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Crop phenology and growth of zero till wheat as affected by different sowing dates and preceding cultivars of direct-seeded rice under rice-wheat system

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Abstract
An experiment was conducted to determine the phenology and growth of the zero till wheat crop as affected by different sowing dates and preceded cultivars of direct seeded rice under rice- wheat cropping system during *Rabi* 2014-15 and 2015-16 at CIMMYT-CSISA, Research Farm, CSSRI, Karnal, Haryana. The experiment consisted of thirty-six treatment combinations, comprising of four main plots (Sowing dates) and three sub- plots (preceded cultivars) which were replicated thrice. The seeds of wheat variety HD- 2967 is notified by Government of India. Growth parameters including establishment of plant/m^2, biomass and LAI at 30, 60, 90, 120 and at harvest, phenology parameters including days taken to 50% spike emergence, days taken to 50% anthesis (flowering) and days taken to 20% physiological maturity of wheat crop during the experimental years of 2014-15 and 2015-16.Maximum established plants per metre square, biomass and LAI was recorded with early sowing of 1st November whereas under phenology maximum days taken by spike emergence, anthesis and physiological maturity was recorded where early sowing was done during both the experimental years.

Keywords: sowing date, preceded cultivar, growth parameters, phenology

Introduction
Accounting for a fifth of civilization's food, wheat is an important *Rabi* crop of Indo-Gangetic Plains of India. It is the second most important crop after rice as a source of calories in the diets of consumers in developing countries and is first as a source of protein (Braun *et al*., 2010). Wheat (*Triticum aestivum* L.) being world first ranked cereal crop with cultivated area (223.8 m ha), production (733.1 m t) and with productivity of (3280 kg ha^{-1}) is the base of the agricultural economy. India is the second largest producer of wheat next to China in the world. The area, production and productivity of wheat in India is 30.7 m ha, 97.4 m t and 3172 kg ha^{-1}, respectively, while area, production and productivity of wheat in Haryana state is 2.54 m ha, 11.4 m t and 4407 kg ha^{-1}, respectively (AICRP on Wheat and Barley, Director's Report 2016-17). Phenology of wheat is generally considered as variations occurred from emergence to maturity and the influence by sowing dates and the cultivars thus the duration and stages of phenological traits are significant indicators for potential yield of the crop.

One of the most important factors of wheat is sowing time that governs the crop phenological development and efficient conversion of biomass in to economic yield. Normal sowing of wheat has longer growth duration, which subsequently provides a prospect to accumulate more biomass as compared to late sowing and hence leads in higher grain and biological yield (Singh and Pal, 2003). Forced maturity and reduction in grain yield was recorded in the wheat crop when exposed to sub-optimal temperatures at established and supra-optimal temperature at reproductive phases in case of delayed sowing (Sardana *et al*., 1999) [10]. For ensuring optimum productivity growing of suitable variety at an appropriate time is essential. Being a thermo-sensitive crop, choice of suitable variety for different sowing time further gets major importance. Temperature is an important environmental factor influencing the growth and development of plants. Influence of temperature on phenology and yield of crop plants can be studied under field condition through accumulated heat units system (Bishnoi *et al*., 1995) [1]. A definite temperature has been needed by plants before they attain certain phenological stages.

Through accumulation of degree-days and days taken to achieve each development stage is relatively constant and independent of sowing date; crop variety may modify, it considerably. Under delayed sowing the maturity of wheat has been accelerated due to gradual increase in ambient temperature in north Indian conditions. Hence, it becomes domineering to have knowledge of exact duration of phenological stages in a particular crop-growing environment and their impact on growth of crop. Therefore, an experiment was planned to determine the phenology and its effect on growth of wheat crop under different sowing dates and preceded cultivars of DSR under rice-wheat cropping system.

Material and Methods

The field experiment was conducted during *Rabi* seasons of 2014-15 and 2015-16 at CIMMYT-CSISA Research Farm of Central Soil Salinity Research Institute, Karnal (Haryana). The geographical location of Karnal is 29º 42' N latitude and 76º 57' E longitude with an elevation of 243 m above the mean sea level. The soil of the experimental site was silt-loam, having organic carbon (0.53 g kg $^{-1}$) and available NPK (150, 22.4, 277 NPK kg ha^{-1}). The experimental was laid at out in a split plot design with these replications and comprised of four sowing date combinations as main plot (S1- 1st November, S2- 7th November, S3- 23rd November and S4- 6th December) and three preceded cultivars of DSR (V1- Arize-6129, V2- Arize-6444 and V3- Pusa-44). The chemical fertilizers as per the recommended package and practice was done. The seed of the variety of wheat used was HD- 2967 which is registered variety by Government of India for northern plains of India.

Determination of growth parameters

Growth parameters included- Established plants/m^2 was recorded after 15 DAS at 50% emergence was recorded whereas biomass and leaf area index was recorded at 30, 60. 90, 120 and at harvest.

Determination of phenology

Days taken to 50% spike emergence and days taken to 50% flowering was recorded visually when in field spike and flower emerges 50% dates was recorded and analysed whereas days taken to 20% physiological maturity was recorded when physiological maturity was 20% recorded.

Statistical analysis

The experimental data obtained were subjected to statistical analysis by the method of analysis of variance (ANOVA) technique for split plot design by using software OPSTAT. Critical difference was used where ANOVA was found significant and the treatment means were compares at 5% level of significance.

Results and Discussion

Growth parameters

Number of established plants/m^2

Number of established plants per meter square was recorded at crown initiation stage and has been shown in the Table 1. Sowing dates affected the number of establishment plants significantly. The number of plants per meter square was significantly at par in 1 and 10 November sowings and both these dates had significantly more number of plants per meter square than other sowing dates *i.e.* 23 November and 6 December. Minimum number of established plants were recorded when sowing was done at 6th December. Plant establishment among cultivar of preceding rice crop on wheat did not differs significantly.

Table 1: Effect of sowing dates and cultivars of different maturity classes of DSR on establishment of plants of succeeding wheat crop

Treatments	No. of established plant/m^2	
Sowing dates		
	2014	**2015**
1 November	225	231
10 November	220	227
23 November	208	212
6 December	200	208
SE (m)±	1.96	2.47
C.D. at 5%	6.78	8.80
Cultivars of preceding rice crop		
Arize-6129	210	215
Arize-6444	218	214
Pusa-44	227	231
SE (m)±	1.26	1.32
C.D. at 5%	NS	NS

Dry matter accumulation (g/m^2)

Dry matter accumulation by wheat plants was recorded at 30, 60, 90 and 120 DAS and at maturity during both the experimental years 2014-15 and 2015-16 (Table 2). The increase in dry matter was slow up to 60 DAS and thereafter from 60-120 DAS it was increased remarkably and then again the increase was at slow rate till maturity. Sowing dates affected dry matter accumulation of wheat significantly. Plant dry matter accumulation was the maximum in 1st November sowing throughout the growth phase but significantly at par with all the sowing dates at 30 DAS but after that till 120 DAS it shows significantly at par with 10th November, whereas, 23rd November and 6th December was also significantly at par to each other from 60 to 120 DAS. Minimum dry matter accumulation was observed when sown on 6th December during both the crop seasons.

Table 2: Effect of sowing dates and cultivars of different maturity classes on dry matter (g/m^2) of succeeding cultivar of wheat crop

Treatments	Days after sowing									
	30		60		90		120		@ harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Sowing dates										
1 November	35	38	154	159	1120	1128	1428	1432	1596	1600
10 November	32	35	144	150	1103	1108	1390	1394	1523	1528
23 November	29	32	136	139	1010	1020	1327	1331	1480	1488
6 December	27	30	127	130	975	980	1291	1294	1415	1420
SE (m)±	1.7	1.9	4.8	4.9	11.7	12.1	15.2	15.9	17.1	17.2
C.D. at 5%	5.9	6.1	15.3	15.5	36.2	38.9	48.0	48.3	53.4	53.9
Cultivars of preceding rice crop										
Arize-6129	26	29	134	138	1043	1050	1349	1353	1496	1502
Arize-6444	30	33	142	145	1050	1057	1360	1364	1504	1509
Pusa-44	36	39	148	150	1064	1070	1367	1372	1511	1515
SE (m)±	0.5	0.6	2.1	2.3	5.5	6.0	7.2	7.5	8.2	8.4
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Dry matter was not affected by preceding cultivar of direct seeded rice that was succeeded by cultivar HD-2967 of wheat. Maximum dry matter accumulated by HD-2967 where preceding cultivar was Pusa-44 (1511 and 1515 g/m^2). Minimum dry mater accumulated where the preceding cultivar was Arize-6129 (1496 and 1502 g/m^2) at maturity during 2014 and 2015.

Leaf area index (LAI)

Among all the crop growth phases, leaf area index was found maximum at 90 DAS (Table 3). Sowing dates affected leaf area index significantly at all the stages. Maximum LAI was recorded when wheat was sown on 1st November followed by 10th November and 23rd November. Lowest leaf area index was recorded when wheat was sown on 6th December which resulted due to low temperature effect on plant growth resulting in weak seedling. Sowing on 1st November (0.93 and 0.97) gave significantly higher LAI than other dates of sowing except, 10th November (0.90 and 0.95) at 30 DAS where both these dates were at par in both the years. The preceding cultivar of direct seeded rice did not cause significant variation in LAI of wheat crop at all the stages in both the years.

Table 3: Effect of sowing dates and cultivars of different maturity classes of DSR on LAI of succeeding cultivar of wheat crop

Treatments	Days after sowing							
DAS	30		60		90		120	
	2014	2015	2014	2015	2014	2015	2014	2015
Sowing date								
1 November	0.93	0.97	2.57	2.61	3.16	3.20	2.28	2.34
10 November	0.90	0.95	2.46	2.51	2.82	2.89	2.07	2.12
23 November	0.85	0.90	2.35	2.39	2.67	2.72	1.98	2.02
6 December	0.77	0.81	2.12	2.19	2.55	2.60	1.82	1.86
SE (m)±	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
C.D. at 5%	0.03	0.03	0.04	0.04	0.07	0.08	0.08	0.08
Cultivars of preceding rice crop								
Arize-6129	0.82	0.89	2.35	2.40	2.78	2.84	2.01	2.08
Arize-6444	0.85	0.91	2.38	2.43	2.80	2.85	2.03	2.09
Pusa-44	0.89	0.92	2.40	2.46	2.87	2.87	2.06	2.10
SE (m)±	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

The effect of dates of sowing in general, relates to the prevailing climatic conditions during the vegetative and reproductive phases of crop growth. So, far as the vegetative phase, was concerned the maximum and minimum temperatures were in the congenial range during the growth phase. Wheat crop sown on 1st November and 10th November got greater advantage because early sowing favours wheat as it suppress the weed germination. The data on growth parameter presented in Table 1-3 indicated that sowing date of 1st November and 10th November were at par and significantly better than later sowing date in respect of plants per meter square. Maximum dry matter accumulation and LAI was observed with the sowing date of 1st November followed by 10th November and lower values of these parameters in late sowings. This is due to favourable weather and profuse tiller growth in early sowings. Minimum dry matter accumulation and LAI was recorded with sowing date of 6th December. These results are in line with the findings of Jat *et al.* (2013) [5], Kamrozzaman *et al.* (2016) [6], Suleiman *et al.* (2014) [12], Gupta *et al.* (2017) [3], Ram *et al.* (2004) [9]. They also found that delay in sowing results in the reduction of dry matter production, which may be due to less crop establishment.

Crop phenology of wheat

Phenology of wheat is generally considered as the variation occurred from emergence to maturity and it is influenced by sowing dates. Therefore, crop duration and stages of phenological traits are considered as significant indicators for the potential yield of a crop.

The results indicated that wheat crop development was influenced by time of sowing as a reducing trend was found in days taken to spike emergence, flowering and physiological maturity with delayed sowing dates (Table 4). Maximum days taken to spike emergence, flowering and physiological maturity was observed with sowing of 1st November (92 and 93, 112 and 113, 137 and 136, respectively during the year 2014-15 and 2015-16. Each delay in sowing time reduced days of 50% spike emergence, 50% flowering and 20% physiological maturity except number of days to 50% flowering in crop sown on 23rd November and 6th December both being at par during both the years. Wheat sowing at 6th December (79 and 78, 92 and 91, 127 and 126) took the minimum days to reach spike emergence, flowering (anthesis) and physiological maturity during 2014-15 and 2015-16, respectively.

Table 4: Effect of sowing dates and cultivars of different maturity classes of DSR on phenological dates of succeeding crop of wheat

Treatments	Days taken to 50% spike emergence		Days taken to 50% flowering (anthesis)		Days taken to 20% physiological maturity	
	2014	2015	2014	2015	2014	2015
Sowing date						
1 November	92	93	112	113	137	136
10 November	89	88	107	106	133	132
23 November	83	82	90	90	129	128
6 December	79	78	92	91	127	116
SE (m)±	0.61	0.61	0.63	0.63	0.28	0.27
C.D. at 5%	1.91	1.89	2.04	2.04	0.93	0.91
Cultivars of preceding rice crop						
Arize-6129	85	85	99	99	131	131
Arize-6444	86	86	100	100	132	131
Pusa-44	86	86	101	101	132	132
SE (m)±	0.18	0.18	0.24	0.24	0.19	0.17
C.D. at 5%	NS	NS	NS	NS	NS	NS

The cultivars of preceding rice crop had no significant effect on physiological stages of wheat crop. However, the minimum days taken to 50% of spike emergence, flowering (anthesis) and 20% of physiological maturity were observed where the preceding rice cultivar was Arize-6129 (85 and 85, 99 and 99, 131 and 131) and the maximum days were taken where the rice cultivar Pusa-44 as the preceding cultivar (86 and 86, 101 and 101, 132 and 132) during both the experimental years, respectively. Days taken to 50% spike emergence, 50% flowering (anthesis) and 20% physiological maturity were maximum with the early sowing of 1st November (Table 4.24). Khavse *et al.* (2015) [7], Mumtaz *et al.* (2015) Verma *et al.* (2016) and Gupta *et al.* (2017) [3] evaluated in their experiments that the number of days taken to attain different pheno-phases decreases with the delay in sowing which resulted in a reduced life span of late sown crop. Similar findings have also been reported by Pandey *et al.* (2009).

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