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Effect of sowing time on growth, yield and phenology of wheat (*Triticum aestivum* L.) genotypes in North-Western plain zone

Vanshi Dhar Yadav, NS Rana, Harveer Singh and SS Tomar

Abstract
The field experiment was conducted at CRC Farm Chirrori, Sardar Vallabhbhai Patel Agriculture University Meerut during *rabi* 2012-13 and 2013-14. The experiment comprised of three sowing time i.e. I week of December, III week of December and I week of January with four wheat genotypes viz. Raj 3765, PBW 590, DBW 16 and WH 1021. The experiment was laid out in split-plot design, replicated with three times. The result expressed that Sowing of wheat on I week of December noticed significantly higher effective tillers, higher dry matter accumulation, higher leaf area index and crop growth rate than other sowing time. Significant reduction was recorded between the times of sowing and genotypes. The yield and yield attributes in terms of spikelet's spike^{-1}, spike length (cm), 1000-grain weight (g), harvest index (%), biological yield and grain yield (q ha^{-1}) recorded marked reduction under delayed sowing. Moreover, in overall among the genotypes, PBW 590 was found to be best performance followed by WH 1021 at December I week sowing as compared to all other sowing dates.

Keywords: sowing time, genotypes, phenological stages, leaf area index, crop growth rate, yield attributes

Introduction
Wheat is one of the most important food crops of the world in terms of area harvested, production and nutrition. It provides more than 19% calories and 21% of the protein to the world population (FAO, 2011) besides it is major source of energy, protein and dietary fibre in human nutrition since decades. In India, it covers an area of 29.65 million hectare with total production of 93.50 million tons and average productivity of 31.53 q ha^{-1}. Wheat has wide latitudinal distribution. It is grown near to equator as well as 60^0 North and 40^0 South latitudes and it can with stand in varying temperature from extremely low to fairly high. The photoperiod and temperature differ markedly with high altitude at the time of sowing and during apex differentiation and grain development. Minimum, optimum and maximum (cardinal) temperature for germination of wheat crop are 4^0 to 5 ^{0}C, 24 ^{0}C to 25 ^{0}C and 30 ^{0}C to 32 ^{0}C for growth and development. In western Uttar Pradesh it is grown under rice-wheat and sugarcane cropping system hence, it's sowing must delay up to month of December and sometime 1st week of January. Delay in the sowing of wheat crop causes the substantial loss in grain yield due to high temperature at later phenological stages (maturity). Delayed germination due to low soil and ambient temperature prevailing at the time of late sowing and short vegetative period of the crops are the main causes of low yield under late sown condition. If wheat is sown late, the crop is induced to flower quite early due to onset of spring season cutting vegetative phase short which result in shortening of source and sink capacity. The optimum sowing time and selection of improved cultivar play a remarkable role in exploiting the yield potential of the crop under particular agro-climatic condition. It governs the crop phenological development and efficient conversion of biomass in to economic yield. Growing of suitable genotypes at an appropriate time is an essential for ensuring optimum crop productivity.
Keeping this in view, an attempt was made to evaluate the Performance of four wheat (*Triticum aestivum* L.) genotypes under various sowing time in North-Western plain zone.

Materials and Methods
The field experiment was conducted during the *rabi* season of 2012-13 and 2-13-14 at CRC, of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, (29^0 13' N, 77^0 68' 43 E, 237 m above mean sea level) Meerut, India. Climate is semi arid sub tropical with extremes of hot weather in summer and cold in winter season. There is gradual decrease in mean daily temperature from October reaching as low as 2-4 ^{0}C in January and further a

gradual increase is registered from February reaching as high as 43-45 ^{0}C in May. The rains are predominantly caused by south-west monsoon which sets in the last week of June, reaches its peak in July-August and withdraws by the end of September. The area receives 862 mm of rains annually on an average, of which 90% is confined to rainy season (July-September). Soil of experimental field was loam with pH of 8.2, Electric Conductivity (EC) 0.61 dSm^{-1}, low in organic C (0.33%), available N (175 kg ha^{-1}), medium in available P (28 kg ha^{-1}) and K (247 kg ha^{-1}). A range of mean weekly maximum temperature varied from 11.0 ^{0}C to 36.2 ^{0}C, and the mean weekly minimum temperature ranged from 1.2 ^{0}C to 164.4 ^{0}C during 2012-13. During next season i.e. 2013-14, mean weekly maximum temperature varied from 15.4 ^{0}C to 38.7 ^{0}C, and the mean weekly minimum temperature ranged from 4.7 ^{0}C to 20.8 ^{0}C were recorded in the cropping season. The total of 183.9 mm rainfall was received during 2012-13 and 42.3 mm during 2013-14. The experiment was laid out in 3 replicates in a split-plot design and treatment consisting 3 sowing time in main plots (I Week of December, III Week of December and I Week of January) and 4 genotypes *viz.* (i) Raj 3765 (ii) PBW 590 (iii) DBW 16 (iv) WH 1021, in sub- plots with three replication. Wheat crop was sown with the row spacing of 20 cm as per treatments. Four irrigations (75 mm irrigation in each) were applied at four critical phenological stages. In regards to fertilizer application of the crop, 150 kg N, 60 kg P_2O_5 and 40 kg K_2O were applied. Out of which, 1/3rd N and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing by broadcasting method. The remaining 2/3rd dose of N were applied in two splits at CRI and late tillering stages. Total tillers and ears recorded as per square metre. Five spike were randomly selected and threshed manually, grains counted and data presented as grains per spike. The sample of 1000-grains collected from each plot, weighed and presented as gram. Total bundle weight was recorded from each plot at the time of harvesting. The crop was threshed and grain were weighed and presented as quintal per hectare. Meteorological data, *viz.,* rainfall, relative humidity, maximum and minimum temperature, bright sunshine hours, day length etc. were recorded from Agrometeorological observatory, PDFSR, Meerut. Weeds were controlled with Isoproturon @ 1.0 kg ha^{-1} as post-emergence application after 35 DAS. Data on plant growth, yield attributes, biological yield, harvest index and grain and straw ratio were recorded at crop maturity. Standard procedures were used for chemical analysis of soil and plant sample. The data were analyzed by using the 'Analysis of Variance Technique' as per the procedures described by Panse and Sukhatme, (1967) [8]. The treatment means were compared at 5% level of significance

Result and Discussion

Growth and development

The data presented in Table 1 revealed that sowing time significantly influenced the growth character viz. plant population m^{-2} initial and at maturity, shoot length, dry matter accumulation, leaf area index and crop growth rate (CGR). Plant population m^{-2} initial and at harvest was significantly maximum in I week of December sown crop than that sown on III week of December and I week of January. Wheat sown on I week of December recorded plant population per m^{-2} at harvest which was 5.0 and 15.7 percent higher than III week of December and I week of January sown crop. Prabhakar *et al.* 2003 [9] and Gupta *et al.* 2007 [4] also observed that significant reduction in plant population with each successive delay in sowing time. Data pertaining to shoot length clearly revealed that shoots were taller in case of I week of December sown crop as compared to III week of December and I week of January (Naniwal and Singh 2000) [7]. Significantly higher dry matter was observed at maturity in the treatment where wheat was sown at I week of December as compared to III week of December and I week of January. The LAI was significantly higher at 90 DAS in the treatment where wheat was sown at I week of December as compared to succeeding sowing crop. Similarly Pal *et al.* (1996) also reported higher plant population and dry matter accumulation of wheat under December sown crop than January.

Wheat genotypes had also significant difference for shoot length. At maturity higher plant dry matter accumulation was recorded with PBW 590 which was significantly superior to Raj 3765 and DBW 16 but at par with WH1021 (Sanghera *et al.* 2014) [10]. However at maturity wheat variety PBW 590 produced significantly higher plant population over all varieties except WH 1021 during 2013-14 while during 2012-13 the genotypic differences were non-significant. The plant population produced by genotypes PBW 590 and WH1021 were at par among themselves but significantly superior over DBW 16 and Raj 3765 (Tahir *et al.* 2009) [12]. At 90 DAS the LAI of genotypes raj 3765 , PBW 590 and WH 1021 were at par with each other, but the variety raj 3765 showed significant superiority over DBW 16 during 2012-13 while during 2013-14 genotypic difference were found non-significant. These results are similar to those of (Mishra, 2002 and Singh *et al.*, 1995) [6, 11].

Phenological studies

Phenological stages of wheat as affected by sowing time and genotypes have been presented in Fig. 1&2. Days taken to emergence, CRI and tillering was recorded significantly maximum under I week of January sown crop than that sown on III week of December and I week of December. While days taken for heading, dough and maturity were recorded significantly higher under I week of December as compared to III week of December and I week of January sown crop. Genotypes also had significant variation on phenological stages at dough and maturity whereas at emergence, CRI, Tillering, and heading were obtained in Raj 3765 followed by WH 1021 and DBW 16 while minimum in PBW 590 genotype during both the years. Amrawat *et al.* 2010 and Gill *et al*. 2013 [3] also observed that delay in sowing significantly affected the required days to germination, booting, anthesis, maturity including the yield as compared to normal sowing.

Yield and yield attributes

Effective tillers m^{-2}, spikelet's spike^{-1} grains spike^{-1}, grain yield, 1000-grain weight and grain: straw ratio was significantly influenced by sowing time and genotypes Table 2. Significantly highest effective tiller m^{-2} were recorded in crop sown on I week of December than that sown on III week of December and I week of January (Das *et al.* 2013) [2]. Among genotypes, PBW 590 recorded maximum effective tiller m^{-2} and lowest was recorded in Raj 3765. I week of December sown crop gave significantly higher spikelet's spike^{-1} than other sowing crop. Among the genotypes, PBW 590 recorded significantly higher number of spikelet's spike^{-1} as compared to other genotypes, except WH 1021. Perusal of data indicated that number of grains spike^{-1} decrease with delay in sowing time. Crop sown I week of December recorded significant higher number of grains spike^{-1} than that sown in I week of January and at par with the III week of

December during 2012-13. While during 2013-14 I week of December was recorded significantly more number of grains spike^{-1} as compared to succeeding sowing time. Genotypes exhibited significant difference on number of grains spike^{-1} during 2013-14 whereas during 2012-13 there was no significant differences were found. Among the genotypes, PBW 590 remaining at par with WH 1021, registered significantly higher number of grains spike^{-1} than Raj 3765 during 2013-14 while, during 2012-13 the differences were, however, not significant between genotypes. Genotypes, PBW 590 recorded highest number of grains spike^{-1} and Raj 3765, the lowest. Crop sown on I week of December (32.2 g and 32.3 g) and III week of December (31.5 g and 31.6 g)) which were at par produced significantly more test weight than that sown I week of January (30.3 g and 30.6 g) during both the years. Similarly, genotypes PBW 590 and WH 1021 which were at par recorded significantly more test weight during 2013-14, while during 2012-13, the maximum test weight was 32.0 g was recorded in genotypes PBW 590 and Raj 3765, the lowest. I week of December sown crop produced significantly higher grain yield (38.2 and 39.4 q ha^{-1}) as compared to crop sown on III week of December (32.6 and 34.3 q ha^{-1}) and I week of January (26.2 and 26.8 q ha^{-1}) on the basis of mean yield of, I week of December sown crop produced higher yield over the succeeding sown time. Similarly, genotypes also had significant differences on grain yield, PBW 590 recorded higher grain yield (34.5 q ha^{-1}) than Raj 3765 (29.1 q ha^{-1}) and DBW 16 (32.2 q ha^{-1}) during 2012-13, but remained at par with WH 1021. Similar trend was also followed in second year [1 &5]. Grain to straw ratio was found higher in I week of December sown crop as compared to rest. Among genotypes, higher ratio was found in WH 1021 (0.58) during 2012-13 while during 2013-14 it was found in PBW 590.

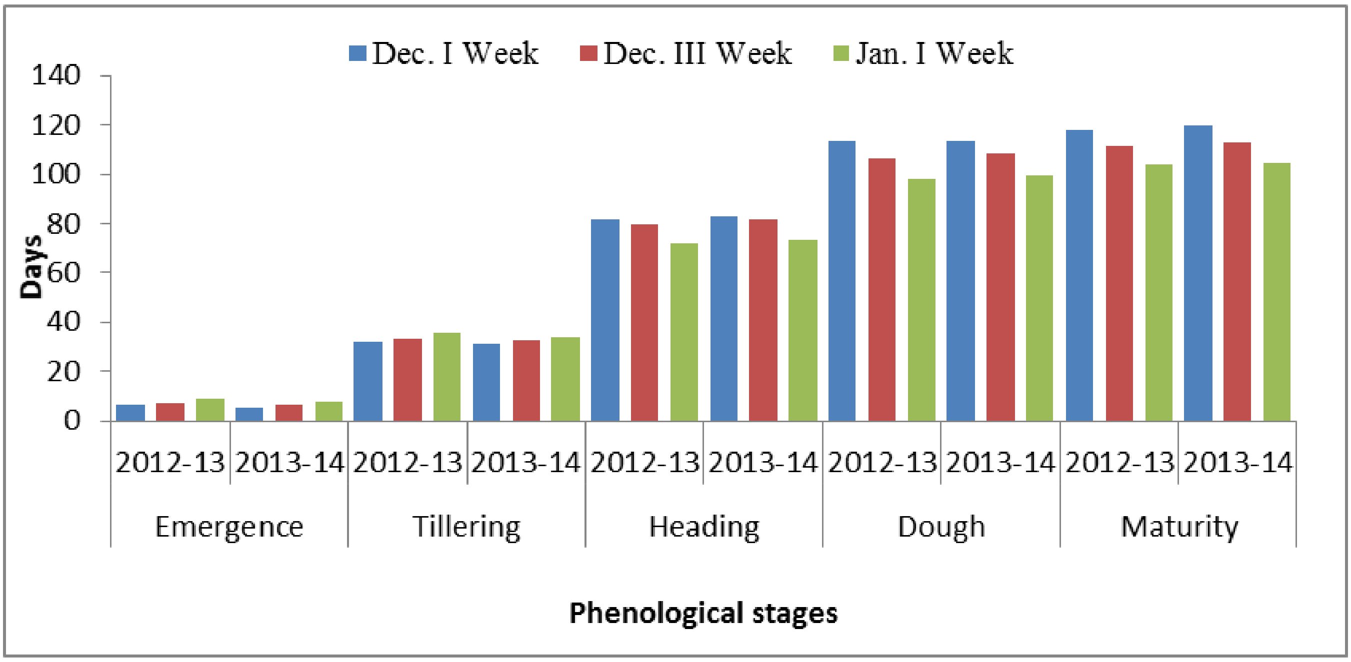

Fig 1: Effect of sowing time on days taken to attain different phenological stages

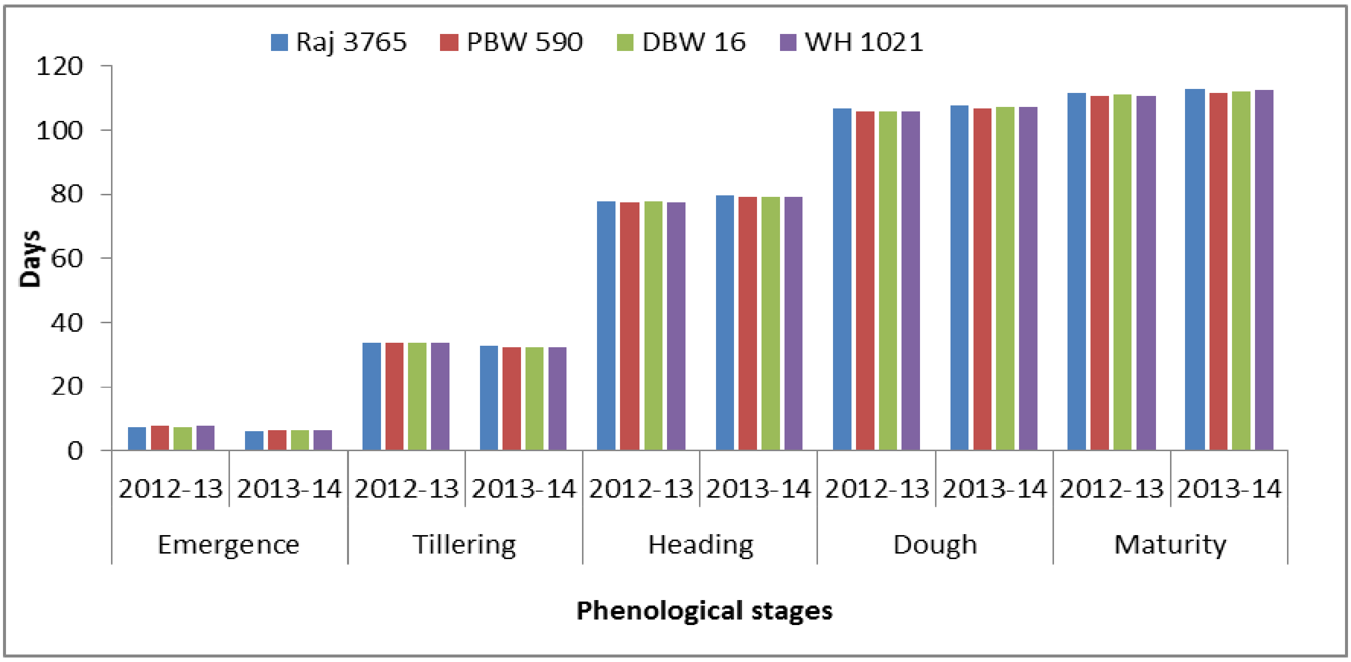

Fig 2: Effect of genotypes on days taken to attain different phenological stages

Table 1: Plant population, shoot length, dry matter accumulation, leaf area index and crop growth rate of wheat influenced by sowing time and genotypes

Treatment	Initial plant population (No. M^{-2})		Plant population at harvest (No. M^{-2})		Shoot length (cm)		Dry matter accumulation at harvest (g m^{-2})		Laf area index at 90 DAS		Crop growth rate at 90 (g m^{-2} day^{-1})	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Sowing dates												
Dec. I Week	223.4	226.8	328.7	332.1	75.18	77.42	979.6	986.5	3.81	3.95	11.1	10.9
Dec. III Week	207.6	210.7	310.4	314.5	69.58	72.72	830.8	843.3	3.76	3.92	8.7	8.9
Jan. I Week	190.5	192.1	284.8	288.2	63.89	66.30	732.8	744.1	3.41	3.64	8.7	8.8
S.Em±	1.9	1.4	1.5	1.3	1.49	1.75	3.7	5.0	0.03	0.05	0.2	0.1
C.D (P=0.05)	7.6	5.7	6.1	5.3	6.02	7.07	14.9	20.2	0.13	0.21	0.8	0.6
Genotypes												
Raj 3765	203.8	207.1	301.7	306.5	73.63	75.79	830.9	844.5	3.74	3.94	9.5	9.7
PBW 590	209.3	212.3	313.1	316.7	67.99	70.23	857.5	867.3	3.70	3.82	9.4	9.4
DBW 16	206.7	209.0	306.8	310.6	66.36	69.30	847.8	857.3	3.58	3.71	9.8	9.6
WH 1021	208.6	211.0	310.2	312.8	70.23	73.27	854.7	862.4	3.64	3.86	9.5	9.4
S.Em±	1.1	1.1	3.8	1.4	1.35	1.56	2.7	5.1	0.03	0.05	0.2	0.3
C.D (P=0.05)	3.4	3.4	NS	4.4	4.06	4.68	8.7	15.3	NS	0.15	NS	NS

Table 2: Yield and yield attributing characters of wheat influenced by sowing time and genotypes

Treatment	Effective tiller m^{-2}		Spikelet's $spike^{-1}$ (No.)		Grains $spike^{-1}$(No.)		Grain yield (q ha^{-1})		Harvest index (%)		Grain: straw ratio	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Sowing dates												
Dec. I Week	325.7	327.4	16.5	18.5	39.1	40.7	38.2	39.4	38.1	38.5	0.60	0.62
Dec. III Week	308.1	311.6	15.0	17.1	37.2	38.6	32.6	34.3	37.1	37.6	0.50	0.60
Jan. I Week	284.5	286.5	14.4	15.8	32.7	33.2	26.2	26.8	33.3	34.7	0.50	0.53
S.Em±	2.2	1.4	0.2	0.1	1.1	0.7	0.3	0.2	0.5	0.2	0.01	0.006
C.D (P=0.05)	9.2	5.6	0.6	0.65	4.7	2.9	1.5	1.2	2.0	1.0	0.05	0.02
Genotypes												
Raj 3765	301.3	305.1	15.0	16.6	34.1	35.9	29.1	30.0	35.5	36.6	0.55	0.57
PBW 590	310.6	312.8	16.2	18.1	38.2	39.3	34.5	35.8	36.6	37.4	0.57	0.60
DBW 16	305.8	307.7	14.8	16.0	35.5	36.8	32.2	33.0	35.7	36.7	0.55	0.58
WH 1021	306.8	308.3	15.6	17.6	37.6	38.1	33.7	35.1	36.5	37.1	0.58	0.59
S.Em±	3.5	2.1	0.3	0.4	1.1	0.6	0.2	0.2	0.3	0.3	0.009	0.01
C.D (P=0.05)	NS	NS	0.8	1.2	NS	2.2	0.8	0.8	NS	NS	NS	NS

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