield declined by $0.97 \pm 0.22\%$ with each one-day change (either early or delayed) in sowing beyond the normal sowing date. Delayed sowing also increases the possibility of crops exposure to high temperature during the grain filling stage, which is harmful to leaf photosynthesis, grain filling, and final yield formation. These are considered to be the key stressors for wheat production in many environments around the world [8]. Grogan et al. [9] revealed that the yield plasticity of a genotype was positively correlated with its maximum and minimum grain yield across environments, indicating greater plasticity was favorable under optimal conditions, without a penalty under low-yielding conditions. Xiao et al. [10] highlight that the modern cultivars and

agronomic management contributed dominantly to yield increase. Trnka et al., [11] revealed that climate scenarios based on the most recent ensemble of climate models and greenhouse gases emission estimates, we assessed the probability of single and multiple adverse events occurring within one season.

Climate is a reality and affects the poor in a developing country in many ways such as growth potential. An analysis of crop relationship using historic production statistics for the Wheat crop. Global warming over recent decades has created extended growing periods prior to wheat wintering, encouraging farmers to delay the sowing date for winter wheat [12,13]. An overview of the state of the knowledge of the possible effect of the climate variability and change on wheat production indicates that an increase in 10⁰C mean temperature, associated with Co₂ increase could not cause any significant loss to wheat production if simple adaptation strategies such as a change in planting and varieties are used. Early sowing enhanced germination unit area⁻¹, plant height, spikelets spike⁻¹, grains spike⁻¹ and 1000-grain weight over late sowing. Among various factors responsible for the low growth of the wheat crop, sowing time and varietal selection are of primary importance. Wheat is sown in winter and it has its own definite requirements for temperature and light for emergence, growth and flowering. Farooq et al., [14] revealed that warm temperature (>30 °C) significantly inhibits plant photosynthesis under water stress conditions (shortage of rainfall). The optimum growth of the wheat crop is showing decreasing trends as the sowing delay due to shorter growth period available to late sown crop coupled with high temperature. Too early sowing produces weak plants with a poor root system as the temperature is above optimum. Temperature above optimum leads to irregular germination and the embryo frequently dies and the endosperm may undergo decomposition due to activities of bacteria or fungi. Rezaei et al., [15] concluded that the single-cultivar concept commonly used in climate change impact assessments results in an overestimation of winter wheat sensitivity to increasing temperature, which suggests that studies on climate change effects should consider changes in cultivars. Baloch et al., [16] reported that October 20th recorded higher plant height 98.7 cm as compared to October 30th planted wheat 84.6 cm. this reduction was subsequently increased with delay in sowing. The increasing trends of plant height were observed in a period

of 7- 70 days and average 7.47 number of tiller spike⁻¹. Taqa et al., [17] revealed the changes in crop system dynamics and cultivars traits have to be sufficiently taken into account to improve the prediction of climate impacts and to plan adaptations for future. The observed length of spike 4.81 to 13.86 and the number of grain spike⁻¹ varied between 23.22 and 93.51 dates after sowing. The effect of date of sowing on the growth of wheat was assessed on a stand counts per m⁻², plant height at various stages (cm), leaf area index at different stages, dry matter accumulation and number of tillers m⁻² and yield attributes viz. test weight, number of grains ear head⁻¹, ear head m⁻², length of the ear (cm). Different varieties respond variably under different dates of sowing. It has been realized that the average yield of wheat in this region, sown during November, is well comparable to the state average, but the declining trend in wheat yield has been noticed with delayed sowing i.e. in December and January. Impacts of temperature on wheat sown on 15 March were found to be as severe as to exterminate the crop before heading [18]. It is mostly due to the shorter growth period available to late sown wheat coupled with high temperature and hot winds during the reproductive growth period, which leads to forced maturity and ultimately poor grain yield. In addition to this, improper selection of varieties in this region also affects the crop yield He et al., [19] reported that applying a crop simulation model using a field-tested standard cultivar across locations and years indicated that the simulated phenological stages have accelerated with the warming trend more than the observed phenological stages. This indicated that, over the last decades, later sowing dates and the introduction of new cultivars with longer thermal time requirement have compensated for some of the increased temperature-induced changes in wheat phenology. At present, there is tremendous scope for increasing the yield of wheat with the use of multi-character high yielding varieties [20]. Zhang et al. [21] reported that the grain yield from the field measured data with weather factors showed that sunshine hours and diurnal temperature difference (DTR) were positively, and relative humidity was negatively related to grain yield of winter wheat. Wheat growers at different locations will require different strategies in managing the negative impacts or taking the opportunities of future climate change [22]. It is clear that under late sowing conditions, plants faced adverse weather factors such as low temperature and less thermal exposure during sowing to wintering stage compared with the

normal sowing date. These disadvantages may affect early crop growth by inhibiting seed emergence, seedling establishment, and tiller development [23]; [24]. Fatima et al., [25] reported that number of different adaptation strategies based on early sowing, irrigation and a combination of sowing and irrigation adaptations were examined to recover the potential losses that would occur due to climate change.

2. METHODS AND MATERIALS

An experiment was carried out during the year 2017-18 (November- April) at Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya 224229 (U.P.) which is geographically situated between 26.47°N latitude to 82.12°E longitude and at an altitude of 113 m above mean sea level. The mean annual rainfall is about 1194 mm. The weekly mean maximum and minimum temperature during the experiment were 39.2°C and 4.7°C, respectively. It falls under semiarid and sub-tropical climate with hot dry summer and severe cold winter of Indo-Gangetic plains having alluvial calcareous soil. The soil was found silty loam having neutral pH and organic carbon with a value of 0.35, EC (0.25). The soil was moderate for the cultivation of the wheat crop.

The experiment was setup according to the split-plot design with three replication, six main plots treatments [HS 562(V₁), HD 2967(V₂), HD3096 (V₃), HI 1544 (V₄), MACS 6222(V₅), WR 544(V₆)] and four sub plots treatments [05th November(D₁), 25th November(D₂), 15th December(D₃), and 05th January(D₄)] Five irrigation including pre-sown irrigation were applied to the experiment. 72 plots were made for the experiment each with a gross size of 2.40 m x 6.0 m = 14.40 m² and net plot size of 2.0m x 5.0 m = 10.00 m² having a row to row distance of 20 cm. To achieve accurate precision, the appropriate sampling techniques were implied for the proper balance in sampling at minimum cost. For biometric observation, plants were selected randomly in each plot to assess the possible relationship between various growth attributes and variability in climate. The observation were recorded at 30, 60, 90 DAS and at the harvest in the marked area of plots. The land was prepared as per the requirement of the experiment.

3. RESULT AND DISCUSSION

Wheat has been occupying the major share of cultivated land and production has been

increased many folds but the productivity of this crop in eastern U.P. is measurably low mainly because of delayed sowing and improper varietal selection. The present investigation entitled “Performance of Wheat Varieties under Different Sowing Dates on Growth and Productivity in Eastern Uttar Pradesh” was carried out during Rabi season 2017-18. Growth parameter of Wheat viz. stand count m^{-2} , number of tillers m^{-2} , plant height at various stages (cm), leaf area index at different stages and dry matter accumulation and yield parameter viz. test weight, number of grains ear head⁻¹, ear head m^{-2} , length of the ear (cm) were decreased significantly with delay in sowing of the crop. The maximum growth was observed in crops sown on 25th November and minimum growth was observed in crops sown on 05th January. This was due to variability in temperature during the growing period of crop. Crop yield is the final

output of the interaction between the genetic composition of the crop plant population and the external environment including soil, which varied in nature. These external factors influence agronomic practices and thereby constitute a major problem in crop production. Although with the advent of short duration semi-dwarf and dwarf varieties of wheat yield has been increased tremendously, hence a new horizon in their economic requirement has been opened up. Each crop requires an optimum temperature, rainfall, humidity, and other related weather conditions, which are necessary for higher yield. However, such ideal conditions seldom prevail and the plant grows satisfactory within a definite range around its optimum point. If the fluctuations are too wide plants may fail to adjust their rhythm of growth and development and finally, the poor yield is achieved.

Table 1. Effect of sowing dates and wheat varieties on stand count m^{-2}

S. no	Treatment	Stand count m^{-2}
(A)		
Date of sowing		
1	05-11-2017	178.22
2	25-11-2017	176.78
3	15-12-2017	176.33
4	05-01-2018	173.95
	SEM \pm	1.359
	C.D. at 5%	N.S
(B)		
Varieties		
1	HS-562	174.92
2	HD-2967	177.67
3	HD-3086	177.00
4	HI-1544	177.00
5	MACS-6222	173.58
6	WR-544	177.25
	SEM \pm	2.331
	C.D. at 5%	N.S

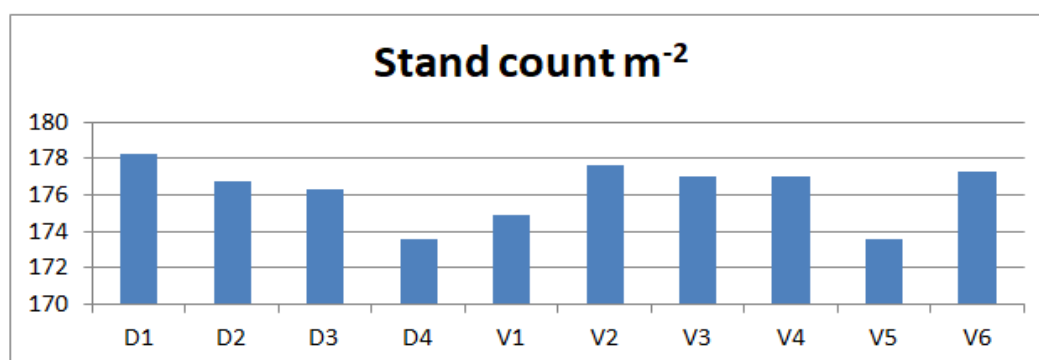


Fig. 1. Effect of sowing dates and wheat varieties on stand count m^{-2}

With delayed sowing time, as was the case with 05th January sowing, winter conditions advanced appreciably and low temperature affected the germination negatively. The crop sown on 05th January therefore, was handicapped from the very start and its germination was lower than the crop sown on 05th November. The germination count was recorded at 15 DAS. It was observed that germination count was gradually decreased as sowing was delayed. However the highest germination count was recorded in the 05th November sown crop (178.22) followed by the crop sown on 25th November (176.68) and the lowest count was recorded in crop sown on 05th January (173.95). Varieties were not found to

bring a significant difference in germination. However, the highest stand count was recorded in HD-2967 (177.67) followed by WR-544 (177.25), HD-3086 (177.0) and the lowest count were recorded in MACS-6222 (173.58) respectively. Cheema et al., [26] reported that the performance of wheat cultivars sown on November 10th and December 10th and noted that crop emergence was impaired when sowing was delayed owing to low temperature prevailing during stand establishment. Which resulted in poor stand establishment and reduced the number of productive tillers and ultimately the final yield.

Table 2. Effect of sowing dates and wheat varieties on plant height at various stages

S. no	Treatment	30 days	60 days	90 days	Harvest
(A)	Date of sowing				
1	05-11-2017	22.66	83.16	92.61	94.50
2	25-11-2017	22.44	80.78	89.96	91.80
3	15-12-2017	21.34	76.82	85.55	87.30
4	05-01-2018	21.56	76.03	84.67	86.40
	SEM±	0.517	1.802	1.227	2.113
	C.D. at 5%	N.S	5.679	3.866	6.657
(B)	Varieties				
1	HS-562	20.04	72.16	80.36	82.00
2	HD-2967	24.44	88.00	98.00	100.00
3	HD-3086	22.98	82.72	92.12	94.00
4	HI-1544	23.22	83.60	93.10	95.00
5	MACS-6222	20.04	72.16	80.36	82.00
6	WR-544	21.27	76.56	85.26	87.00
	SEM±	0.349	1.372	1.420	1.382
	C.D. at 5%	0.998	3.922	4.059	3.950

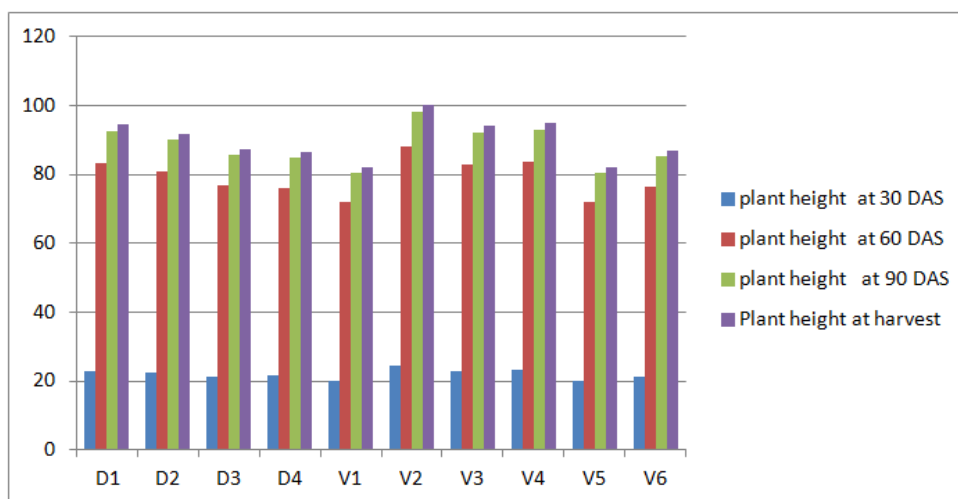


Fig. 2. Effect of sowing dates and wheat varieties on plant height at various stages

The data on plant height was recorded at 30, 60, 90 DAS and maturity as affected by different treatments. An interception of the data revealed that shoot elongation continued to increase with the age of the plants and a fast increase in plant height was found in the early stages of the growth up to 90 DAS and therefore it increases slowly. Plant height showed a decreased trend with delay in sowing. Plant height of Wheat crop sown on 05th November was significantly higher than the crop sown on 15th December and 5th January while remained at par with 25th November sown crops at all the stages of crop growth except at 30 DAS where plant height did not influence significantly. At maturity, the plant

height was highest at crop sown on 05th November (94.50) followed by the crop sown on 25th November (91.80), lowest height was obtained in crop sown on 05th January (86.40) (Fig. 2).

Among the varieties HD-2967 gain significantly higher plant height than the other varieties, at all the stages of crop growth while the lowest height was observed in the varieties HI-1544 (Fig. 2). Pehwa & Gill [27] reported that among the cultivars, PBW-343 had higher value for yield (42.15qha⁻¹) and yield contributing traits under all dates of sowing.

Table 3. Effect of sowing dates and wheat varieties on leaf area index at different stages

S. no	Treatment	30 days	60 days	90 days
(A) Date of sowing				
1	05-11-2017	2.06	4.25	4.51
2	25-11-2017	2.04	4.38	4.59
3	15-12-2017	1.94	4.04	4.26
4	05-01-2018	1.96	4.00	4.15
	SEM±	0.046	0.060	0.077
	C.D. at 5%	N.S	0.189	0.244
(B) Varieties				
1	HS-562	1.82	3.80	3.98
2	HD-2967	2.09	4.35	4.57
3	HD-3086	2.22	4.63	4.84
4	HI-1544	2.11	4.40	4.60
5	MACS-6222	1.93	4.03	4.25
6	WR-544	1.82	3.80	4.02
	SEM±	0.035	0.064	0.069
	C.D. at 5%	0.099	0.182	0.198

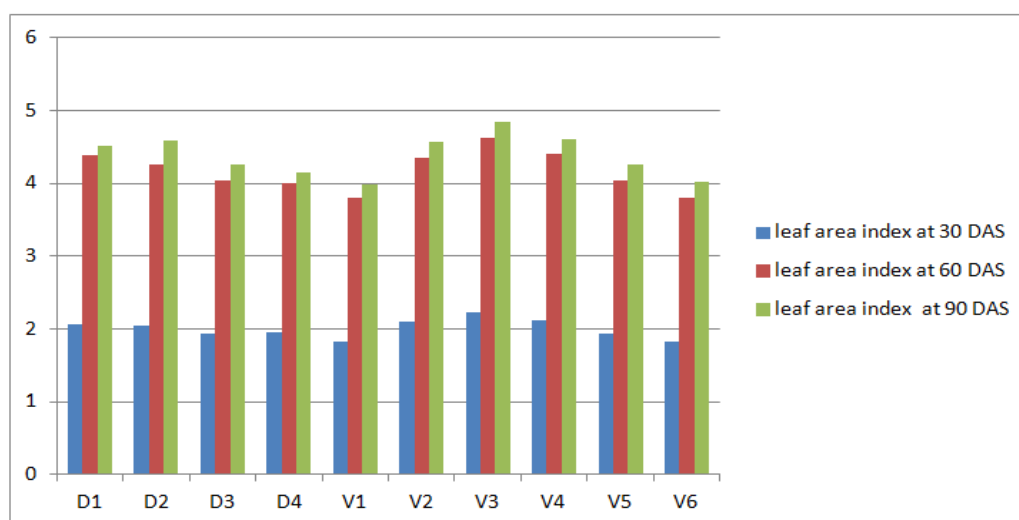


Fig. 3. Effect of sowing dates and wheat varieties on leaf area index at different stages

The data regarding leaf area index was recorded at 30, 60, 90 DAS and the maturity stage of the crop has been summarized in Table no. 3 & Fig. 3. Leaf area index increased at a fast rate up to 60 DAS after that increase was slow. Leaf area index at 30 DAS was found non-significant. However, the maximum leaf area index was recorded under crop sown on 05th November (2.06) (Fig. 3). At 60 and 90 DAS maximum leaf area index (4.25 and 4.51) was recorded with 25th November sowing crop which was at par with 05th November sowing while significantly higher than 15th December and 05th January. Late sowing significantly affected the leaf area index of the wheat crop as the crop sown on 05th January consistently recorded a lower leaf area index (4.15). This might due to the injurious

effect of low temperature on crops during the crop growing season. Alam et al.,[5] reported that sowing of wheat on 25th November resulted in expressing significantly more leaf area index (3.60) resulted in higher than 20th December sown wheat.

Changes in temperature also affect the varietal characteristics. The maximum leaf area index was recorded in HD-3086 (4.84) which was significantly higher than the rest of the varieties. The lowest leaf area index was recorded in HS-562 (3.98) (Fig. 3). Leaf area index increased till 60 DAS stage in all the dates and the maximum leaf area index was recorded in crop sown on 05th November.

Table 4. Effect of sowing dates and wheat varieties on dry matter accumulation at different stages

S. no	Treatment	30 days	60 days	90 days	Harvest
(A) Date of sowing					
1	05-11-2017	249.63	803.60	1071.47	1258.70
2	25-11-2017	241.08	832.11	1109.49	1307.20
3	15-12-2017	198.74	662.47	883.29	1039.17
4	05-01-2018	124.70	356.29	475.06	558.89
	SEM±	4.464	14.639	19.519	22.963
	C.D. at 5%	14.065	46.129	61.505	72.359
(B) Varieties					
1	HS-562	198.57	654.77	873.02	1017.08
2	HD-2967	208.97	681.06	908.08	1052.92
3	HD-3086	216.96	710.63	940.83	1128.40
4	HI-1544	210.36	687.44	916.58	1083.33
5	MACS-6222	200.73	644.86	866.48	1018.44
6	WR-544	185.65	602.97	803.96	945.93
	SEM±	5.427	17.730	23.640	27.812
	C.D. at 5%	15.512	50.676	67.568	79.492

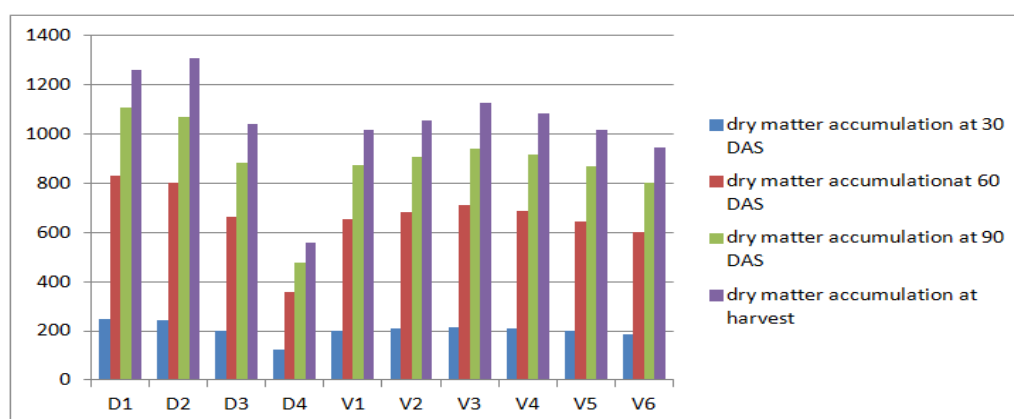


Fig. 4. Effect of sowing dates and wheat varieties on dry matter accumulation at different stages

The data regarding dry-matter accumulation at 30, 60, 90 DAS and at maturity as affected by different treatments have been summarized in Table no. 4 & Fig 4. In general, the dry-matter accumulation by plant continued to increase at successive growth stages and the highest dry-matter accumulation was recorded at maturity. It is marked from the data that dry-matter accumulation significantly decreased by delay in sowing time. At all stages of observation, the crop sown on 25th November accumulated the highest dry-matter, which was significantly higher than the other sowing dates and remained at par

with 05th November sown crop except at 30 DAS where 05th November sowing recorded maximum dry matter which was significantly higher than 15th December and 05th January and at par with 25th November sowing. Varieties differed significantly in their dry-matter accumulation. Variety HD-3086 accumulated significantly higher dry-matter than other varieties at all stages of crop growth, and remained at par with HI-1544 and HD-2967 at all stages of crop growth. HS-562 and MACS-6222 have remained at par with each other and variety WR-544 produced the lowest amount of dry matter.

Table 5. Effect of sowing dates and wheat varieties on tillers at different stages

S. no	Treatment	30 days	60 days	90 days	Harvest
(A) Date of sowing					
1	05-11-2017	191.45	401.72	420.83	412.33
2	25-11-2017	194.61	434.39	455.11	445.94
3	15-12-2017	194.22	385.94	404.56	288.94
4	05-01-2018	196.22	281.56	294.89	396.39
	SEM±	1.509	5.282	5.484	5.480
	C.D. at 5%	N.S	16.645	17.282	17.267
(B) Varieties					
1	HS-562	192.58	367.92	375.75	368.00
2	HD-2967	191.17	376.50	400.92	395.42
3	HD-3086	194.92	391.75	419.83	411.58
4	HI-1544	195.67	382.50	405.75	397.75
5	MACS-6222	195.17	372.50	380.75	372.58
6	WR-544	194.75	364.25	380.02	370.08
	SEM±	2.527	6.418	6.723	6.593
	C.D. at 5%	N.S	18.344	19.215	18.844

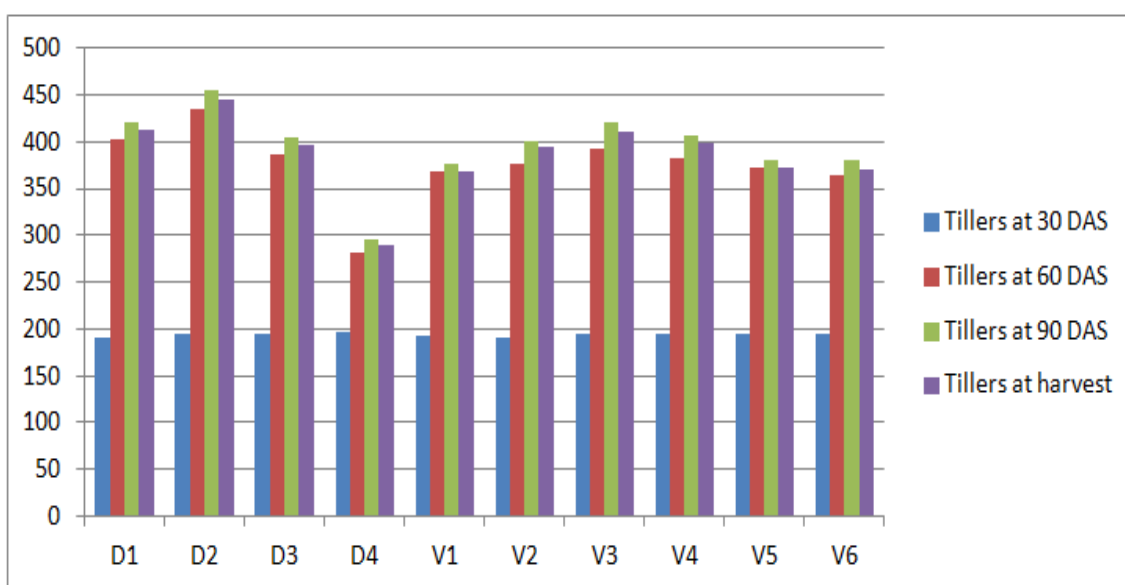


Fig. 5. Effect of sowing dates and wheat varieties on tillers at different stages

The data on number of tillers m⁻² as affected by different treatments was recorded at 30, 60, 90 DAS and at maturity are presented in Fig 5. It is apparent from the data that maximum number of tillers m⁻² was recorded at 90 DAS irrespective of treatments. The dates of sowing significantly influenced the number of tillers m⁻². It showed a decreased trend with delay in sowing. The number of tillers m⁻² at 30 DAS did not influence significantly by the sowing dates while at 60, 90 DAS and at harvest the maximum no. of tillers recorded with 25th November sowing

which was significantly higher than 05th November, 15th December and 05th January sowing. The lowest tiller m⁻² was obtained on 05th January at 60, 90 DAS and harvest (Table. No-5 & Fig.5). The number of tillers m⁻² differed significantly among varieties and it was recorded highest in variety HD-3086, which was significantly superior to the other varieties and at par with HD-2967 and HI-1544 at all stages of crop growth except at 30 DAS, where no of tillers did not influence significantly.

Table 6. Effect of sowing dates and wheat varieties on number of grains/earhead, length of ear, 1000 grain weight and Ear head m⁻²

S. no	Treatment	No. of grains/earhead	Length of ear (cm)	1000 grain weight (g)	Ear head m ⁻²
(A) Date of sowing					
1	05-11-2017	46.35	9.87	40.83	382.61
2	25-11-2017	46.53	9.54	40.15	413.78
3	15-12-2017	39.98	9.19	38.00	367.72
4	05-01-2018	22.37	8.89	37.31	268.11
5	SEM±	0.891	0.115	0.630	5.034
	C.D. at 5%	2.807	0.361	1.985	15.862
(B) Varieties					
1	HS-562	37.97	8.98	36.18	345.25
2	HD-2967	40.28	9.54	38.17	362.17
3	HD-3086	41.62	9.94	39.63	378.50
4	HI-1544	40.62	9.63	39.28	368.33
5	MACS-6222	37.64	9.27	37.08	349.33
6	WR-544	34.70	8.98	37.66	344.75
	SEM	0.948	0.149	0.963	6.114
	C.D. at 5%	2.986	0.425	2.752	17.475

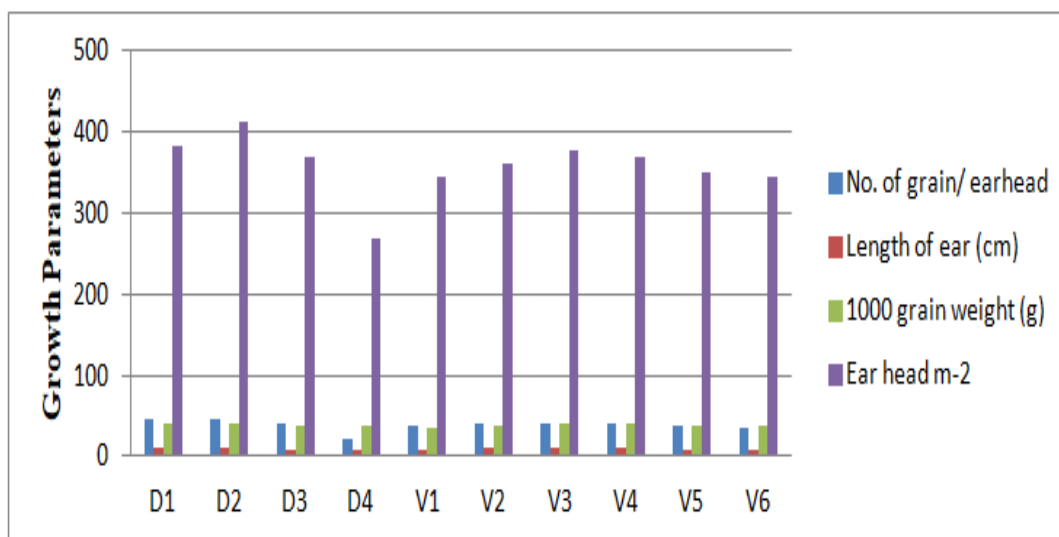


Fig. 6. Effect of sowing dates and wheat varieties on yield attributes

Test weight particularly influenced by temperature prevailed during the time of vegetative and reproductive stages. Data obtained revealed the significant effect between planting dates and wheat cultivars on the wheat seed index. 1000-seed weight of all the studied six cultivars was progressively decreased by delaying the sowing date. It was highest in the crop sown on 05th November (40.83g) which was significantly higher than 15 December and 05th January sowing (37.17 g) and remained at par with the crop sown on 25th November (40.15 g). Test weight is an important yield contributing traits of wheat which is significantly influenced by the prevailing growing conditions and genetic potential of a variety. The highest test weight was recorded in HD-3086 (39.63 g) which was at par with HI-1544 (39.28g) and HD-2967 (38.17g) and significantly higher than MACS-6222 (37.08 g) and WR-544 (37.66 g) and the lowest test weight was recorded in HS-562 (36.18 g).

In this experiment length of the ear head showed a decreasing trend as the delay occurs in sowing. The highest length of ear head is recorded in crop sown on 05th November (9.87 cm) which was significantly superior to the crops sown on other dates and at par with crop sown on 25th November (9.54 cm). Ear length of the crop sown on 15th December (9.19 cm) and on 05th January (8.89 cm) did not show a significant difference between each other. However, the lowest length is recorded in the crop sown on 05th January (8.89 cm). Shorter life span and change in climate is the main reason of reducing the length of an ear head. In this experiment the change in climate especially in temperature causes a significant influence on the length of the ear head. Varieties also showed significant influence on the length of the ear head. Among the varieties, HD-3086 was recorded with a maximum length of ear head (9.94 cm) which was remained at par with HI-1544 (9.63 cm) and HD-2967 (9.54 cm) and significantly higher than MACS-6222 (9.17 cm). Among the varieties WR-544 (8.98 cm) and HS-562 (8.98 cm) were recorded with the lowest length of the ear head.

The number of grains earhead⁻¹ is an important yield contributing factor of wheat which is significantly influenced by the prevailing growing conditions and genetic potential of a cultivar. The number of grains earhead⁻¹ in the wheat crop was found to be highest in crop sown on 25th November (46.53) which was significantly higher than the crop sown on 15th December (39.98) while at par with 05th November sowing (46.53). The lowest number of grains earhead⁻¹ was

recorded in crop sown on 05th January (22.37). The difference in the number of grains earhead⁻¹ among the varieties was found significant. However, the highest number of grains earhead⁻¹ was observed in HD-3086 (41.62) which was at par with HI-1544 (40.62) and HD-2967 (40.28) while significantly higher than HS-562 (37.97) and MACS-6222 (37.62). The minimum number of grains earhead⁻¹ was recorded in WR-544 (34.70).

Late sowing of crop affected the number of ear heads m⁻². The maximum number of ear head m⁻² was observed in crop sown on 25th November (413.78) which were significantly superior to other sowing dates. It was at par with crops sown on 05th November (382.61) and 15th December (367.72). The minimum number of ear head m⁻² was obtained in crop sown on 05th January (268.11). The number of ear head m⁻² gradually decrease as per the delay in sowing of crops. Among the varieties HD-3086 recorded the highest number of ear head m⁻² (378.50) which was significantly higher than the rest of the varieties while remained at par with HD-2967 and HI-1544. The lowest number of ear head m⁻² was recorded in WR-544 (344.75).

All the dates of sowing showed significantly different responses to each other in term of grain yield. The data indicated that the grain yield was significantly decreased as sowing was delayed from 25th November. This might be due to the cumulative effect of poor expression of vegetative growth and yield contributing characters i.e. number of ear heads m⁻², ear length and test weight under late shown conditions accompanied with high temperature and hot winds which leads towards forced maturity of the crop and ultimately resulted in lower grain yield. The highest gain yield was obtained in the crop sown on November, 25th (49.50 q ha⁻¹) was at par with November, 05th (49.31 q ha⁻¹) and significantly higher than December, 15th (42.53 q ha⁻¹) and January 05th. The crop sown on 05th January obtained the lowest yield (23.79 q ha⁻¹) respectively. Similar results have been reported by Jat et al. [28]. The grain yield was significantly influenced by different varieties and all varieties were noticed to be significantly different from each other. The highest grain yield was produced by HD-3086 (44.15 q ha⁻¹) followed by HI-1544 (43.21 q ha⁻¹), HD-2967 (42.79 q ha⁻¹), HS-562 (40.46 q ha⁻¹) and MACS-6222 (40.17 q ha⁻¹), respectively. These findings are similar to that of Bannayan et al., [29], Bai et al., [30], Sial et al., [31] Pal et al., [32].

Table 7. Effect of sowing dates and wheat varieties on grain yield (q/ha), straw yield (q/ha), biomass yield q/ha and harvest index

S. no	Treatment	Grain Yield	Straw yield	Biomass Yield q/ha	Harvest index %
(A) Date of sowing					
1	05-11-2017	49.31	76.56	125.87	39.17
2	25-11-2017	49.50	81.22	130.72	37.86
3	15-12-2017	42.53	61.39	103.92	40.92
4	05-01-2018	23.79	32.09	55.89	42.56
5	SEM±	0.948	1.501	2.296	0.552
6	C.D. at 5%	2.986	4.729	7.236	1.738
(B) Varieties					
1	HS-562	40.46	61.25	101.71	39.77
2	HD-2967	42.79	62.50	105.29	40.64
3	HD-3086	44.15	68.69	112.84	39.12
4	HI-1544	43.21	65.12	108.33	39.89
5	MACS-6222	40.17	61.67	101.84	39.44
6	WR-544	36.92	57.67	94.59	39.03
7	SEM±	1.098	2.241	2.781	1.012
8	C.D. at 5%	3.138	6.406	7.949	N.S

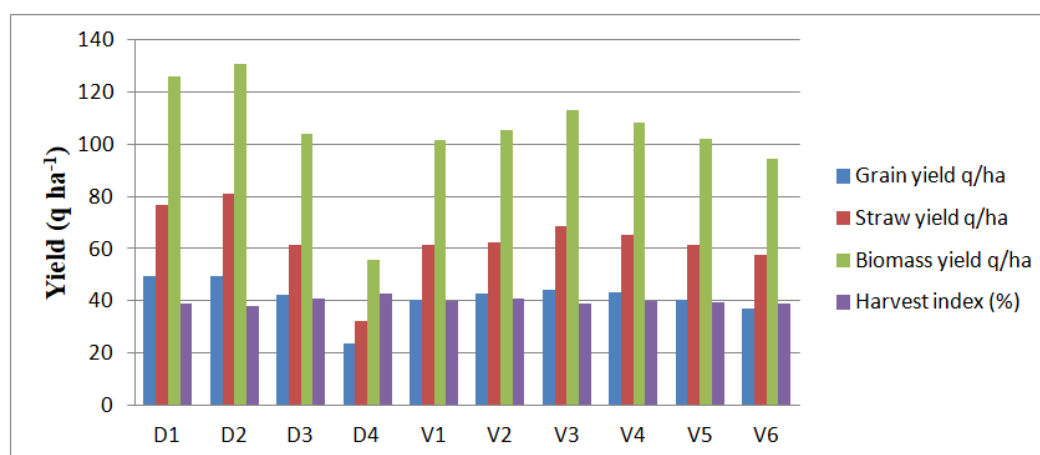


Fig. 7. Effect of sowing dates and wheat varieties on crop productivity

The data related to straw yield as affected by different treatments have been presented in Table no. 7 and Fig. 7. It was indicated that straw yield was significantly affected by the sowing time of the crop. The highest straw yield was recorded in the crop sown on 25th November (81.22 q ha⁻¹) which was remained at par with 05th November sowing and significantly higher than the 15th December & 05th January sowing. The difference in straw yield (q ha⁻¹) of varieties was significant. The maximum straw yield was recorded in HD-3086 (68.69 q ha⁻¹) which was at par with HI-1544 (65.12 q ha⁻¹), and HD-2967 (62.50 q ha⁻¹), respectively. Harvest index was highest in the crop sown on 5th January (42.56%)

which was at par with 15th December (42.56%) higher than 25th November (39.26%) and 5th November (37.77%). Varieties did not influence the harvest index significantly. However, highest harvest index was recorded in HD-2967 (40.64%) followed by HI-1544 (39.89%), HS-562 (39.77%), MACS-6222 (39.44%), HD-3086 (39.12%) and WR-544 (39.03%).

4. CONCLUSION

From the overall results, it can be concluded that sowing made around November 25th is the best time of sowing as it gives higher growth of wheat and varietal comparison of wheat growth.

Therefore sowing date plays a vital role in the yield potential of wheat production. Whereas, among the varieties, the higher growth was recorded in HD-3086 as compare to HD-2967, HS-562, HI-1544, MACS-6222 and WR-544 as its growth attributes was significantly higher than other varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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