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Influence of dates of sowing on phenology, growth, and yield of diverse wheat varieties under changing climate in eastern sub-Himalayan Indian plains

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Abstract

An experiment was carried out during 2017-18 and 2018-19 at sub-Himalayan plains of West Bengal to find out the optimum time of sowing for better yield of diverse wheat varieties (*Triticum aestivum* L.) and to quantify the yield losses due to delayed sowing. The experiment was laid out in split plot design having four dates of sowing (November 5, November 25, December 15 and January 05) as main plots and six wheat varieties (HS 562, HD 2967, HD 3086, HI 1544, MACS 6222 and WR 544) as sub-plots. The plant height, tiller number as well as LAI (Leaf Area Index) recorded at different stages of growth during both the years differed significantly with different dates of sowing. All these growth attributes were recorded higher in November 25 sowing. The total biomass production (95.90 q ha^{-1}) was significantly higher on November 25 sowing over the other dates. The number of spikes m^{-2}, number of grains spike^{-1} as well as 1000-grain weight were also influenced significantly by various dates of sowing. The maximum numbers of spikes m^{-2} (273), grains spike-1 (40) as well as 1000-grain weight (40.14 g) were obtained under November 25 sowing. The crop sown on November 25 produced the maximum yield (41.2 q ha^{-1}) over the other dates of sowing during both the years of experiment. Among varieties, HD 2967 (34.4 q ha^{-1}) had maximum grain yield followed by variety HD 3086 (31.6 q ha^{-1}). December 15 sowing recorded an estimated overall yield reduction of 40.7 kg ha^{-1} day^{-1} over November 25 sowing and at the same time November 05 sowing also resulted in a yield reduction of 42.7 kg ha^{-1} day^{-1} indicating the optimum sowing window is late November for eastern sub-Himalayan plains.

Keywords: Growth attributes, time of sowing, variety, wheat, yield, yield reduction

1. Introduction

Commonly known as the king of cereals, wheat (*Triticum aestivum* L.) occupies the prime position among the food crops in the world. In India, it is the second important food crop being next to rice and contributes to the total food grain production of the country to an extent of about 25%. Currently, India is the second largest producer of wheat in the world after China with about 12% share in total world wheat production. The production level of wheat in India had a quantum jump from 6.46 million tonnes from an area of 9.75 million ha in 1950-51 to 103.60 million tonnes from an area of 29.6 million hectare during 2018-19. Maintaining the appropriate sowing time is one of the most important agronomic practices for getting optimum plant growth and yield of wheat under heat-stressed environment (Kajla *et al.,* 2015). Selection of suitable cultivars can maintain higher productivity of wheat in any region. In general, all wheat varieties, when sown late, faces severe temperature stress that significantly affects phenology, growth and finally yield (Hossain and da Silva, 2012 ; Hakim *et al.,* 2012). Under changing climate perspective it is the need of the hour to optimize the sowing window which may have a great role towards better performance of the crop.

The low productivity of wheat in North Eastern Plains Zone (NEPZ) is due to shorter favourable growing period as in recent years the temperature began to rise from mid February and thus a short cool spell during its growing season with more fluctuation in temperature hampers the crop productivity. Temperature impacts crop phenology and each species has a specific lower temperature value or base temperature, an optimum temperature value, and an upper temperature limit which actually determines the performances of the species (Hatfield *et al*., 2011). Among various agronomic practices proper time of sowing is an important factor and it is a no-monetary input for achieving maximum yield. The deviation from recommended sowing time of a genotype for a particular set of environment results in failure to achieve its maximum production potential. Advancing sowing time for a particular variety may not be always feasible in a high rainfall zone like sub-Himalayan plains of West Bengal where there is plenty of moisture in the soil even during harvesting of rice in early November. Keeping in view the role of proper sowing time in wheat production under changing climate, this experiment was planned to optimize the date of sowing for better yield of wheat varieties and at the same time to quantify the yield losses under various sowing dates.

2. Materials and methods

The field experiment was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar located at 26°24'02.2"N latitude, 89°23'21.7"E longitude and at an elevation of 43 meters above mean sea level (msl). It was carried out during *rabi* seasons of two consecutive years, *i.e*., 2017-18 and 2018-19. The experimental site was bestowed with sub-tropical per humid climate. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.81) with organic carbon content 0.94%. It was low in available nitrogen (138.9 kg ha^{-1}), high in available phosphorus (32.6 kg ha^{-1}) and medium in available potassium (146.8 kg ha^{-1}).

The experiment was laid out in a split plot design having 24 treatment combinations each replicated thrice. Four different dates of sowing November 5 (D_1), November 25 (D_2), December 15 (D_3) and January 5 (D_4) were randomly allotted in each main plot, while six different genotypes (HS 562, HD 2967, HD 3086, HI 1544, MACS 6222, WR 544) were randomly allocated in sub-plots.

The seeds were sown manually in line with a seed rate of 100 kg ha^{-1} for D_1 and D_2, 125 kg ha^{-1} for D_3 and D_4 at a row spacing of 20 cm. The fertilizers were applied as per the recommendation: 150:60:40 kg NPK ha^{-1}. Entire dose of P and K were applied as basal along with 1/3rd N and rest N were applied in two equal splits at 21 days after sowing (DAS) and 42 DAS. Boron was applied twice @ 0.20% with solubor (20% B), once at 35-40 DAS and the next at 55-60 DAS. Zinc (Zn) was applied@ 0.10% with B in the second spray in the form of Chelated Zn. During both the years, 4 irrigations were given at CRI, active tillering, booting and milking stage. Check basin method of irrigation was followed keeping the depth of irrigation at 5 cm measured through volume basis. Harvesting of the crop was done manually and yield was estimated on net plot basis excluding the border rows. After harvesting, the produce was threshed and grains were dried to record yield. The data were analyzed by using standard analysis of variance procedures and mean comparisons were performed based on least significant differences test at 0.05 probability.

3. Results and discussion

3.1 Growth attributes of wheat varieties under different dates of sowing

The results of the experiment (Table 1) indicated that the growth attributes *i.e.*, plant height, tiller number, leaf area index and biomass production were affected significantly with varying dates of sowing under both the years of experimentation. The maximum plant height at harvest was recorded under November 25 sowing (95.1cm) followed by December 15 sowing (91.5 cm). Due to exposure to a favourable temperature during end-November to mid-December, the crop exhibited higher plant heights. Similar results were reported by Kamrozzaman *et al.* (2016), who recorded the maximum plant height (97.93 cm) in November 25 sown crop which was statistically at par with other sowing dates except December 15. Irrespective of sowing time, the crop produced the highest number of tillers at 60 days after sowing (DAS) after which it reduced due to tiller mortality at later phases. For tillering of wheat, the crop needs a cooler temperature which is prevalent during December end to January in this zone. It coincided with the active tillering phases of November 25 sown crops leading to higher tiller number. The differential variation for tiller production among genotypes might be due to their genetic variability. Leaf Area Index (LAI) at different stage of growth was found to differ significantly with various dates of sowing and the highest LAI was recorded when the crop achieved flowering under all the dates of

Table 1: Effect of dates of sowing on growth parameters of wheat varieties (Pooled data of two years)

Treatments	Plant height (cm)	Tiller number (no m^{-2})			LAI			Biomass production (q ha^{-1})
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
Dates of sowing								
Nov 5	88.0	113	294	275	0.84	1.71	3.34	77.15
Nov 25	95.1	139	342	323	1.06	2.01	4.16	95.90
Dec 15	91.5	129	281	267	0.82	1.77	3.82	75.90
Jan 5	74.3	104	218	196	0.56	1.53	2.98	45.75
SEm(±)	2.2	3.2	6.8	7.4	0.04	0.07	0.08	1.47
CD(P=0.05)	7.8	11.0	24.1	26	0.15	0.25	0.27	5.22
Varieties								
HS 562	90.4	116	280	263	0.93	1.73	3.67	67.65
HD 2967	93.4	129	303	285	1.08	1.98	4.37	83.45
HD 3086	85.9	108	291	275	0.53	1.47	4.09	75.95
HI 1544	84.8	134	277	249	1.195	2.11	2.82	63.30
MACS 6222	85.4	134	271	252	1.165	2.12	3.97	78.80
WR 544	81.3	137	268	230	1.19	2.15	3.03	72.85
SEm(±)	2.9	3.75	7.9	8.45	0.11	0.12	0.12	2.08
CD(P=0.05)	8.35	10.65	22.6	24.2	0.30	0.34	0.35	5.64

sowing. The canopy almost covered the ground area at flowering for which there was higher LAI. It was noticed that two short duration varieties, *i.e.*, HI 1544 and WR 544 achieved the highest LAI values at 60 DAS due to their shorter duration after which it reduced, while the other four varieties *i.e.*, HD 2967, HD 3086, HS 562 and MACS 6222 exhibited the higher LAI values at 90 DAS. The highest total biomass production was achieved during November 25 sowing (95.90 q ha^{-1}). Higher values in leaf area with increased plant height and tiller number as well as superiority of yield components *viz*., number of spike m^{-2} and number of filled grains $spike^{-1}$ were achieved in 25 November sown crop, which was mainly responsible for this increased biomass production. This was in line of conformity with the findings of Hossain *et al.* (2018) who reported higher plant biomass under 25 November sowing rather than 5 November or 15 December sowing.

3.2 Phenological stages

It was observed (Table 2) that the dates of sowing had a significant influence on the attainment of different phonological stages in wheat. The varieties HD 2967, HS 562 and MACS 6222 took 73-74 days for achieving 80% booting under November 5-25 sowing while this stage was attained at 64-65 days in HD 3086 and 54-56 days in WR 544 and HI 1544. With further advancement in sowing dates beyond November 25, the long duration varieties *viz.*, HD 2967, HS 562 and MACS 6222 attained this stage earlier (67-68 days) though not much variation was observed for short duration varieties WR 544 and

Table 2: Phenological dates of wheat varieties under various dates of sowing

Varieties	Days to 80% booting				Days to 80% heading				Days to 50% flowering				Days to 80% physiological maturity			
	Nov 15	Nov 30	Dec 15	Jan 5	Nov 15	Nov 30	Dec 15	Jan 5	Nov 15	Nov 30	Dec 15	Jan 5	Nov 15	Nov 30	Dec 15	Jan 5
HS 562	73	73	67	63	84	84	75	69	90	89	80	72	117	116	115	92
HD 2967	74	73	68	63	85	84	77	69	91	90	83	73	118	116	116	94
HD 3086	65	64	62	54	76	73	72	60	82	80	78	65	110	108	107	87
HI 1544	56	55	54	46	66	65	64	54	72	70	69	60	99	95	94	80
MACS 6222	74	74	65	64	83	82	75	70	90	89	82	74	117	115	114	93
WR 544	56	54	54	43	67	65	63	53	72	71	70	59	98	95	93	80

HI 1544. However, under January 5 sowing, the period for attaining 80% booting stage was drastically reduced in all the varieties (63-64 days for HD 2967, HS 562 and MACS 6222 while only 46-47 days for WR 544 and HI 1544). Therefore, it was noted that the time to achieve 80% booting was reduced by around 10 days under late sowing. Similarly the days to achieve 80% heading was reduced by around 13-15 days under late to very late sown conditions. The short duration varieties HI 1544 and WR 544 took around 95- 99 days to get mature under November 5-25 sowing, whereas it got matured within 80 days under January 5 sowing. Increasing temperature during late sown conditions attributed in quick achievement of reproductive stages for which the phenophases attained quicker in later sowing dates. Earlier attainment of various phenophases resulted in poor yield performances in later dates.

3.3 Yield and yield attributes of wheat as influenced by dates of sowing and varieties

Grain yield of wheat is a resultant effect of various yield attributing characters like spikes m^{-2}, filled grains $spike^{-1}$ and 1000-grain weight along with environmental factors. Amalgamating their influences over the grain yield (Table 3), it was found that the grain yield was greatly influenced with respect to sowing dates and varieties. The grain yield was found to be maximum under November 25 sowing (41.2 q ha^{-1}) followed by November 5 sowing (32.8q ha^{-1}) which may be due to higher values of yield attributing characters. Under November 25 sowing, the crop achieved the highest number of spikes m^{-2} (273), grains $spike^{-1}$ (40) and 1000-grain weight (40.14 g). The straw yield was also found to be maximum in November 25 sowing (50.5 q ha^{-1}) followed by December 15. The delayed sowing on 25th December in comparison to timely sowing on 20th November reduced the numbers of spike $plant^{-1}$, grains $spike^{-1}$ and 1000 grain weight by 4.8, 12.0 and 18.5 per cent, respectively (Dhaka et al., 2006). In this experiment also, the sharp decline in yield in December 15 sowing (28.59q ha^{-1}) may be attributed to significant reduction in grains $spike^{-1}$ and 1000-grain weight. Marasini *et al.* (2016) found a sharp decrease in grains per spike number with delayed sowing under sub-Himalayan plains of Nepal. Due to high residual moisture resulted from late cessation of monsoon rain in this part of the country, the stand count was not perfect under November 5 for which the yield was lesser than November 25 sown crop. Again under late sowing, the crop exposed to higher mean temperature early as the night temperature raised to 15-16 degree centigrade in mid-February for which there was huge yield reduction. This was in line of conformity with the findings of Suleiman *et al.*(2014) and Hussain *et al.* (2018) who reported poor yield under very late sowing due to exposure of the crop to much higher temperature. The influence of varietal characteristics over grain yield of wheat was also found significant during both the years of experiment. The variety HD 2967(34.4 q ha^{-1}) achieved maximum grain yield followed by variety HD 3086 (31.6 q ha^{-1}) which was at par with variety MACS 6222 (31.25q ha^{-1}) and lowest grain yield was reported in variety HI 1544 (25.35q ha^{-1}). This may be due to better growth attributes and yield attributing characters of variety HD

Table 3: Yield attributes and yields of wheat varieties under various dates of sowing (two years pooled data)

Treatments	No. of spike m^{-2}	No. of grains $spike^{-1}$	Spike length(cm)	1000-grain weight(g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index
Dates of sowing							
Nov 5	230	39	10.58	39.75	32.8	44.3	0.41
Nov 25	273	40	10.64	40.14	41.2	50.5	0.43
Dec 15	210	37	10.19	37.73	28.9	46.9	0.38
Jan 5	159	30	9.03	31.04	14.7	31.0	0.32
SEm(±)	3.15	0.75	0.16	0.26	1.01	0.30	0.02
CD(P=0.05)	11.35	2.60	0.57	0.94	3.57	1.08	0.05
Varieties							
HS 562	209	38	10.53	36.75	27.2	40.5	0.39
HD 2967	244	41	10.63	37.95	34.4	49.1	0.40
HD 3086	232	36	9.77	36.77	31.6	44.3	0.40
HI 1544	197	34	9.87	38.75	25.3	37.9	0.39
MACS 6222	225	38	10.21	36.08	31.2	47.6	0.38
WR 544	208	35	9.65	36.70	26.8	44.4	0.33
SEm(±)	5.04	0.80	0.15	0.32	0.81	0.31	0.02
CD(P=0.05)	14.45	2.35	0.43	0.91	2.33	0.90	NS

2967 and HD 3086 over other varieties. Perusal of data indicated that harvest index (HI) value was influenced significantly under different dates of sowing during both the years of experimentation. It was noted that November 25 sowing resulted in higher harvest index value (0.43) over November 5 sowing (0.41) and December 15 sowing (0.38). It was probably due to slightly higher proportionate grain yield over straw yield resulting from higher grain-straw ratio under November 25 sowing.

Table 4: Yield reduction under various dates of sowing based on two years pooled data

Varieties	Yield reduction (kg ha^{-1} day^{-1})			
	Nov. 5	**Nov.25**	**Dec. 15**	**Jan. 05**
HS 562	23.5	*	46.7	95.8
HD 2967	66.2	*	63.4	127.8
HD 3086	66.3	*	48.0	134.6
HI 1544	27.8	*	22.2	82.1
MACS 6222	36.3	*	46.9	99.0
WR 544	35.8	*	17.1	76.9
Mean	42.7	*	40.7	102.7

*November 25 was considered as Optimum sowing dates and the yield reduction under respective dates was calculated based on yield deviation from November 25 sowing.

As far as the extent of yield reduction was considered, December 15 sowing recorded an estimated overall yield reduction of 42.7 kg ha^{-1} day^{-1} over November 25 sowing indicating the optimum sowing window in late November (Table 4). Again, the yield decreased steadily and significantly due to further delay in sowing, *i.e.*, under January 05 sowing, the yield reduction was estimated to be 102.7 kg ha^{-1} day^{-1}. 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, was not having the desirable stand due to high soil residual moisture for which it also yielded lesser. However, for varieties like HS 562 or HI 1544, the yield reduction under November 05 sowing was lesser as compared to varieties like HD 2967 or HD 3086. Irrespective of variety, November 25 sowing exposed the crop to favourable weather condition for longer duration which in turn resulted in better growth and higher productivity.

4. Conclusions

The study indicated that last week of November was appropriate sowing window for wheat in eastern sub-Himalayan plains of the country. The grain yield reduced to a huge extent with advancement or delayed and January sowing should be avoided. The variety HD 2967 and HD 3086 could be recommended for sowing under 25th November for achieving the higher yield.

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