Effect of different date of sowing and cultivars on growth and yield of wheat (Triticum aestivum L.)

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Abstract

The contribution of wheat is significant owing to its wide adaptability to non-traditional rice growing area in eastern India as well as late sown and problematic areas. Wheat maintains superiority in area, production and versatility in adopting a wide range of agro climates. Effective management of natural resources, integrated approach to plant-water, nutrient and pest management and extension of wheat cultivation to newer areas under different cropping systems will play a key role in further increasing and stabilizing the productivity and production of wheat. Planting date is one of the most critical considerations and agronomic factors involved in producing high yield of small grain cereal crops like wheat. Planting date is one of the most important agronomic factors involved in producing high yielding small grain cereal crops. Early or late sowing dates increases the risk of wheat yield losses. Late sowing reduces chance of survival, generally delays maturity, increases disease chances and reduces yield potential. In this review we present a different case study related to the effect of different date of sowing and cultivars on growth and yield of wheat.

Introduction

Wheat is a cereal grass of the Graminae (Poaceae) family and of the genus *Triticum* is the world's largest cereal crop. It has been described as the "King of Cereals" because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. Wheat (*Triticum aestivum* L.) is the most important *rabi* cereal crop of Northern India. India is one of the largest wheat producing country contributing >30% in world wheat production. Among the wheat growing stats, Punjab contributes 50-70% to the central pool of wheat.

Wheat is an important staple food of the world's population. India stands second in wheat production next to the China. Area under wheat crop in India is reported 35.5 m ha with production 89.7 MT during 2017-18 (Anonymous, 2018). It contributes about 25 per cent of the total food grain production of the country. Wheat crop has remarkable adaptability. In Uttar Pradesh, wheat is grown in about 9883.9 thousand hectare with production of 34971 MT and productivity of 35.38 q/ha (SAD, 2017). It provides about 20 per cent of total food calories for human being. It considered important food crop due to its bread making quality. It contains the characteristics substance 'gluten' which providing structural framework for the spongy cellular structure of bread and chapatti.

The contribution of wheat is maximum as a result of its wide adaptability occupying in non-traditional rice growing area in eastern India as well as late sown and problematic areas about from the amenability to technological innovation. Wheat maintains superiority in area, production and versatility in adopting a wide range of agro climates. Nevertheless, the progress should not make us contented as the country face countless challenges in the form of population growth coupled with decreasing arable land, depleting water resources and climate change. Increasing population leads to an increase demand of wheat with no possibility in further increase in area due to growing urbanization. In plateau region of Uttar Pradesh, wheat is grown as a second crop in sequence after *kharif* crops. At present wheat production in state faces large gap in potential and realized yield. Among production factors, sowing time and wheat varieties are the most crucial factors deciding its productivity. Sowing of wheat in Jharkhand generally starts from November and ends in late December depending on the weather; topography and harvesting of the preceding crop. 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 favourable moisture for better growth and development. Late planting of wheat is one of the major reasons of yield reduction because of rice-wheat cropping system. In Uttar Pradesh, late planting of wheat expressed to high temperature at reproductive stage causes reduced grain yield. About 80 per cent of the wheat crop cultivated at late sowing condition after harvesting the transplanted rice and this problem will be further increased due to global warming. In spite of low yield of wheat due to post anthesis heat stress, cultivation of wheat cannot be avoided totally. Therefore, efforts ought to be made to minimize the effect of temperature variation caused due to changed sowing date by choosing appropriate wheat varieties which can synchronize its temperature requirement (Alam *et al.,* 2013).

Among these, the time of sowing and different varieties are of great significance which determine the proper stand establishment of the growing crop through balancing the plant to plant competition and ultimately affect the yield (Kabesh *et al.,* 2009; Nakano and Morita, 2009). It has been observed that early sowing gives high yield than late sowing due to longer growing period (Munir *et al*., 2002; Tanveer *et al.,* 2003) and vigorous growth associated with rapid and uniform seedling emergence (Kirby, 1993) and better combination of leaf size and tiller number (Regan *et al.,* 1992).

Planting date is one of the most critical considerations and agronomic factors involved in producing high yield of small grain cereal crops like wheat. Planting date is one of the most important agronomic factors involved in producing high yielding small grain cereal crops (Subedi *et al.,* 2007). Early or late sowing dates increases the risk of wheat yield losses (Ali *et al.*, 2010, Hasina *et al.*, 2012 and Madani *et al.,* 2010). Late sowing reduces chance of survival, generally delays maturity, increases disease chances and reduces yield potential (El-Gizawy *et al.,* 2009).

Effect of Date of Sowing

Growth and development attributes

Behera *et al.* (2000) reported non-significant influence of seeding dates on dry-matter accumulation in wheat, however the maximum dry-matter accumulated in 1 November sown crop followed by 1 December and 15 November sown wheat, respectively. Ghosh *et al.* (2000) reported that delay in sowing decreased the dry-matter accumulation at all the growth stages under study. Early sown crop (16 November) recorded the highest dry-matter accumulation at all growth stages than the crop sown on 26 November and 6 December. The increased dry-matter accumulation in early sown crop was mainly because of favorable cool weather available for longer period than what was available to the late sown one. Nainwal and Singh (2000) revealed that sowing time significantly affect germination. It was drastically reduced (27.2%) in crop sown on 27 December (85.9 m-2) in comparison to that on 27 November (118.0 m^{-2}). Plant height is mainly controlled by the genetic makeup of a genotype, but it is also affected by environmental conditions thus it varies from variety to variety. However, up to some extent it is also governed by dates of sowing. Kumar and Sharma (2003) reported from IARI, New Delhi, that sowing time significantly affects the number of tillers m^{-1} row length. The crop sown on 30 November (105.0) produced significantly higher number of tillers m^{-1} row length than the crop sown on 16 (94.1) and 31 December (94.1); latter dates of sowing did not differed significantly. Kumar and Sharma (2003) reported from IARI, New Delhi, that sowing time significantly affects the height of plant. The crop sown on 30 November (89.0 cm) produced significantly taller plants than the crop sown on 16 (83.3 cm) and 31 December (83.3 cm); later dates of sowing did not differed significantly. Shahzad *et al.* (2007) reported that the plant height was decreased with delay in sowing. The crop sown on November, 15 produced significantly taller plants (88.73 cm) than that sown on November, 30 (86.77 cm) and December, 15 (85.41 cm). Melladoze (1980) had also reported the similar results. Mishra *et al.* (2003) reported significant differences due to dates of sowing in leaf, stem and spike dry weight. Delayed sowing resulted in significant reduction in leaf dry weight. Low temperature experienced by late-sown crop during early growth or immediately after seedling emergence might have resulted in poor leaf development. Significantly higher stem dry weight was recorded under normal-sown crop (normal temperature) in both the years at all stages except at 35 days in both the years and at 10 days after anthesis during the first year of experimentation. Dhaka *et al.* (2006) found in pooled analysis of two years of study, that the numbers of tillers per plant, were reduced by 4.8 per cent when wheat sown on 25 December (3.9 tillers $plant^{-1}$) instead of 20 November (4.1 tillers $plant^{-1}$), but this difference was not statistically significant. Ali *et al*., (2018) recorded that the first sowing was done as early sowing on 15 November and second sowing on 01 December as mid sowing for evaluating whether different sowing time affect growth and yield parameters such as plant height (cm), Grain filling duration (days), Spike length (cm), Spike weight (g), Number of spike per plant, physiological maturity (days), Grain yield per plant (g), Grain yield per spike, Harvest index, Test weight (g) were considered for evaluating growth and yield.

Yield and yield attributes

Ghosh *et al.* (2000) reported that the highest number of ears m-2 was obtained from 16 November sown crop which was at par with the crop raised on 26 November. The lowest value of the ears m-2 was recorded from late sown crop (6 December). Ghosh *et al.* (2000) reported that the highest number of grains ear^{-1} was obtained from 16 November sown crop which was at par with those of the crop raised on 26 November and gradually decreased with delay in sowing. The lowest value of the grains ear^{-1} was recorded from late sown crop (6 December). Behera *et al.* (2000) reported that seeding dates significantly influenced the 1000-grain weight in wheat, as such the maximum 1000-grain weight (50.08 g) was obtained in 1 November followed by 15 November sown wheat, which was superior to both 15 November and 1 December sowing. This difference cause significant reduction in grain yield under delayed sowing. Ghosh *et al.* (2000) reported that the test weight gradually decreased with delay in sowing. Highest test weight was obtained from 16 November sown crop which was at par with the crop raised on 26 November. The lowest test weight was recorded from late sown crop (6 December). Nainwal and Singh (2000) reported that with one month delay in sowing after 27 November there was significant reduction in 1000-grain weight. Immature and shriveled grains are produced in late sown crop, which remain in the milk stage during the period of high temperature. On the other hand, the timely sown crop gets an advantage because after having completed its vegetative growth satisfactory it comes in the earing stage when the temperature is quite favourable. Behera *et al.* (2000) reported that seeding dates significantly influenced the grain yield in wheat, as such the maximum grain yield (4.8 t ha^{-1}) was obtained in 1November followed by 15 November sown wheat, which was superior to 1 December sowing. This difference in yield was attributed to significant reduction in 1000-grain weight under delayed sowing. Ghosh *et al.* (2000) reported that the highest grain yield was recorded on 16 November sown crop which was at par with 26 November sown crop. The yield decreased steadily and significantly due to further delay in sowing. Poor growth of the late sown crop that exposed to high temperature at grain filling stage was responsible for low productivity. The early sown crop, on the other hand, having favourable cool weather condition for longer duration recorded better growth and greater productivity of wheat. Nainwal and Singh (2000) reported that the average grain yield decreased significantly with delay in sowing after 27 November. The crop sown on 27 November gave 8.6% higher grain yield than 27 December sown crop. Singh and Jain (2000) observed that mid-November sown crop gave significantly higher grain yield than the early and late sown crops and the extent of increase was 12.3 and 33.6%, because of more number of effective tillers. Kulhari *et al.* (2003) revealed that early sown crop failed to record significant grain yield over normal sowing. However, both early and normal sown crops produced significantly higher grain yield than late sown crop. Thus, a consequence of favourable climatic conditions, improvement in growth and yield components under early and normal sowing resulted in realization of higher yield compared to late sowing. Similar findings were also reported by DWR, 1995. Kumar and Sharma (2003) from IARI, New Delhi, found that delay in sowing from 30 November to 31 December decreased grain yield. The first 15 days delay in sowing reduced the grain yield by 8 per cent and the second 15 days delay by 19 per cent. Higher grain yield in early sowing as compared to late sowing was due to favourable temperature during early vegetative growth and grain filing period, which resulted in improvement in yield attributing characters. The adverse effect of delayed sowing on grain yield of wheat has also been reported by Hundal and Sandhu (1990). Mishra *et al.* (2003) recorded higher mean grain yield in 22 November sown crop and delay beyond this date resulted in reduction in grain yield. Higher grain yield of November sown crop may be due to high amount of assimilate produced by more leaf dry weight resulting in the production of more number of shoots with larger sink (spikes). Ahuja *et al*. (1996), reported higher grain yield from the crop sown in November than December. Mishra *et al.* (2003) reported that the difference in spike dry weight due to sowing time was significant during both the years of experimentation. The crop sown on 22 November produced significantly heavier spike than 22 December sown crop. Kumar and Sharma (2003) at IARI, New Delhi, reported significant effects of dates of sowing on ear length. The crop sown on 30 November (9.1 cm) produced significantly more ear length in comparison to 31 December (8.9 cm) sown crop, whereas it was statistically at par with the crop sown on 16 December (9.1 cm). Kumar and Sharma (2003) from IARI, New Delhi found significant effect of dates of sowing on ears m^{-1} row length. The crop sown on 30 November (96.2) produced significantly more number of ear m^{-1} row length over 31 December (87.3) sown crop, whereas it was statistically at par with the crop sown on 16 December (88.4). Negi *et al.* (2003) reported from Palampur (H.P.) that sowing dates significantly affects the effective tillers. Significantly higher number of effective tillers m-2 was recorded in crop sown on 28 November (245.6) than the crop sown on 28 October (186.8). Nainwal and Singh (2000) reported that the straw yield decreased significantly with delay in sowing. The crop sown on 27 November gave significantly higher straw yield than the crop sown on 27 December. Kulhari *et al.* (2003) revealed that early sown crop failed to record significantly higher straw yield over normal sowing. However, both early and normal sown crop produced significantly higher straw and biological yield over late sown crop. Dhaka *et al.* (2006) found in pooled analysis of two years of study, that the number of grains $spike^{-1}$ were reduced by 12.0 per cent when crop sown on 25 December (43.8 grains $spike^{-1}$) instead of 20 November (49.8 grains $spike^{-1}$), which was a significant difference. Dhaka *et al.* (2006) found in pooled analysis of two years of study that, 1000-grain weight reduced by 18.5 per cent when wheat was shown on 25 December (30.3 g 1000-grain^{-1}) instead of 20 November (37.2 g1000-grain^{-1}) which was statistically significant. Shirpurkar *et al.* (2007) reported non-significant effect of sowing dates on 1000-grain weight, however high test weight was recorded in November 11 in comparison to November, 27 sown crop. Shahzad *et al.* (2007) reported that the earlier sowing resulted in better development of the grains accordingly and resulted in higher 1000-grain weight. Shirpurkar *et al.* (2008) revealed that, the early sowing (8th Nov) gave significantly more 1000-grains weight (48.01 g) than the mid sowing (30th Nov) (47.93 g) and late sowing (20th Dec) (44.13 g). Suleiman (2014) reported that the sowing dates shown significant effect on yield and yield components that decreased with delay in sowing date and the highest values were obtained when cultivars sown on 1st November and 15th November. This indicated that late sowing shortened the development phases of wheat and adversely affected the grain development and thus the grain yield. The interaction effect of sowing date and wheat cultivar also remained significant on grain yield and 1000 grain weight in both seasons. Wahid & Al-Hilfy (2018) reported that the Sowing dates distributed in main plots and cultivars in sub plots with three replications. Sowing date 10^{th} November was superior in grain yield (4.96 and 5.21 t ha^{-1}) and most of its components (number of spikes 403.3 and 408.6 spike m^{-2} and number of spikelets per spike 22.08 and 22.26 spikelet $spike^{-1}$ and number of grains per spike 56.37 and 58.63 grain $spike^{-1}$), and some other traits (number of tillers 448.6 and 442.0 tiller m^{-2} and spike length 15.84 and 14.39 cm) for both seasons, respectively. Saddam *et al.,* (2018) found that sowing dates 15thNovember followed by 1st November sowing produced significantly better results for the growth and yield contributing characters of wheat varieties. It was concluded that variety Imdad-2005 was superior in all the growth and yield contributing characters, followed by W.R.I-11 and SKD-2; while among sowing dates, 15th November was remained appropriately best sowing time for producing highest grain yield in all varieties respectively.

Effect of Varieties

Growth and development attributes

Musaddique *et al*. (2000) from Faisalabad (Pakistan) revealed that plant height was significantly affected among various cultivars. The maximum plant height of 109.1 cm was recorded in cv. Rohtas-90 which was significantly taller than all other varieties. Pak-81, Faisalabad-85, Pasban-90 and Inqalab-91 were, however, at par in plant height. The minimum plant height (78.5 cm) was recorded in cv. Perwaz- 94. Overall, average plant height was 88.00 cm. The differences in plant height among various cultivars are in general, due to their genetic constitution. These results are in line with those of Afzal and Nazir (1986) and Ahmad (1991), who also reported that plant height significantly varied among different genotypes of wheat. Tripathi *et al.* (2000) reported significant difference in plant height due to varieties. Varieties A, 9-30-1, Sujata and HI 1277 did not differ significantly but these were significantly superior to GW 1034, during both the years of experimentation. Nainwal and Singh (2000) at Pantnagar (Uttarakhand) recorded the significant difference in plant height of different varieties. HS 240 (107.6 cm) recorded maximum plant height which was significantly superior over other eleven varieties under comparison and HD 2402 recorded shortest plant height. Ghosh *et al.* (2000) reported that the wheat variety 'Sonalika' produced significantly higher dry-matter accumulation than 'UP 262' in all stages of phonological development except at CRI stage. Musaddique *et al.* (2000) revealed that total dry-matter (TDM) yield was differed significantly among various genotypes of wheat. The Inqalab-91 produced the highest TDM (13.5 t ha-1) followed by Pasban-90 (12.3 t ha^{-1}), Rohtas-90 (11.6 t ha^{-1}) and Faisalabad-85 (11.3 t ha^{-1}). Both Pak-81 and Perwaz-94 produced the lowest TDM than all other genotypes. Overall, average TDM was 11.7 t ha^{-1} which compares favourably with the values of 9.5 to 15.0 t ha^{-1} as reported by Hussain *et al.* (1997). Mishra *et al.* (2003) reported significant difference due to varieties in leaf, stem and spike dry weight. Among varieties, UP 2425 being at par with UP 2338, NIAW 34, Raj 3765, PBW 343, UP 2382 and Raj 3077 produced significantly higher leaf dry weight than other varieties during 2000-2001, whereas UP 2382 being at par with UP 2338 recorded significantly higher leaf dry weight during 2001-2002. At the time of physiological maturity, significantly higher stem dry weight was recorded with PBW 343 than other varieties during both the years, but it was at par with UP 2425, WH 896, UP 2382, Raj 3765 and NIAW 34 during 2000-2001, and with PBW 373, UP 2382, NIAW 34, CPAN 3004, Raj 3765 and WH 896 during 2001-2002. The lowest stem dry weight was recorded with Raj 3071 and UP 2003 during 2000-2001 and 2001-2002, respectively. Jat and Singh (2004) reported from Maharana Pratap University of Agriculture and technology, Udaipur, Rajasthan, that among four varieties, Raj 3077 (88.3 cm) produced significantly higher plant height followed by HI 8498 (86.1 cm) as compared to other varieties. Singh (2005) reported significant difference in dry-matter accumulation by different genotypes. The variety HP-1744 produced significantly high dry-matter as compared to HP-1633, HUW-234 and HP-1731. Dhaka *et al.* (2006) reported that among the six genotypes tested the highest tillers plant-1 was obtained in PBW 343 (4.5 tillers plant-1) which was statistically superior to all genotypes except HD 2428 (4.3 tillers plant-1). Hussain *et al.* (2006) reported significant differences in plants per metre square of the four wheat cultivars. The tillers per metre square for the four cultivars averaged over doses of nitrogen showed that Dera-98 produced the maximum number of plants per metre square (336.3) followed by Inqilab-91 (315) and Punjab-96 (256.1). Daman-98 produced the lowest number of plants per metre square (241.2). Singh and Singh (2006) reported from crop research station Ghaghraghat, Bahraich (U.P.) that among the varieties Sonalika resulted in maximum plant height during first year while in second year HUW-234 recorded maximum plant height followed by HD-2285. Mattas *et al.* (2011) at PAU, Ludhiyana, reported significant difference in height of different genotypes. PDW 274 recorded significantly higher plant height (95.18 cm) than PDW 291 (84.51 cm).

Yield and yield attributes

Musaddique *et al.* (2000) revealed that final grain yield of wheat is mainly a function of the number of spike bearing tillers (fertile tillers) per unit area at harvest. Fertile tillers per unit area (m-2) significantly varied among various cultivars. The highest number of fertile tillers 540 m-2 was observed in Perwaz-94 which differed significantly from Rohtas-90 (413), Pasban-90 (389) and Inqalab-91 (409). The genotypes Pak-81, Rohtas-90, Pasban-90 and Inqalab-91 produced statistically same number of fertile tillers per unit area (m^{-2}). The minimum number of fertile tillers 343 m^{-2} was given by cv. Pak-81. Overall, average number of fertile tillers was 447 m^{-2}, which was slightly less than the number of tillers (506) reported by Hussain *et al.* (1997) among various genotypes. Musaddique *et al.* (2000) noticed non-significant differences in 1000-grain weight of different cultivars. The grain weight varied from 44.7 to 50.5 g 1000- $grains^{-1}$ for various genotypes. Overall mean grain weight was 47.8 g 1000-$grains^{-1}$. Hussain *et al.* (1997) reported mean grain weight of 38-51 g 1000-grains-1 among various genotypes. Tripathi *et al.* (2000) reported significant difference in productive tillers $metre^{-1}$ row length in different varieties. Variety A,9-30-1 and Sujata had almost equal number of productive tillers metre-1 row length but both were significantly superior to GW 1034 and HI 1277 in this regards. Musaddique *et al.* (2000) revealed that number of grains per spike is an important yield contributing factor of wheat which is significantly influenced by the prevailing growing conditions and genetic potential of a cultivar. The maximum number of grains per spike (48.96) was produced by Pak-81 which differed significantly from Faisalabad-85 and Perwaz-94 which produced the minimum number of grains per spike (43.35). Similarly, Pasban-90 and Inqalab-91 were also at par in the number of grains with each other. The mean number of grains per spike was at 44.3. The difference in grain number per spike was probably due to the variation in their genetic potential. New cultivars of wheat have been found to produce more grains per spikelet than old tall varieties probably due to more favourable distribution of assimilate to the ear. Generally, new semi dwarf cultivars partition more dry matter to the ears and less to the stem, and this is reflected in more fertile florets and grains per spikelet than in general standard cultivars. Ghosh *et al.* (2000) reported that the Sonalika gave significantly more grain yield than UP 262. The high grain yield of Sonalika was mainly responsible for greater LAI acting over grain filling stage than UP 262. These results are in conformity with the findings of Singh *et al.* (1995). Nainwal and Singh (2000) revealed that varieties showed significant differences in their grain yield. Raj 3077 recorded the highest grain yield and was on a par with UP 2338 and PBW 266. Lowest grain yield was observed in UP 2121 which was on a par with GW 190, HUW 234, UP 2402 and UP 2425. Saikia *et al.* (2000) found that the maximum grain yield was recorded in HUW-234 which remained at par with HUW-498, NV-1038, K-9107 and NW-468, and was significantly superior to rest of the varieties. Kulhari *et al.* (2003) found that both varieties tested i.e. WH 896 and Raj 1555 remained at par in straw yield in both the years. This seems to be due to variation in harvest index between the varieties. It was observed that variety WH 896 was efficient in utilizing biomass toward yield formation which might have led to reduced straw weight. Negi *et al.* (2003) reported that the number of effective tillers was significantly affected by varieties. Higher number of effective tillers was recorded in VL 758 followed by HS 240 among 14 varieties tested. Mishra *et al.* (2003) reported significant difference in spike dry weight of different varieties. At the time of anthesis, UP 2425 followed by UP 2003, PBW 343 and UP 2338, respectively, produced heaviest spike during 2000-2001, whereas UP 2338 exhibited the highest spike dry weight during 2001-2002. Jat and Singh (2004) reported that among varieties, HI 8498 (42.29) followed by Raj 3077 (40.64) differ significantly from rest of the varieties, while Raj 3077 was significantly superior over Raj 1555 (39.77) and Lok 1 (39.31) only. The superiority of HI 8498 seems to be on account of higher LAI and efficient translocation of metabolites towards grain formation, as evident from higher harvest index. Mishra *etal.* (2000) also reported similar results. Dhaka *et al.* (2006) found that among the genotypes the highest grain yield was obtained in PBW 343 because of higher biomass accumulation and its proper partitioning as evident from equally higher harvest index. Singh and Singh (2006) reported that the variety Sonalika gave highest grain yield (25.5 q ha^{-1}) in comparison to rest of the varieties during 2003-04 while during 2004-05 the variety HUW-234 recorded highest grain yield (25.1 q ha^{-1}) followed by HD-2285 (22.4 q ha^{-1}). Hussain *et al.* (2006) reported non-significant differences in number of grains $spike^{-1}$ of the four wheat cultivars. However, Punjab-96 produced the maximum number of grains spike-1 (51.8) followed by Dera-98 (51.8) and Inqilab-91 (51.6) whereas Daman-98 produced the lowest number of grains spike-1 (50.0). Hussain *et al.* (2006) reported non-significant differences in total spikes per metre square in four wheat cultivar under study. He is also reported non-significant differences in spikes weight of four wheat cultivars. Daman-98 produced the heaviest spike (3.9 g) while Dera-98 produced the lowest spike weight (2.9 g). Shirpurkar *et al.* (2007) reported significant effect of genotypes on number of ear heads. The ear heads (m-2) were recorded maximum in the genotypes Raj 4037 (332) and GW 344 (335), and both were significantly superior over rest of the genotypes under study. Shirpurkar *et al.* (2007) reported significant effect of genotypes on grain yield. The wheat genotype Raj 4037 (31.51 q ha-1) has significantly out yielded rest of the genotypes except GW 344. Shirpurkar *et al.* (2007) reported significant effect of genotypes on number of grains $earhead^{-1}$. HD 2189 recorded the maximum number of grains $earhead^{-1}$, which was significantly superior over rest of the genotypes under study, except GW 344, NIDW 295 and GW 1189 durum genotypes. Shirpurkar *et al.* (2008) reported that the number of grains earhead-1 significantly differed from genotype to genotype. Shirpurkar *et al.* (2008) found that the grain yield difference due to different genotypes was significant. The variety GW-322 (43.66 q ha-1) out yielded all other varieties. Variation in yield of wheat varieties due to the heterogeneity in genetical constitution has also been reported by Rawat *et al.* (2000). Shirpurkar *et al.* (2008) reported that the 1000-grain weight of genotypes differed significantly. Among six varieties MACS-2846 (53.52 g) and GW-322 (42.33 g) produced highest and lowest 1000-grain weight, respectively. Shirpurkar *et al.* (2008) reported significant difference in number of ear heads in different genotypes. The variety Raj 4037 (413.78) produce highest number of ear heads (m-2) among six tested varieties. Shirpurkar *et al.* (2008) reported that the straw yield difference due to different genotypes was statistically significant. The variety NIAW-34 (78.89 q ha^{-1}) out yielded all other varieties except remaining at par with Raj-4037 (78.87 q ha-1). Tahir *et al.,* (2009) suggested that the sowing dates significantly maximum grain yield (4289.54 kg ha^{-1}) was obtained when crop was sown on 1st December against the minimum grain yield (2109.50 kg ha^{-1}) in case of late sowing i.e. 30th December. Among of varieties Inqlab-91 gave significantly maximum yield (3550.44 kg ha^{-1}) while minimum yield (2932.59 kg ha^{-1}) was obtained by AS-2002. Mattas *et al.* (2011) reported that the variety PDW 291 recorded significantly higher number of effective tillers (56.84) per metre row length than PDW 274 (53.17) at the time of harvest. Dhugga and Waines (1989) also observed similar findings. Mattas *et al.* (2011) reported that the PDW 274 recorded significantly higher ear head length (7.42 cm) than PDW 291 (6.73 cm). The results are in accordance with those of Kaya *et al.* (2002) who reported that plant height had a significant positive correlation with spike length. Singh (1996) also reported similar findings based on two varieties PBW 34 and PDW 233 of Durum wheat. PDW 233 had high height and ear length than PBW 34. Mattas *et al.* (2011) reported that the variety PDW 274 produced significantly higher number of grains per ear (48.18) than the PDW 291 (42.16). PDW 274 had significantly more ear head length and therefore more number of grains per ear head than PDW 291. Kaya *et al.* (2002) also recorded significant positive correlation between ear length and number of grains per ear. Singh (1996), Abad *et al.* (2004) had also observed significant differences in grains per ear among wheat varieties. Mattas *et al.* (2011) recorded that the variety PDW 291 gave higher 1000- grain weight (51.97 g) which was statistically at par with that of PDW 274 (50.48g). PDW 274 had significantly higher ear length and more number of grains per ear which might have contributed to its lower 1000-grain weight owing to the increased competition between the ear to the density of grains. Kaya *et al.* (2002) also reported a negative correlation between ear length and number of grains per ear to the density of grains. Ranu *et al.,* (2018) suggested that the effect of five dates of sowing (20th October,5th November, 20th November, 5th and 20th December) on growth, yield attributes and yield of four wheat varieties (VL-829,VL-907,VL-892 and HS-490) on a silty clay loam soil at Palampur (HP), India. Wheat sown on 20th November recorded significantly highest plant height, tillers/m2, Dry matter accumulation, grains/spike, grain and straw yield. Among varieties, VL-907 recorded significantly highest grains/spike, grain and straw yield and hence recorded significantly highest grain yield. Ali et al., (2018) recorded that varieties sown early performed better than mid sown wheat varieties in terms of plant height (cm), spike length (cm), spike weight (g), number of spike per plant, grain yield per plant (g), grain yield per spike (g), harvest index, test weight (g). On the basis of 12 early sown wheat varieties, HD-2967 showed maximum number of spike per plant (8.33), spike length (13.98 cm), spike weight (130.00 g), grain yield per spike (17.94 g) and grain yield per plant (18.30 g), test weight (48.80 g) whereas PBW-550 showed minimum plant height (74.33 cm) and grain filling duration (32.00 days). In mid shown wheat varieties Super-252 showed high Number of spike per plant (8.33), spike length (12.36 cm), spike weight (113.33 g), grain yield per spike (15.40 g), grain yield per plant (18.21 g), and harvest index (84.25), test weight (43.5 g). Lodo *et al.,* (2018) reported that the wheat variety Imdad-2005 proved to be more promising variety as compared to W.R.I-11 and SKD-2 varieties; with a plant height of 100.31 cm and 94.57 cm and 92.02 cm, tillers plant-1, 6.11, 5.24 and 4.64, spike length, 10.37 cm, 9.92 and 9.44 cm, grain weight plant-1 27.50 g, 25.32 g and 23.72 g, maximum biological yield 10355.49, 10162.14 and 9423.41 kg ha-1 were recorded from SKD-2 followed by Imdad-2005 and W.R.I-11 wheat varieties, grain yield 6134.60, 5962.03 and 5892.36 kg ha-1 and seed index value 5.26 g, 5.20 g and 4.64 g respectively.

Interaction Effect of Dates of Sowing and Varieties

Growth and development

Nainwal and Singh (2000) reported significant interaction effect of sowing dates and varieties on plant height. Significant reduction in plant height was recorded in late sowing in all the varieties except HD 2402 and PBW 226. Among varieties, HS 240 produced the tallest plant in both the sowing dates, which was at par with PBW 226 in 27 December sowing.

Yield and yield attributes'

Nainwal and Singh (2000) reported significant interaction effect of sowing dates and varieties on number of grains spike^{-1}. There was reduction in grain number spike-1 with shift of sowing date from 27 November to 27 December in all the varieties except HD 2402, PBW 266, Raj 3077 and UP 2121. Raj 3765, which recorded the highest number of grains spike-1 in both the sowing dates, had significantly higher number of grains than all the varieties except GW 190 and HS 240 in 27 November sown crop. But this variety was at par with HD 190, UP 2338, PBW 266 and HS 240 in 27 December sown crop. Nainwal and Singh (2000) reported significant interaction effect of sowing dates and varieties on test weight. UP 2425 recorded the lowest weight of 1000-grains in 27 December sowing, but it had higher 1000-grain weight in 27 November sowing. Shirpurkar *et al.* (2007) reported significant interaction effect of sowing dates and wheat genotypes for test weight. It is revealed that the significantly superior 1000-grain weight was recorded by the genotype MACS 2846 with the normal sowing in first fortnight of November, which was at par with the genotype Raj 4037 and GW 1189 with the same sowing environment. The genotype MACS 2846 with the late sowing in second fortnight of November recorded the highest 1000-grain weight than all other genotypes under comparison. Shirpurkar *et al.* (2007) reported significant interaction effect of sowing dates and wheat genotypes for grain yield. They revealed that normal sowing in first fortnight of November produced significantly higher grain yield of all the genotypes except the genotype Raj 4037 than the late sowing in second fortnight of November. The genotypes GW 344 and Raj 4037 produced significantly higher grain yield than rest of the genotypes when sown in first fortnight of November however, Raj 4037 produced significantly higher grain yield with late sowing than rest of the genotypes.

Economics

Alam et al., (2013) revealed that wheat sown on 25th November achieves higher net return of Rs 37400 with benefit: cost ratio of 1.34 which is 88.70 per cent higher than 20th December sown wheat. Among wheat varieties K 0307 proved superiority in total tillers (492m-1), dry matter accumulation (1120.60 g m-2), grain yield (45.40 q ha-1), net return (Rs 31090 ha-1) and benefit: cost ratio (1.14) than that of mean of rest of the four varieties i.e. Raj 4229, K 0906, HD 2733 and DBW 39. Bachhao et al., (2018) reported that the wheat variety Tapowan was found better to sowing date of 1st week of December with regards to growth and yield attributes (43.28 q ha-1). Economically Tapowan wheat variety in S2 (1st week of December) sowing date attained higher gross (72318 Rs ha-1), net monetary returns (36517 Rs ha-1) and B: C ratio 2.02.

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