

## Review Article

# Impact of planting time on the performance of different wheat varieties: A Review

### Abstract

Wheat (*Triticum aestivum* L.) is among the most widely cultivated cereal crops globally. Wheat belongs to family Poaceae and genus *Triticum* and its center of origin is South Western Asia. Following China, India is the second-largest wheat producer in the world. Among different species of wheat crop, *Triticum aestivum* is the most prime because of its higher calorific values as well as a good addition for nutritional requirement of human body due to appearance of 9-10 % protein and 60-80 % carbohydrates. Choosing the appropriate sowing time and selecting suitable cultivars are crucial for achieving higher wheat yields. Early sowing with the optimal plant population promotes better growth and nutrient uptake, leading to increased crop production. Delayed sowing reduces the growth, yield, and quality of wheat grain, while early sowing leads to greater yields thanks to a longer grain development phase. Additionally, cultivar selection played a crucial role in determining wheat performance. Some cultivars exhibited greater adaptability to varying sowing dates, maintaining higher yields and better stress tolerance. Proper selection of cultivars is obtained to maximum yield due to variation among the weather conditions and genetic diversity. Optimum sowing dates give suitable temperature to obtain maximum productivity and cultivars selection also play a prime role in obtaining maximum wheat production. Improper selection of cultivars produces lower grain yield.

**Key words:** Cultivars, Growth, Temperature, Productivity and Sowing time

### Introduction

Wheat (*Triticum aestivum* L.) is the world's foremost grain crop, and staple food for millions of people worldwide. Due to its extensive adaptability, *Triticum aestivum* is cultivated across a broad range of environmental conditions. It thrives in temperate irrigated regions as well as in areas characterized by both low and high rainfall. Wheat is also known as 'King of cereals'. Wheat (*Triticum aestivum* L.) is the second most important staple food crop globally, following rice. Its nutritional value is paramount, as it provides a significant portion of the caloric intake, protein, dietary fiber, B-group vitamins, and essential minerals in the human diet. Due to its wide range of adaptability and great nutritional value, it is grown all over the world. "Wheat being a cool season crop requires low temperature during its vegetative phase and flowering. climate is the most important factor in

realizing their yield potential, which is further influenced by their response to different sowing dates. Wheat (*Triticum aestivum* L.) is a temperature-sensitive crop, with late sowing often resulting in reduced yield components and adverse effects on various aspects of its growth and development. As a C<sub>3</sub> type crop (C<sub>3</sub> plant is a type of plant that produces a three-carbon compound (3-phosphoglyceric acid) through the Calvin-Benson cycle), it thrives well in cool environment. It has been observed that wheat sown at the optimal sowing date generally exhibits a longer growth duration, which provides the crop with increased opportunity for biomass accumulation. Achieving high wheat yields requires selecting the appropriate sowing time to ensure favourable growth conditions. There are significant opportunities to boost wheat production by developing new high-yield cultivars and optimizing sowing schedules”[1].

“The timing of sowing and the selection of cultivars play crucial roles in establishing a successful crop stand. The timing of sowing is a key agronomic factor for achieving high yields in small grain cereal crops, that impacts the timing and duration of vegetative and reproductive growth phases. Therefore, one of the requirements for obtaining high yield is the choice of the suitable sowing date due to variations in weather conditions among seasons and developing new high yielding cultivars and by adopting proper sowing date”[2].

“An appropriate time of sowing & different cultivars are the most important and low-cost production factors which determines the good crop stand which in turn influences the higher production[3]. Sowing of wheat crop at optimum time according to environmental conditions is the best way to increase growth and yield of crop. Late sowing of crop causes the reduction in number of days taken to booting, heading, anthesis and maturity which also causes the reduction in yield and yield component. Late sowing of wheat significantly decreased the germination percentage. Delay sowing of crop cause reduction in growth as well as yield of crop”[4]. “Proper sowing time avoids high temperature stress during blossoming and grain filling which ultimately resulted in higher wheat yield. So, proper sowing time is a fundamental factor for deciding the crop performance and achieving the higher yield”[5].

“Among the various factors that contribute to low wheat crop yields, varietal selection is most importance for high yield. Improper selection of cultivars also affects crop yield because performance of cultivars varies correspondingly with their genetic potential and adaptable environment, so there is scope for increasing yield of wheat with proper selection of cultivars” [6]. “Introducing new wheat cultivars with high yield potential and broad adaptability is a key factor in boosting wheat production. Proper selection of cultivars effects the plant population, plant height, number of tillers, 1000 grain weight, grain yield and straw yield. Wheat yield can be increased 10 to 80% through proper selection of sowing time and suitable cultivars” [7]. Effective management of sowing dates,

cultivar selection, and environmental conditions has the potential to increase wheat grain yields by 10 to 80%.

### **Effect of sowing dates on growth of wheat**

Tahir et al. [5] conducted a field experiment during winter 2005-2006 to study the effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) at Faisalabad-Pakistan. They reported that wheat crops sown on 1<sup>st</sup> December recorded maximum germination count ( $m^{-2}$ ), no. of fertile tillers ( $m^{-2}$ ) and plant height (cm) rest than other sowing dates.

Mukherjee [8] carried out field experiment at Uttar Banga Krishi Vishwavidyalaya, Kalimpong with five different dates of sowing (1<sup>st</sup> November, 15<sup>th</sup> November, 30<sup>th</sup> November, 15<sup>th</sup> December and 30<sup>th</sup> December) and six varieties and reported that different growth indices such as plant height, dry matter was significantly influenced by different dates of sowing.

Pal et al. [9] conducted a field experiment crop characteristics of wheat genotypes with three sowing at Pant Nagar and revealed that timely sown wheat crop performed better photosynthesis due to greater leaf area index and significantly produce higher dry matter production with more number of tillers per plant.

Mumtaz et al. [2] conducted field experiment at agronomy research station, Bahawalpur, Pakistan with six genotypes (V-Aari-11, V-Aas-11, V-Meraj-08, V-Millat-11, V-Punjab-11, V-Seher-06) and six different sowing dates (D-1 November, D-11 November, D-21 November, D-1 December, D-11 December, D-21 December). They reported that sowing date on 11 November performed higher with respect to days taken to different growth stages such as booting, heading, anthesis and maturity, germination count ( $m^{-2}$ ), number of tillers ( $m^{-2}$ ), plant height (cm).

Gupta et al. [3] studied the effect of different sowing dates (1<sup>st</sup> December, 20<sup>th</sup> December and 6<sup>th</sup> January) on growth and yield attributes of wheat crop at G.B. Pant University Uttarakhand and found that the number of days taken by different growth stages such as leaf area index, dry matter accumulation was significantly influenced by among dates of sowing.

Acharya et al. [10] conducted “field experiment at Agronomy Farm of the Agriculture and Forestry University (AFU), Rampur, Nepal on response of wheat cultivars in different agricultural practices differed by sowing date (14<sup>th</sup> November, 29<sup>th</sup> November and 14<sup>th</sup> December). They reported that significantly higher Number of effective tillers<sup>-2</sup>, Number of grains spike<sup>-1</sup>, 1000-grain weight, grain yield, straw yield and harvest index was recorded in 14<sup>th</sup> November date of sowing”.

Pathania et al. [11] carried out “research trial effect of five dates of sowing (20<sup>th</sup> October, 5<sup>th</sup> November, 20<sup>th</sup> November, 5<sup>th</sup> and 20<sup>th</sup> December) on growth, yield attributes and yield of four wheat varieties at northwestern Himalayas and found that 20<sup>th</sup> November date of sowing produced maximum plant height, tillers  $m^{-2}$ , dry matter accumulation”.

Wahid and Al-Hilfy[12] conducted field experiment at Research Station, State Board for Seeds Testing and Certification, Baghdad, Iraq during 2015-2016 and 2016-2017 seasons to determine the effect of four sowing dates (20<sup>th</sup> October, 10<sup>th</sup> November, 30<sup>th</sup> November and 20<sup>th</sup> December) on grain yield and its components of three wheat cultivars. They reported that the 10<sup>th</sup> November date of sowing of wheat crop recorded significantly higher number of spikes m<sup>-2</sup>, number of spikelets spike<sup>-1</sup>, number of grains spike<sup>-1</sup> and grain yield as compared to other sowing dates.

Singh et al. [13] studied “the effect of sowing dates and mulch on wheat crop and weeds. They reported 25<sup>th</sup> November date of sowing recorded maximum plant height(cm) and tillers count(number m<sup>-2</sup>) rest than to other sowing date 10<sup>th</sup> December”.

Chauhan et al. [14] conducted “research trial at Narendra Deva University of Agriculture & Technology, Faizabad (U.P.) to study the effect of different dates of sowing on growth and yield of wheat (*Triticum aestivum* L.) cultivars. They found that the different sowing dates (November 20, November 30 and December 10) and cultivars significantly influenced the growth characters of wheat crops such as highest initial plant population(m<sup>-2</sup>), plant height(cm), number of tillers(m<sup>-2</sup>), dry matter accumulation (g m<sup>-2</sup>), leaf area index, days taken to 50% ear emergence and maturity as compared to other sowing dates”.

Kaur et al. [15] conducted “field experiment to study the effect of sowing dates (25<sup>th</sup> October, 25<sup>th</sup> November and 25<sup>th</sup> December) and varieties on growth and yield of wheat in Himachal Pradesh and reported that the timely date of sowing of wheat crop recorded significantly highest plant height, tillers m<sup>-2</sup>, dry matter accumulation, grains spike<sup>-1</sup>, grain and straw yield”.

Singh et al. [16] studied the effects of sowing dates (26<sup>th</sup> November, 11<sup>th</sup> December and 25<sup>th</sup> December) on yield and yield components of different varieties of wheat at Agricultural Research Farm, Moradabad (UP) and found that wheat sown on 26<sup>th</sup> November recorded maximum plant height, tillers plant<sup>-1</sup>, spikes<sup>-1</sup> plant, as compared to late sown wheat crop on 11<sup>th</sup> December and 25<sup>th</sup> December.

Mitasha et al. [17] conducted experiment to “evaluate the performance of new wheat varieties at different dates (13<sup>th</sup> November and 3<sup>rd</sup> December) of sowing under irrigated conditions at Agriculture and Research Station, Sarkanda and found that the timely dates of sowing produced maximum plant population, growth parameters, including plant height, dry matter accumulation (g plant<sup>-1</sup>) and number of tillers as compared to the other date of sowing”.

Alam et al. [18] studied “the effect of sowing dates (5<sup>th</sup> November, 25<sup>th</sup> November, 15<sup>th</sup> December, 5<sup>th</sup> January) and varieties of wheat crop on growth and productivity at Acharya Narendra Deva University of Agriculture and Technology, Ayodhya (U.P) and found that growth parameter of wheat crop were reduced (number of tillers m<sup>-2</sup>, plant height at various stages (cm), leaf area index) when wheat crop was

sown under late sown conditions”.

During winter 2021 Habibi et al. [19] conducted “a study at Baghlan University, Afghanistan to study impact of during winter sowing dates on three different varieties. They found that February 22 sowing date resulted in higher plant height and germination count  $m^{-2}$  while lowest plant height and germination count  $m^{-2}$  was reported in 23 March sowing date”.

Mukhtarullah et al. [20] conducted “field experiment at Agriculture Research Station (ARS), Ahmad Wala (Karak-Pakistan) on yield comparison of some improved wheat varieties under different sowing dates (Oct. 29, Nov. 10, Nov. 25, Dec. 10 and Dec. 25) as rainfed crop and they found that 10<sup>th</sup> November sowing dates produced highest spike number, spike weight, thousand grain weight and grain yield as compared to other sowing dates”.

### **Effect of sowing dates on yield and yield attributes of wheat**

Baloch et al. [21] conducted a field experiment at Agricultural Research Institute, Dera Ismail Khan on different sowing dates (October-25, November-10, November-25, December-10 and December-25) and different seed rates of 100, 125, 150, 175 and 200  $kg\ ha^{-1}$ . They found that the wheat crop sown between October-25 to November-10 with seed rate of 150  $kg\ ha^{-1}$  produced higher grain yield, spike length and 1000-grain weight.

Khosravi et al. [22] studied “the effect of different sowing dates on yield and yield components of wheat cultivars at Kerman University, Iran and found that maximum number of tillers per plant, number of spikes per plant, number of grains per spike<sup>-1</sup> and 1000-grain weight was produced when wheat crop was sown in the month of October”.

Said et al. [23] conducted “a study at Agricultural Research Institute, Peshawar Pakistan with different planting dates & seedling rates and they found that 15<sup>th</sup> November sowing dates produced highest grain yield, biological yield, 1000 grain weight and harvest index (%)”.

Aslani and Mehrvar [24] A field trial was conducted on farmer’s fields to investigate the effect on different sowing dates and reported that optimum sowing date (1<sup>st</sup> November) produced higher biomass and grain yield, number of spike  $m^{-2}$  and 1000 – grain weight as compared to late date of sowing.

In Inceptisol soil of Banaras Hindu University Varanasi, (UP) Jat et al. [25] laid out a field experiment to study the effect of sowing date and fertilizer on growth and yield of wheat crop. They reported that significantly higher plant height, tillers  $m^{-1}$ , ear length, grains ear<sup>-1</sup>, ear weight, grains ear<sup>-1</sup>, test weight, grain and straw yield was recorded in 20<sup>th</sup> November date of sowing.

A two year’s field study was conducted by Mumtaz et al. [2] at Agronomic Research Station, Bahawalpur, Pakistan with six different planting dates and six genotypes. They reported that

wheat crop which was sown on 11<sup>th</sup> November produced higher number grains spike<sup>-1</sup>, 1000-grain weight and grain yield of wheat whereas late sown wheat resulted in reduction of all these attributes.

At crop research station, Masodha NDU&T Faizabad Verma et al. [26] conducted a field study to assess the response of different wheat varieties in timely sown conditions. They observed that 15<sup>th</sup> November sowing date of wheat reported higher values of yield & yield components while lower values were reported 25<sup>th</sup> November.

A two-year field trial was laid out in sandy loam soil at Faizabad Kumar et al. [27] to study the response of sowing time and nitrogen scheduling in wheat crop under late sown condition. They observed that wheat crop sown on 1<sup>st</sup> date of sowing (5<sup>th</sup> December) produced highest grain, straw and biomass yield and 1000-grain weight as compared to other dates of sowing studied.

Ali et al. [28] studied “the effect of sowing date (November 1<sup>st</sup>, November 15<sup>th</sup> and December 1<sup>st</sup>) and nitrogen fertilization level on growth and productivity of some durum and bread wheat varieties at Agricultural Research Station, Faculty of Agriculture, Alexandria University, Egypt and reported that wheat crop sown on November 15<sup>th</sup> recorded maximum spike length, no. of spikelets spike<sup>-1</sup>, number of grains spike<sup>-1</sup> and 1000-grain weight, grain yield and straw yield as compared to other dates of sowing”.

Pathania et al. [11] studied “the effect of five different dates of sowing on growth, yield attributes and yield of four wheat varieties at Palampur and found that the wheat crop sown on 20<sup>th</sup> November date of sowing recorded highest grains spike<sup>-1</sup>, grain yield and straw yield as compared to other dates of sowing”.

Shabnam et al. [29] conducted “a field experiment during winter 2010-11 and 2011-12 to study the effect of seeding time on the growth, development and productivity of wheat cultivars under alfisol at university farm of Birsa Agricultural University, Ranchi. They reported that wheat crop sown on 15<sup>th</sup> November sowing dates produced highest spikes m<sup>-2</sup>, grains spike<sup>-1</sup> and 1000 grain weight”.

Singhet al. [13] conducted a field experiment to find out the effect of sowing dates and mulching on growth and yield of wheat at Banaras Hindu University, Varanasi. The result showed that wheat crop sown on 10<sup>th</sup> December date of sowing resulted in higher grain and straw yield as compared to other date of sowing (25<sup>th</sup> November).

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al. [18] studied “the effect of sowing dates (5<sup>th</sup> November, 25<sup>th</sup> November, 15<sup>th</sup> December, 5<sup>th</sup> January) and cultivar of wheat crop on growth and productivity at Acharya Narendra Deva University of Agriculture and Technology, Ayodhya (U.P) and found that yield parameters test weight, number of grains ear head<sup>-1</sup>, ear head (m<sup>-2</sup>) and length of the ear (cm) was decreased in late sown wheat crop”.

At Baghlan University, Afghanistan Habibi *et al.* [19] carried out “a field experiment during winter 2021 to study the performance of different sowing dates (February 22, March 8 and March 23) on growth and yield of spring wheat. They found that wheat crop sown on 22<sup>nd</sup> February recorded maximum number of grains spike<sup>-1</sup>, grain yield and stover yield as compared to other sowing dates”.

### **Effect of sowing dates on economics of wheat**

Mukherjee [8] studied the effect of different sowing dates and cultivars on yield of wheat at Uttar Banga Krishi Vishwavidyalaya, Kalimpong. They reported that maximum net returns (Rs. 24,926 and Rs. 23,192) and higher B:C ratio (2.11 and 2.03) was recorded with 15<sup>th</sup> November and 30<sup>th</sup> November sowing dates.

Alam *et al.* [30] studied the performance of wheat varieties under different sowing dates at Birsa Agricultural University, Ranchi and recorded that wheat crop sown on 25<sup>th</sup> November achieve higher net returns of (Rs. 37400) with B:C ratio of (1.34) as compared to 20<sup>th</sup> December sowing date.

Tomar *et al.* [31] studied the effects of various sowing dates on yield and yield components of wheat at Agricultural research farm, Gwalior (MP) and recorded that the wheat varieties sown on 14<sup>th</sup> November resulted in maximum total income, net income and B:C ratio than the crop sown on 21<sup>st</sup> November.

Bachhao [32] conducted the field experiment to study the effect of different sowing dates and different wheat varieties at Mahatma Phule Krishi Vidyapeeth, Maharashtra and reported that the maximum gross returns (Rs. 73,194 ha<sup>-1</sup>), net returns (Rs. 38,194 ha<sup>-1</sup>) and B:C ratio (2.09) was recorded in wheat crop sown on 1<sup>st</sup> week of December.

Yusuf *et al.* [33] studied the effect of sowing dates and varieties on yield and quality performance of wheat at CCS Haryana Agricultural University, Hisar and observed that wheat crop sown on 5<sup>th</sup> November recorded higher net returns (Rs. 54,262 ha<sup>-1</sup>) and B:C ratio (1.73) as compared to other sowing dates.

Kumar *et al.* [34] studied the effect of sowing dates on different wheat genotypes at Rajendra Agricultural University, Pusa (Bihar) and found that wheat crop sown on 27<sup>th</sup> November recorded highest net returns and B:C ratio which was followed by 11<sup>th</sup> December.

On the basis of field trial conducted to identify the optimum date of wheat at Shaheed Gundadhoor College of Agriculture, Chhattisgarh Netam *et al.* [35] reported that wheat crop sown on 15<sup>th</sup> November recorded significantly higher gross returns (Rs. 61763 ha<sup>-1</sup>), net return (Rs. 35498 ha<sup>-1</sup>) and B:C ratio (2.35) as compared to other dates of sowing.

Kumari *et al.* [36] studied the effect of date of sowing on yield attributes, yield and profitability

of wheat at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) and they found that the crop sown on 15<sup>th</sup> November resulted in significantly higher gross income (Rs 118837.667 ha<sup>-1</sup>), net income (Rs. 49087.66 ha<sup>-1</sup>) as well as B:C ratio (1.7) of wheat as compared to 30<sup>th</sup> November, 10<sup>th</sup> December date of sowing.

Singh et al. [37] studied the effect of sowing dates (15<sup>th</sup> November and 15<sup>th</sup> December) on growth and yield attributes of wheat variety (K 1317) at Acharya Narendra Dev University of Agriculture and Technology, Ayodhya and they found that crop sown on 15<sup>th</sup> November resulted in significantly higher benefit:cost ratio from early sowing 3.45 as compared to 15<sup>th</sup> December date of sowing.

### **Effect of varieties on growth of wheat**

At the University of Agriculture, Faisalabad, Pakistan, Tahir et al. [5] examined the effect of different sowing dates on growth and yield of three wheat varieties (Inqilab-91, AS-2002 and Bhakkar-2002). The result showed that the lower number of fertile tillers was produced by AS-2002 whereas Inqilab-91 produced the tallest plants in comparison to the other varieties.

In a field experiment conducted in the Bahawalpur zone by Akhtar et al. [38] to study the effect of late planting on emergence and tillering of different varieties of wheat. The result showed that Bhakkar-2002 recorded the maximum germination percentage and number of tillers over as Inqilab-91, Punjab-96 and MH-97.

Mumtaz et al. [2] studied the performance of different wheat genotypes and reported that higher germination count m<sup>-2</sup>, numbers of tillers m<sup>-2</sup> and plant height was recorded in genotypes Millat-11, Meraj-08 and Sehar-06.

Uddin et al. [39] carried out a field experiment at Sher-e-Bangla Agricultural University, Dhaka, to investigate the impact of sowing date on the growth and yield of four wheat varieties (BARI Gom-21, BARI Gom-24, BARI Gom-25, and BARI Gom-26). They found that BARI Gom-21 taken higher number of days to reach anthesis and produced the maximum plant height.

A field study was conducted at Bangladesh Agricultural University, Mymensingh by Madhu et al. [40] to study the effect of sowing date on the growth and yield performance of wheat varieties (BARI Gom 25, BARI Gom 26, BARI Gom 27 and Shatabdi). They revealed that BARI Gom 25 produced the maximum plant population m<sup>-2</sup> and plant height than other wheat varieties.

Parveen et al. [41] tested the performance of different cultivars of wheat at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad and reported significantly higher plant height, number of tillers and number of spikelets spike<sup>-1</sup> in variety HD 2967 as compared to PBW 502 and PBW 154.

In sandy loam soil of Agricultural Research Institute, Rajendranagar, Telangana Goverdhan et al. [42] laid out field trial to evaluation of wheat genotypes (Raj 4037, HP 4080 and PDW 315) under different dates of sowing and result showed that PDW 315 recorded maximum plant height, number of tillers  $m^{-2}$ .

Netam et al. [35] performed a field experiment at Shaheed Gundadhoor College of Agriculture, Chhattisgarh and reported that wheat variety Sujata showed substantially higher plant height, number of tillers, panicle emergence as compared to other varieties.

Singh et al. [16] tested the performance of five wheat varieties (HD 2733, HD 2824, PB343, PBW443 and UP 262) at Krishi Vigyan Kendra, Jamui (Bihar) and reported higher plant height and number of tillers in HD2733 as compared to other variety HD2824.

Sah et al. [43] conducted a field trial to examine the Impact of Sowing Dates on Wheat Varieties (BL 4407, BL 4621, BL 4699, and Vijay) and result showed that BL 4699 recorded maximum plant height and spike length rather than other varieties.

Experiment carried out by Karada et al. [44] at the Forestry Research Farm in Jabalpur (MP) to determine the performance of wheat varieties and the result showed that MP-3336 variety exhibited higher plant population, while the GW-322 variety showed taller plants at harvest.

A field experiment was conducted at University Farm of Dr. Rajendra Prasad Central Agricultural University Bihar by Sattar et al. [45] to assess the responses of phenology and yield attributes with three prominent cultivars of the region (RAU-3711, HD-2824, and HD-2733) and found that wheat cultivar RAU-3711 attain lesser days to different growth stages such as booting, 50% flowering, milking, dough, and maturity stages as compared to HD-2824 and HD-2733.

Singla and Sarlach [46] studied the performance of different wheat cultivars at RIMT University, Punjab. They reported that wheat variety PBW 725 had significantly higher plant height and dry matter accumulation at all growth stages compared to other variety.

#### **Effect of varieties on yield and yield attributes of wheat**

A field trial was conducted by Ali et al. [47] to study the effect of Two newly evolved wheat varieties SH-2002 and AS-2002 and a check (Uqab-2000) on yield at Adaptive Research Farm, Vehari, Pakistan. The results revealed that wheat variety AS-2002 produced maximum grain yield and proved better than SH-2002 and Uqab-2000.

Al-Musa et al. [48] studied the performance of different wheat varieties (BARI ghom-23, BARI ghom-24, BARI ghom-25 and BARI ghom-26) at Patuakhali Science and Technology University, Patuakhali and reported that variety BARI ghom-26 resulted in maximum yield and yield attributes (grains per spike, 1000-grain weight, higher grain and straw yield and greater harvest index)

of wheat as compared to other varieties in HD-2733 as compared to other varieties.

Chourasiya et al. [49] assisted a field trial at Gird region of Madhya Pradesh to find out the response of different wheat varieties and the result revealed that among varieties, HI 8498 produced significantly maximum grain and straw yield. They also showed that HI 8498 recorded maximum number of tillers  $m^{-2}$ , ear head  $m^{-2}$ , number of grains spike $^{-1}$  and test weight as compared to rest of the varieties.

A field experiment was conducted at Institute of Agriculture and Animal Science (IAAS), Rampur by Marasini et al. [50] to find out the response of wheat varieties (Tillotama, Danfe and Vijay) under different sowing dates and reported that Danfe produced maximum number of effective tiller  $m^{-2}$  and straw yield whereas Number of grain spike $^{-1}$  Tillotama was highest.

Awan et al. [51] conducted field experiment at Agronomy Research Farm, the University of Agriculture Peshawar, Pakistan on yield comparison of potential wheat varieties by delay sowing as rainfed crop for Peshawar climate. The results revealed that wheat variety Ghanemat-2015 produced maximum grains spike $^{-1}$ , 1000-grains weight, biological yield and grain yield.

Habibi and Fazily [52] compared the performance of four wheat varieties (Solh02, Gul09, Muqawim 09, Kabul 013) and reported that wheat varieties Kabul 013 and Gul 09 was better in terms of higher number of effective tillers plant $^{-1}$ , test weight and grain yield of wheat over rest of the varieties.

On the basis of field investigation carried out to study the effect of sowing date on the performance of wheat varieties Madhu et al. [40] reported that BARI Gom-25 produced higher number of effective tillers, number of total spikelet's spike $^{-1}$ , spike length, no. of grains spike $^{-1}$ , grain yield and straw yield as compared to other varieties.

In a field experiment conducted at National Wheat Research Program, Bhairahawa, Nepal to study the effect of sowing dates on yield of different wheat varieties (Vijay, NL971 and BL4316) Yadav et al. [53] found that NL971 produced significantly higher grain yield, 1000-grains weight, total biomass and harvest index as compared to Vijay and BL4316.

Yusuf et al. [33] compared the performance of different varieties at CCS Haryana Agricultural University, Hisar and reported that significantly higher number of effective tillers, grains per spike and spike length was recorded in variety HI1544 as compared to other varieties tested.

Kumar et al. [34] conducted a field experiment at Rajendra Agricultural University, Pusa (Bihar) to study the performance of four wheat varieties (K 9107, PBW 343, HP 1744 and NW 1014) and reported that significantly higher grain yield was recorded in varieties K 9107 and PBW 343 as compared to other varieties evaluated (HP1744 and NW1014).

Kaur et al. [15] studied the performance of four wheat varieties at Palampur H.P. and reported that varieties HPW- 349 and VL- 907 recorded significantly higher grains spike $^{-1}$ , test weight, grain

yield and straw yield.

Singh et al. [16] compared the performance of different wheat varieties at IFTM University, Moradabad (UP) and reported that wheat variety HD 3086 resulted in higher grain yield and test weight. They also reported that higher straw yield, biological yield and harvest index was recorded in variety HD2967 as compared to other varieties.

Roshan et al. [54] studied the influence of sowing dates and varieties (Chounth 1-2010, Moqawim-09, Shisham Bagh-08, Dar-ul-Aman-07, and Solh 2002) on the biological yield of wheat crop (*Triticum aestivum* L.) at Dar-ul-Aman Research Farm, Kabul Afghanistan and reported that wheat variety Solh 2002 produced maximum number of spikelets spike<sup>-1</sup>, number of spike m<sup>-2</sup>, number of grains spike<sup>-1</sup> and biological yield as compared to other varieties.

Kumari et al. [36] conducted field trial to assess the performance of three wheat varieties at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) and reported that variety HD-2967 recorded highest values of yield and yield attributes of wheat (spike length, number of grains spike<sup>-1</sup>, 1000-grain weight and grain yield) as compared to other varieties.

Kumar et al. [55] compared the performance of wheat varieties and reported that higher yield and yield attributes was recorded in variety VL-907.

Singla and Sarlach [46] conducted field trial to assess the cultivars at RIMT University, Punjab and reported that wheat cultivar PBW 725 resulted in higher yield contributing characters and yield as compared to cultivar HP2967.

Elbatrawy et al. [56] studied the effect of sowing dates on productivity and seed quality on some wheat varieties (Sakha 95, Sakha 94, Misr 3, and the Chinese cultivar Jinqiang 7) at Tag Al-Ezz demonstration Farm, Agriculture Research Center, Dakahlia governorate, Egypt. They reported that wheat cultivar Sakha 95 was better in terms of higher number of spikes m<sup>-2</sup>, number of grains spike<sup>-1</sup>, spike length, 1000 kernel weight and grain yield of wheat over rest of the cultivars.

#### **Effect of varieties on economics of wheat**

Mali and Choudhary [57] studied the performance of bread wheat varieties (GW 322, GW 366 and HI 1544) and reported that higher net returns (Rs. 52,813) and B:C ratio (2.84) was recorded in wheat variety GW366.

Chourasiya et al. [49] studied the response of different wheat varieties at Madhya Pradesh and they reported wheat variety HI 8498 recorded highest gross returns (Rs. 112324), net returns (Rs. 95410) and B:C ratio (5.64).

Nagarjuna et al. [58] conducted a field experiment with four wheat cultivars at Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) and found that maximum net returns and B:C

ratio was reported in wheat cultivar MACS 2971 while the wheat cultivar DDK 1009 resulted in lower net returns and B:C ratio.

According to Verma et al. [26] the wheat DBW 39 recorded highest net returns (Rs. 22556.00) and B:C ratio (1.86) which was followed by (HD 2967, HD 2733 and PBW 502) wheat variety. They further reported that wheat variety PBW 502 resulted in lower net returns (16998.0) and B:C ratio (1.65).

Netam et al. [35] conducted a field experiment with four cultivars at Chhattisgarh and found that maximum net returns and B:C ratio was reported in wheat cultivar GW 273 while the wheat cultivar Kanchan resulted in lower net returns and B:C ratio.

At Acharya Narendra Deva University of Agriculture & Technology, Faizabad (U.P.) Chauhan et al. [14] conducted a field experiment to study the effect of different varieties (Malviya-234, PBW-343 and NW-1012) on growth, productivity and economics of wheat. The result revealed that PBW-343 recorded higher gross return (Rs. 95580 Rs. ha<sup>-1</sup>) net return (Rs. 54547 ha<sup>-1</sup>) and benefit cost ratio (1.33) rather than other wheat varieties.

Singh et al. [16] studied the effect of dates of sowing and different varieties (HD 2967, NW 1012, NW 5054 and DBW 187) on growth and yield of wheat at Agronomy Research Farm, Ayodhya and found that maximum net returns (102581 Rs. ha<sup>-1</sup>) and B:C ratio (2.46) was reported in wheat variety DBW 187 while the other varieties resulted in lower net returns and B:C ratio.

Kumari et al. [36] compared the performance of three wheat cultivars at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) and reported that significantly higher gross returns (Rs. 115612.66), net returns (Rs. 45862.66) and B:C ratio (1.65) while significantly lowest net returns and gross returns was observed in variety VK1006.

### **Conclusion**

It may be concluded optimum planting time and suitable varieties play an important role in achieving higher productivity of wheat. Growth and yield of wheat are affected by environmental conditions which can be regulated by planting time and different wheat varieties [59]. When wheat is planted at the optimum temperature, the photosynthetic process is more efficient, leading to better growth, nutrient uptake, and overall yield. At optimum temperature, early sowing and proper selection of wheat varieties enhances the growth and nutrient uptake and causes higher crop production in wheat.

### **Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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