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Effect of different sowing times on the plant developmental parameters of wheat (*Triticum aestivum* L.): A review

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Abstract
Studies on plant development phases and yield component patterns of wheat are essential for a better understanding of adaptation in wheat. Temperature is an important climatic factor which has profound effects on the yield of rabi crops. Changes in temperature affect the grain yield, mainly through phenological development processes. Winter crops are especially vulnerable to high temperature during reproductive stages and differential response to temperature change (rise) to various crops has been noticed under different production environments. The effect of temperature on the wheat phenological can easily by seen in Central India because of high inter-annual fluctuations in the productivity due to fluctuations in temperature. The productivity of wheat is largely dependent on the magnitude of temperature change. 1 °C increase in temperature throughout the growing season will have no effect or slight increase on productivity in North India. But, an increase of 2 °C temperature reduced potential grain yield at most of the places (Agrawal and Sinha, 1993). Deshmukh *et al.* (2015) reported that significant increase yield when the wheat crop was sown at 45 MW than 48 MW. Grain yield was significantly higher when crop was sown at 45 MW sowing.

Keywords: Wheat, *Triticum aestivum* L., sowing times, phonological and productivity

Introduction

Wheat (*Triticum aestivum* L.) a staple food for two third of the total world population, is cultivated under different environmental conditions ranging from humid to arid, subtropical to temperate zone. It is an important protein containing cereal with high amount of carbohydrates. It is one of the cheapest sources of carbohydrates and its grain is superior to that of rice in nutritional quality and contains approximately protein 12%, fat 1.72% carbohydrate 69.60%, mineral 27.2% and much amount of gluten. However, one challenge for global nutrition is to increase grain yield per unit area while maintaining its end use value. Wheat protein is known as 'gluten' is used for making bread, biscuit and pastry products. Wheat belongs to Poaceae family and prefers cool and dry climate. Generally, wheat is sown in November to ensure optimal crop growth and development.

Among the sowing variables responsible for wheat yield are, sowing methods, seed rate, time of sowing and spacing are very important. Plant spacing determines the area available to each plant which in turn determines nutrient and moisture availability to the plant. Row spacing determines resource availability and utilization by individual plants in a given species. If the row is too wide, the crop is unable to rapidly shade the inter-row area to capture sunlight and weeds quickly become established. If the row is too narrow, inter-row crop competition results in poorer yields, difficulties in disease and insect control, and greater likelihood of lodging. The yield of wheat in the farmer field is much lower than that in the research farm. The yield and quality of wheat grain is known to be influenced by several factors such as variety, sowing time, sowing depth, seed rate, water and nutrient management, harvesting time and other agronomic practices. Inappropriate seed rate and improper crop management practice result low grain yield in wheat. Higher seed rate is not only required for Broadcasting method but also resulted in lower plant population Keeping these above information in view a systematic review of literature is discussed on the following headings.

Review of literature

1. Heat units on various phenophases

Singh *et al*. (1997) [5, 6, 17-22] concluded that heat tolerance of 10 varieties (HI 977, HI 116, HI 1123, HD 2270, HD 1558, GW 120, Sonalika, Lok-1, RH 2825 and GIPSI of wheat (*Triticum aestivum*) in terms of phenological development, grain yield and its components under 3 dates of sowing (15 November, 15 December and 15 January) under irrigated conditions. Increased temperature significantly reduced the days to anthesis and maturity duration. Likewise, higher post-anthesis temperature *i.e.* 26.6 – 30.6 °C contributed to declining in productive ears, biological yield, 1000 grain weight and grain yield under late sowing compared with normal sowing. Agrawal *et al*. (1999**)** [1, 2] observed that sowing of wheat crop often gets delayed which affects its phenology and productivity in the soybean-wheat cropping system. Two wheat varieties *viz*., WH-147 and Lok-1 were sown at three dates of sowing consisted of early (Mid-November- D1), normal (Early December-D2) and late sowing (End December- D3).

Rao *et al*. (1999) [9, 17, 20] reported that highest heat use efficiency (HUE) in wheat in terms of seed yield was observed (2.56 kg ha-1 day-1 in 1993-94 and 2.18 kg ha-1 day-1 in 1994-95) as compared to mustard and chickpea crops in that order. HUE values varied between two seasons within dates of planting in three crops. The HUE in terms of dry matter accumulation (DMA) was highest in mustard followed by chickpea and wheat and decreased when planting was delayed after recommended time of sowing for these crops. Singh *et al*. (2001**)** [5, 6, 17-22] concluded that the phenology, growing degree days and phasic development of wheat (*Triticum aestivum*). Sown on 25 November took a number of days from sowing to maturity than late sown and the duration consistently reduced with the subsequent delay in sowing. Decreasing trend in accumulated growing degree days with the delay in sowing was also noticed. Sharma *et al*. (2003) [3, 18] observed that five cu1tlvars V_I (WH 542), V_2 (PBW 343), V_3 (UP 2338), V_4 (Raj 3765) and V_5 (Sonak) were sown on three dates 25th November, 10th December and 25th December. Delay in sowing from 25th November to 10th December significantly reduced the radiation use efficiency. Efficiencies varied from 1.24 to 2.85 intercepted photosynthetically active radiation (IPAR) for the wheat crop. Karambir *et al.* (2003) [6] found that the heat use efficiency (HUE) increased with growing period and attained the maximum at hard dough stage with little variations and then decreased at maturity in all treatments, except in the third sowing date. HUE showed a negative linear response with weather parameters (maximum, minimum and mean temperature) and parabolic response with sunshine hours and relative humidity. Amrawat *et al.* (2013) [3] found that the grain yield recorded on 5th November was statistically at par with 20th November. The significant reduction in grain yield of timely sown varieties was recorded when sowing was delayed beyond 20 November. Among the varieties highest grain yield of 62.81 q ha was recorded in varieties Raj 4037, which was significantly superior over HI-1544 (58.75 q ha-1) and MP-1203 (50.32 q ha-1). Among the varieties MP-1203 took highest calendar days GDD, PTU, HTU to reach the maturity. The variety Raj 4037 recorded the highest grain yield at 5 November sowing as compared to all other sowing dates.

Kaur *et al.* (2004**)** [7] studied with three wheat cultivars, under two dates of sowing, (1st fortnight of November and 1st Fortnight of December) at Ludhiana during Rabi 1996-97 to 2000 2001 to workout growing degree days and heat use efficiency. The accumulated growing degree day from sowing to physiological maturity ranged between 1476 to 1968 for different wheat cultivars with an average of 1762. Mean heat-use efficiency (HUE) was 2.13 kg/ha/°C day for grain yield and 5.30 kg/ha/°C day for biomass yield. The highest heat-use efficiency of 2.89 kg/ha/°C day for grain yield and 7.25 kg/ha/°C day for biomass yield was recorded. Mallick *et al.* (2006) [11] reported on the basis of dates of planting, the number of days taken for maturity were maximum on 12 November (151 and 155 days), followed by 27 November (137 and 141 days) and lowest on 12 December (126 and 129 days).

Patra and Sahu (2007) [14] reported that in normal sowing condition the crop accumulated the higher amount of heat units than late sown conditions. The RUE and HUEs were also higher for earlier sowing than later sowings. They suggested that the appropriate time of sowing for wheat is 15th Nov. to 25th Nov. for getting higher and stable yield of wheat under South Saurashtra Agroclimatic Zone of Gujarat. Mishra *et al.* (2007) [12, 19] analyzed the heat unit requirement of wheat cultivars for 4 moisture level *viz*. M1 (one irrigation given at crown root initiation stage), M2 (two irrigation given at CRI and flowering stage), M3 (three irrigation given at CRI, late tillering and flowering stage) and M4 (four irrigation given at CRI+late tillering+late jointing+ear head formation stages) with the combination of three varieties *viz*.-HUW-234, HD-2285 and PBW-154 as treatments.

2. Soil and air temperature on various phenophases

Ortiz-Monasterio *et al.* (1994) [13] found that delayed the emergence of seedlings caused by low temperature and enhance most of the early maturity due to high temperature during reproductive stage with short duration available for the expression of various phenophases particularly the process of grain filling in the case of very late sown crop. Stone and Nicolas (1995) reported the genotypic difference of grains/spike in response to high temperature. High temperature may affect the pollen viability and fertilization and thereby reduce the number of grains/spike. Individual grain weight which is considered as one of the major yield contributors was also significantly influenced by temperature. Savin and Nicolas, (1996) reported that pre-anthesis period is strongly influenced in terms of spikelet and floral or kernel numbers by the environment. Sowing time is another factor, where in crop growth is decided by the environment. Even under optimum conditions, small variation in temperature influenced the growth and development of wheat. Macas *et al.* (2000**)** studied the tolerance of durum wheat to high temperature during grain filling in an experiment in south Portugal. Nine durum *(Triticum durum)* and eight bread wheat *(Triticum aestivum)* genotypes were exposed to two different sowing date's *i.e.* normal and late. It was observed that grain yield and individual grain weight were significantly affected by the increase in temperature.

Aslam *et al*. (2003) [4] reported that less number of tillers in late sowing was the result of less germination count per unit area which occurs due to low temperature. In the case of delayed sowing the temperature was not as per used tillering requirement resulted in less number of tillers m^{-2}. Prasad *et al.* (2008) [10, 16] found that the plant height and tiller numbers were not significantly influenced by high night-time temperatures. Dry weights (vegetative) were significantly influenced by high night-time temperature and the response was best described by curvilinear relationship. Vegetative growth was not affected as night-time temperature increased from 14 to 20 °C, but the further increase to 23 °C significantly decreased vegetative dry weights. Grain yield linearly decreased (0.25 Singh *et al.* (2008) [5, 6, 17-22] stated that maximum temperature in the range 17-19 °C during January, less than 20 °C during February and 28-30 °C during March were the most favorable for better wheat yield. However, the maximum temperature more than 21 °C, 24 °C and 30 °C during the month of January, February and March, respectively, resulted in lowest yield. On the other hand, the minimum temperature in the range of 6-8 °C in January, more than 9 °C in February and 13 °C in March were found favorable for yield whereas minimum temperature less than 4 °C, 5 °C, and 11 °C during the month of January, February and March respectively were less favorable. Dubey *et al.* (2008) [9] studied that the influence of weather parameters on wheat yield under varying sowing dates. The treatment consisted three dates of sowing Nov. 30th, Dec. 15th and Dec. 30th and three genotype namely, HD-2285, K-8804 and K-9107. The yield was significantly influenced by different dates of sowing. The first date of sowing (D1-Nov. 30th) had produced significantly higher grain yield (4574.8 kg ha^{-1}) over the subsequent sowing dates. Thus the reduction in grain yield of wheat was observed to the tune of 20 percent with delayed sowing by 30th days. Crop sown early (Nov. 30th) took more number of days from sowing to maturity than delayed sowing (Dec. 30th). Days taken from sowing to physiological maturity reduced with subsequent delay sowings. Delayed sowing reduced the crop duration by 14 days.

Khan *et al.* (2010) [5, 8] studied that the effects of thermal and radiation regimes on wheat, consisting of five dates of sowing starting from 20 November at weekly interval. They reported accumulated global radiation and PAR during vegetative phase showed significant positive correlation, but during reproductive and grain filling phases they exhibited significant negative correlation with a dry matter. Accumulated GDD during vegetative, entire growth period and grain filling period registered significant positive correlation with grain yield. Accumulated HTU, PTU, global radiation, and PAR, prevailing during reproductive and grain filling phases, showed significant negative association with grain yield. Because of higher values of HUE, HTUE, PTUE, RAUE and PARUE, in terms of grain yield, amounting to 0.1614 g m^{-2} GDD, 0.0219 g m^{-2} HTU, 0.0104 g m^{-2} PTU, 0.2220 g MJ^{-1} and 0.1599 g $mmol^{-1}$,

Upadhyay *et al.* (2015) [1, 2, 23] observed that wheat yield and its attributes were significantly affected by different dates of sowing and different varieties during the study period. The delayed sowing caused poor vegetative growth probably due to low temperature during the early vegetative stage and reduced number of tillers as a result of high-temperature exposure during reproductive stage. Thereby reducing growing season length and causing a reduction in wheat yields. Similarly early sown wheat provides poor results because of the shortage of moisture due to a timely onset of monsoon and also high-temperature prevalence; which restricts the proper growth of wheat. In conclusion, November sown variety UP-2572 was found to be superior over UP-1109 and VL-616 for all yield and yield attributing characters of wheat in mid hill region during the study period.

3. Phenological studies of wheat under different growing environment

Paul and Sarker (2000) [15] reported the number of days required to attain different phenological stages decreased with the delay in sowing. For all phenological stages, sowing on 1 November required higher heat sums and produced plants that utilized heat more efficiently. During the early phenological stages, the phenothermal index decreased as sowing was delayed. Singh *et al.* (2001) [5, 6, 17-22] observed that the crop sown on 25 November, took more number of days from sowing to maturity than later sowings and the duration consistently reduced with the subsequent delay in sowing. Late sowing reduced the duration of vegetative and reproductive growth by 17 days. Singh *et al.* (2003) [5, 6, 17-22] studied the effect of shade on phenological development, thermal and radiation use efficiency of wheat genotypes. Phenological stage in wheat took more days under shade stress due to low radiation and thermal regimes in the crop canopies. The difference in cumulative heat units increased with the increase in shade level in advanced phenophases during the crop season. The radiation use efficiency (RUE) increased from crown root initiation till anthesis and then decreased slightly up to dough stage.

Sharma *et al.* (2003) [3, 18] reported that he daily heat units were calculated using 5 °C as base temperature for wheat. The occurrence of different phenological stages i.e. tillering jointing, flag leaf, anthesis, milking, hard dough and maturity required higher heat and photo thermal unit at all stages in D_1, (25th November) sown crop followed by D_2 (10th December) and D_3 (25th December). Among the varieties, V_2 (PBW 343) consumed maximum heat and photothermal units for occurrence of different phenological stages followed by UP 2338, WH 542, Raj 3765 and sonak, respectively. Jat *et al.* (2003) observed that the early sown crop (November 9th) needed significantly higher heat units (1775.96 degree days) to reach maturity stage which was significantly higher by 3.06 and 1.65 per cent over November 23th and December 7th sowing, respectively. Seed rates failed to produce the significant difference in days required for initiation and completion of various successive growth stages of the crop as well as heat unit requirements for the occurrence of the various successive growth stages.

Kaur *et al.* (2007) [7] observed that the phenological calendar for the two methods of sowing did not show any variability with respect to growth stages. Delayed sowing reduced the crop duration considerably by 30 days from the early sown date. The diurnal distribution of short wave radiation and its absorption, its interception in different sowing methods were recorded at grain filling stage in Punjab. Kumari and Prasad (2009) [10, 16] Average maximum and the minimum temperature of 23.4 and 10.9 °C, respectively during the reproductive period were found to be optimum for higher yield and any increase or decrease of maximum and minimum temperature over this range decreased the yield. Kumar *et al.* (2015) [9, 10, 12] reported that among the eight phenological stages, the milk stage was identified as the most sensitive stage and favours of high maximum and minimum temperature adversely affected yield of the wheat crop. The rate of yield reduction with a unit increase in maximum and minimum temperatures (°C) was found to be highest in K-8804 and lowest in HD-2285.

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