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Effect of moisture regime and different sowing dates on growth and yield of wheat

Krishna Deo, Nareshmani Pandey, SR Mishra and Gulab Singh

Abstract
The effect of moisture regime and different sowing dates on growth and yield of wheat were studied. The experiments was conducted at the Agromet Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during year 2014-2015 and 2015-2016. The experiments comprised of four levels of moisture regime *viz.*, I_1 (critical stages), I_2 (0.6 IW: CPE ratio), I_3 (0.8 IW: CPE ratio), I_4 (1:0 IW: CPE ratio) and three dates of sowing namely 15th November, 25th November and 05th December wheat. Growth and yield components were determined at the time of physiological maturity. Late sowing of wheat crop drastically decreased the growth attributes and yield attributes Wheat sown at 15th Nov. followed by 25th Nov. and 05th Dec. reported maximum growth and yield attributes. Maximum reduction in growth and yield of wheat was observed by sowing on fifth December. The findings of present investigation indicated that the growth and yield attributes of wheat were significantly influence due to different moisture regime.

Keywords: Moisture regime, wheat, sowing dates, yield attributes, leaf area index

Introduction
Wheat (*Triticum aestivum* L.) belongs to the poaceae family. It is the single most important cereal crop, that has been considered as integral component of the food security system of several nations. It rank first in the world among the cereals both in respect of acreage 221.76 mha and production 696.64 mt. In India total area under wheat is 29.40 mha with the total production of 93.62 mt and productivity of 2.95 tonnes/ha (Anonymous, 2012-13) [2]. Uttar Pradesh rank first in respect of area and production which is about 9.25mha with the total production 25.60 mt and productivity of 27.90q ha^{-1}, But the average productivity in our state is comparatively much lower than that of Punjab and Haryana. India is the second wheat growing country after China in the world. The mutually reinforcing package of technology, services and public policies led to sustained increase in food grain production in India during the last thirty-five years. Green revolution/wheat revolution, as it is generally called, was due to the incorporation of one single dwarfing gene (Norin gene) in spring wheat. Varieties with this gene responded well to fertilizer and irrigation. This new germplasm received from (Centro International de Mejoramiento de Maizy Trigo-International Maize and Wheat Improvement Centre) CIMMYT, Maxico by Dr. N.E. Borlaug paved the way for wheat revolution in India. Over the last thirty-five years wheat production continues to grow at about 3.5% per annum and is unmatched by any other crop clearly showing that it is an evergreen wheat revolution. There is still great opportunity to keep this change happening by increasing the pace of change in the North-East Plain Zone (NEPZ) and Central Zone (CZ) of the country.

Material and Methods

Experimental site

The experimental site is located at the university on the left side of Faizabad - Raibareilly road at a distance of 43 km away from Faizabad district.

Climate in brief

The location of experimental site lies at a latitude of $26^0$47'N, longitude of $82^0$12'E and an altitude of 113 m above mean sea level, in the gangetic alluvium of eastern Uttar Pradesh. Experimental area was receiving a mean annual rainfall of about 1063 mm, out of which about 89 percent of the total rainfall is received during south-west monsoon with few showers in winter season. On the basis of average rainfall intensity during monsoon season it was that rainfall mostly occurred between July to September while mid-September onwards.

Experimental details

The experiments consist of a treatment combination, which comprised of four irrigation level *viz*. I_1 (critical stages), I_2 (0.6 IW/CEP), I_3 (0.8IW/CEP) and I_4 (1.0 IW/CEP), three dates of sowing, *viz*. (D_1) 15th November, (D_2) 25th November (D_3) 05th December along with two cultivars, *viz*. PBW-343 (V_1) and HD-2733 (V_2).

Scheduling of irrigation

A fixed quantity of 60 mm of water was applied to the concerned experimental plots according to the irrigation schedules of the respective treatment.

Meteorological observations

The Agromet observatory situated at the Student's Instructional Farm and is nearly 50 m away from the experimental site. All the weather parameters *viz*. rainfall, temperature, evaporation, sunshine, wind speed and wind direction along with soil temperatures were recorded twice daily at 07:02 and 14:02 hrs (IST) and were processed, analysed and used for the present investigation. Daily values of incoming solar radiation were computed from observed values of bright sunshine hours using following formula suggested by Angstrom (1924) and modified by Pennman (1948);

$$R = R_{so} [a+b(n/N)]$$

Where

R = Incoming solar radiation received at a place ($MJm^{-2}day^{-1}$)
Rso = Total radiation received if the atmosphere is perfectly transparent, i.e. 1.974xN
N = Actual sunshine received (hours)
N = Maximum possible duration of sunshine, i.e. difference of sunrise to sunset Hours
A = Constant having values 0.25
B = Constant having values 0.50

Initial plant population (m^{-2})

Initial plant population in each treatment was recorded at 20 days after sowing (DAS) from randomly selected three locations with a quadrate in each plot and averaged figures were converted into per m^2 to compute initial plant population.

Plant height (cm)

Five plants were selected randomly in each plot and tagged for measuring height at different intervals. Height was measured at 30, 45, 60, 75, 90, 105 and 120 DAS with the help of meter scale from ground surface to the tip of the topmost leaf before heading and up to the base of the ear head after heading.

Number of shoots m^{-2}

The number of shoots was counted at 30, 45, 60, 75, 90, 105 and 120 DAS by placing quadrate at three places in each plot and the plants which come within the quadrate were averaged out to express shoots per square meter.

Leaf area index (LAI)

The leaf area was measured at 30, 45, 60, 75, 90, 105 and 120 DAS of the crop. The plants of 25 cm row length were taken and green leaves were separated to record their surface area by automatic leaf area meter. All the leaves were grouped into three *viz*., small, medium and large. Five leaves from each group were taken and their surface areas were measured. Areas of five leaves were multiplied with respective leaf numbers of a group and sum of all the three gave the total leaf area. For obtaining index, leaf area was divided by the ground area.

Dry matter accumulation (gm^{-2})

Plant from 25 cm row length from second rows were selected randomly at 30, 45, 60, 75, 90, 105 and 120 DAS and they were cut close to the ground surface. Then they were sun dried and collected individually in paper bags after cutting into small pieces. After sun drying, these samples were put in an electrical oven at 65-70 ^{0}C till the constant dry weight was achieved. The dry weight of the plants obtained was expressed in gm^{-2}

Grain yield (q ha^{-1})

After weighing the total biomass of each plots the produce of each net plot was threshed separately and cleaned grain were air dried to maintain 12 per cent moisture. The grain yield was recorded in kg per plot and finally converted into quintal per hectare.

Straw yield (q ha^{-1})

The yield of straw was calculated by subtracting the grain yield from the total biological yield of the crop.

Harvest index (%)

The recovery of grains in the total harvested produce was considered as harvest index. It was calculated with the help of following formula:

$$HI(\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \text{x}100$$

Results

Initial plant population (m^{-2})

The data pertaining to initial plant population were recorded at 20 days after sowing which are presented in Table 1. Data revealed that dates of sowing, moisture regime and varieties did not influence initial plant stand significantly during both the years. The maximum initial plant population was recorded as 150.3 and 149.9 plants m^{-2} with I_1(critical stages).

However, the variety PBW 343 recorded higher initial plant population (150.6 & 150.3) as compare to variety HD 2733 (149.3 & 149.0) during both of the year. Maximum initial plant population as 152.2 and 151.8 was recorded from D_1 (15th November) during both year 2014-15 & 2015-16, respectively.

Table 1: Effect of moisture regime and different sowing dates on plant population of wheat varieties

Treatments	Initial plant population	
	2014-2015	2015-2016
Moisture Regime		
I_1 (Critical stages)	150.3	149.9
I_2 (0.6 IW: CPE)	149.6	149.1
I_3 (0.8 IW: CPE)	149.8	149.2
I_4 (1.0 IW: CPE)	150.1	150.2
S.Em±	2.20	2.23
CD at 5%	N.S	N.S
Variety		
PBW-343	150.6	150.3
HD 2733	149.3	149.0
S.Em+	2.18	2.17
CD at 5%	N.S	N.S
Date of sowing		
15 Nov.	152.2	151.8
25 Nov.	150.1	150.4
5 Dec.	147.6	146.7
S.Em+	1.92	1.92
CD at 5%	N.S	N.S

Plant height (cm)

Plant height of wheat showed statistically significant variation due to moisture regime at 30,45,60,75,90,105 and at 120 DAS under the present study (Table2). The taller plant (18.3&18.2,32.6&32.5, 43.4&44.1,66.4&67.5, 88.5&90.0, 91.3&92.9, 95.3 & 96.9cm) was recorded from I_1(critical stages) at 30, 45, 60, 75, 90, 105 and 120 DAS both year 2014-15 and 2015-16 respectively and at par with I_4 while the shorter plant (17.3 & 17.2, 28.5 & 28.4, 38.0 & 38.6, 56.6 & 57.6, 75.5 & 76.6, 79.8 & 81.2, 83.4 & 84.8) was recorded from I_2 (0.6 IW:CPE ratio). Plant heights of both varieties (PBW 343 and HD 2733) increased gradually with the advancement of growth stages up to 30 DAS. The variety PBW 343 produced maximum plant height (17.6 & 17.8, 31.7&31.6, 42.2&42.8, 63.7&64.7, 85.0&86.2, 88.8&90.1, 92.7&94.0 cm)at 30, 45, 60, 75, 90, 105 and 120 DAS during 2014-15 and 2015-16, respectively) which was superior to variety HD 2733. The maximum plant height was recorded with 15th Nov. sowing date i.e. 18.1&18.3, 31.4&31.6, 41.9&42.6, 63.7&64.7, 85.0&86.3, 88.2&89.5, 92.0&93.5 cm at 30, 45, 60, 75, 90, 105 and 120 DAS during both the year as compared to other sowing date (25th November and 05th December).

Leaf area index (LAI)

Moisture regime, date of sowing and variety varied significantly in terms of leaf area index of wheat at different days after sowing under the present trial at 30, 45, 60, 75, 90, 105 and 120 DAS (Table 3). Moisture regime, date of sowing and variety had no significant influence on the leaf area index of wheat at 30 DAS. In general the leaf area index increased with the advancement of the crop growth and reached to its maximum at 75 DAS and thereafter it decreased because of senescence of leaves. The I_1 moisture regime noticed significantly higher LAI 2.4 and 2.4 at 45 DAS, 4.0 and 4.1 at 60 DAS, 4.0 and 4.1 at 75 DAS 4.1 and 4.2 at 90 DAS 3.4 and 3.5 at 105 DAS 2.0 and 2.1 at 120 DAS during the year 2014-15 and 2015-16, respectively over other moisture regime. The highest leaf area index was obtained from the 15th Nov. sowing date (4.0 and 4.0) at 90 DAS during both year. The highest (4.0 and 4.0) leaf area index was obtained from the variety PBW 343 at 90 DAS during the year 2014-15 and 2015-16. At 60 DAS, the lowest (2.1 and 2.2) leaf area index was recorded from variety HD 2733 during both years.

Dry matter accumulation (g/m^2)

The data on dry matter accumulation recorded at 30, 45, 60, 75, 90, 105 and 120 DAS, as influenced by different moisture regime and varieties are presented in Table 4. Dry matter production was increased gradually from 30 DAS onwards but being determinate growth habit of the crop, the maximum dry matter production was recorded at 120 DAS. Among the different moisture regime, I_1 recorded significantly higher dry matter production over I_2, and I_3, at 30, 45, 60, 75, 90, 105 and 120 DAS and was at par with I_4. At 120 DAS, 12.5% dry matter increase was recorded in I_4 over I_2 during the year 2014-15 and 2015-16. All the stages of crop growth of wheat dry matter accumulation affected by varieties. Variety PBW 343 was found significantly higher dry matter accumulation at every stages of crop growth as compared to HD 2733. At 120 DAS, dry matter production found in PBW 343 was 7.0% higher over the HD 2733 during the year 2014-15 and 2015-16. The dry matter accumulation in wheat was significantly affected by sowing date at all the stages of crop. At the 15th Nov. sowing date found significantly higher dry matter accumulation at all the stages of crop growth as compared to 25th and 05th Dec sowing date. The dry matter accumulation in wheat during date of sowing of 15th Nov. was at par with date of sowing 25th Nov. At 120 DAS, highest dry matter production was with 15th Nov. sowing date and it recorded increase by 7% as compare to date of sowing 05th Dec. during the year 2014-15 and 2015-16.

Effective tillers (m^{-2})

Moisture regime varied significantly in terms of number of effective tillers (m^{-2}) of wheat as presented in Table 5, revealed that the different moisture regime adopted under the study differed significantly for effective tillers (m^{-2}). Highest number of effective tillers m^{-2} (445.4 and 452.9) were recorded with I_1 (critical stages) as compare to other irrigation levels. The increase in number of tillers might be due to enhanced vegetative growthas a result of beneficial role of water in maintaining cell turgidity, cell elongation and cell division and also meristmatic cell elongation in the axillary buds which in turn trigged the various activities and increases the supply of photosynthates and thereby increase in number of tillers. The lowest number of effective tillers m^{-2} was found in I_2 (331.9 and 337.6) moisture regime, respectively during both of the year. The effective tillers m^{-2} of wheat was significantly affected by varieties. PBW 343 recorded significantly higher no of effective tillers m^{-2} (411.4 and 417.5) as compared to HD 2733 (387.1 and 393.8) during the year 2014-15 and 2015-16, respectively. The data showed that the there was significant effect of different sowing date and highest no. of effective tillers of wheat was recorded with 15th Nov. which was significantly superior from 5th Dec., whereas it was at par with 25th Nov. sowing date during both years 2014-15 and 2015-16 respectively. The data of spike length as influenced by moisture regime and sowing date of wheat varieties presented in Table 5. It is evident from the results that the differences in spike length to different moisture

regime were found significant. However, treatment I_1 (12.5 and 12.7 cm) was recorded highest which was significantly superior over the I_2 and I_3, and found at par with I_4 irrigation level. Spike length of wheat was not significantly affected by varieties of wheat. The PBW 343 recorded (11.7 and 11.9 cm) as compared to the HD 2733 (11.4 and 11.9 cm) during the year 2014-15 and 2015-16, respectively. Similarly, spike length was significantly affected by different sowing dates. Largest spike length of wheat was recorded with 15th Nov. which was significantly superior as compare to 25 Nov. and 05 Dec. sowing dates during both year 2014-15 and 2015-16 respectively. The data recorded on number of grains/spike of wheat as influenced by different moisture regime, varieties and different sowing date are presented in Table 5. The data showed that the different irrigation levels taken in the study differ significantly for number of grains/spike. Among the different irrigation levels, I_1 recorded significantly higher number of grains/spike (46.6 and 47.4) as compared to I_2 and I_3 (39.4& 40.0 and 41.9& 42.6) and at par with I_4 (44.5 and 45.1) during the year 2014-15 and 2015-16, respectively. The maximum number of grains/spike was recorded with variety PBW 343 (43.7 and 44.4) which was significantly higher as compared to variety HD 2733 (42.4 and 45.1) during the year 2014-15 and 2015-16, respectively. The number of grains/spike of wheat was also significantly affected by different sowing date. Under 15th Nov. sowing date recorded the significantly higher number of grains/spike (44.7 and 45.4) as compared to other date of during the year 2014-15 and 2015-16 respectively.

Test weight (g)

The results showed that the moisture regime affected the test weight of wheat grain significantly (Table 5). Significantly higher 1000-grains weight was recorded with I_1 (critical stage) as compared to I_2 and I_3 and was at par with the I_4 in both of the year. Among the varieties, higher 1000-grain weight was recorded by variety PBW 343 but differences were numerical. The 1000-grains weight of wheat under 15th Nov. sowing date recorded the significantly higher (41.8 and 41.7 gm) as compared to other sowing date 05th Dec. (36.8 and 36.6), while at par with 25th Nov. sowing date (38.9 and 39.0) during the year 2014-15 and 2015-16 respectively.

Grain yield (q/ha)

The data pertaining to grain yield was recorded and presented in Table 6. The statistical comparison of the results of grain yield revealed that differences in yield due to differences in the different irrigation treatments were found statistically significant. I_1 (critical stages) treatment yielded the highest (52.3 q/ha and 53.2 q/ha in the year 2014-15 and 2015-16 respectively) as compared to I_2, I_3 and I_4 treatment. However, I_1 and I_4 were found to be at par with each other in respect of their respective yields. The lowest grain yield with I_2 (45.8 and 46.5 q/ha) during the year 2014-15 and 2015-16, respectively. Among the varieties, maximum grain yield was recorded with variety PBW 343 (51.3 and 52.1 q/ha) as compared to HD 2733(47.3 and 48.1q/ha) variety during the year 2014-15 and 2015-16, respectively. The variation in wheat grain yield observed significant due to different sowing date. Grain yield of wheat 51.2 and 52.0q/ha was observed more under with 15th Nov. sowing date as compare to other sowing date (25th Nov. and 05th Dec.) during the year 2014-15 and 2015-16, respectively.

Straw yield (t/ha)

Data pertaining to straw yield indicated that the moisture regimes had significant effect on the straw yield of wheat (Table 6). Highest straw yield (65.8&66.9 q/ha) was recorded in I_1 (critical stages) treatment and lowest (57.5&58.5 q/ha) under I_2 treatment. Treatment I_1 and I_4 treatment were found to be at par with each other. Among the varieties, maximum straw yield was recorded with PBW 343 variety (64.5 and 65.5q/ha) which was significantly superior over HD 2733 (59.5 and 60.5q/ha) variety during both the year. The significantly higher straw yield was observed under 15th Nov. sowing date (64.4 and 65.4q/ha) over the other sowing date 25 Nov. and 05 Dec. during the year 2014-15 and 2015-16, respectively.

Harvest index

The data on harvest index as influenced by different moisture regime, sowing date and varieties are presented in Table 6. Data indicated that moisture regime have been significant effect on the harvest index. Highest harvest index (45.4 and 46.2% during 2014-15 and 2015-16, respectively) was recorded under I_1 (critical stages) irrigation scheduling. However, lowest harvest index was observed in I_2 irrigation scheduling 39.70 and 40.4 during both of the years respectively. Higher harvest index was recorded with PBW 343 as compared to HD 2733 in both of the years but the varietal effect was non-significant on the harvest index during both the years. The effect of sowing date in respect of harvest index was also observed significant in all treatment. The crop sown on fifteenth (15th) of november obtained highest harvest index (44.4) over the other sowing date during both of the year 2014-15 and 2015-16, respectively.

Discussion

Water is the fundamental basis of life. Growth of plant is controlled by rates of cell division, their enlargement and by the supply of organic and inorganic compounds required for the synthesis of new protoplasm and cell wall. Cell enlargement is particularly dependent on least minimum degree of cell turgor. Stem and leaf elongation is quickly checked by water deficit. Thus decreasing water content is accompanied by loss of turgor and wilting, cessation of cell enlargement, closure of stomata, reduction in photosynthesis and interference with many basic metabolic processes (Sharma *et al.* 1990) [13]. Moisture regimes did not change initial plant population significantly because there was enough and uniform moisture at the time of sowing which lead proper germination. This was mainly due to the reason that initial plant population was counted as 15 DAS and irrigation treatments were not applied upto this period. Different irrigation schedules showed significant effect on growth characters *viz.*, plant height and number of shoots m^{-2} as well as leaf area index at 45, 60, 75, 90, 105 and 120 DAS. The plant height, number of shoot m^{-2} and leaf area index did not show variation significantly due to different moisture regimes at initial growth stage (30 DAS) because variable irrigation was received after this stage under different moisture regimes (Sharma *et al.* 1990) [13]. The increase in the plant height under the treatment I_1 might be due to optimum supply of soil moisture. The other reason for increasing plant height might be due to optimum soil moisture supply promoted the cell division and cell expansion and there by stem elongation, which virtually increased the plant height.

The reason for lower plant height might be due to severe moisture stress condition which affected plant growth. These results are substantiated with Brahma *et al.* (2007) [4], Bastia and Rout (2001) and Jana *et al.* (2001) [8]. The leaf generally represents the plants assimilating area and the development of the area determined of the leaf area is vital physiological parameters for the determination of growth of the crop. LAI growth was found higher up to tillering stage and there after it was found constant during booting stage in all the irrigation treatments. The LAI peak was observed almost at 75 DAS in all the treatments with variable LAI. There after LAI decreased under later part of crop. I_1 (critical stages) treatment had higher LAI followed by I_3 and I_2 but at par with I_4 treatment after 45 DAS up to maturity phase of the crop. Lower LAI in I_2 (0.6 IW/CPE) treatment was found mainly due to moisture stress, as compared to other treatments. This shows that optimum moisture play a vital role in enhancing wheat yield. Similar results were obtained by Ahmad (2002) [1] and Saren *et al*. (2004) [12]. The dry matter accumulation recorded maximum with I_1(critical stages)which was significantly higher over the I_2 (0.6 IW/CPE) and I_3 (0.8 IW/CPE) ratio due to availability of sufficient moisture content (Chavan and Pawar (1988) [6]. Yield is the result of coordinated inter play of growth characters and yield attributes. Grain and straw yield were significantly influenced by the different moisture regimes. Highest grain yield was recorded under moisture regime of I_1 (critical stages). This might be due to adequate moisture availability, which contributed to better growth parameters and yield attributes. Productivity of crop collectively determined by vigor of the vegetative growth and yield attributes. Better vegetative growth coupled with higher yield attributes resulted in higher grain and straw yields. Lowest grain yield was recorded under 0.6 IW/CPE due to poor moisture supply during the period of growth. Poor moisture supply during the critical stages reduced the yield attributes and resulted in poor grain and straw yields during 2014-15 and 2015-16. The similar results were reported by Khola *et al.* (1989) [7] and Maliwal *et al*. (2000) [10]. Harvest index is a function of grain and straw yield. Highest harvest index was noted under I_1 (critical stages) and lowest in I_2 (0.6 IW/CPE). This might be due to the fact that adequate moisture under the higher moisture regime increased the grain yield than that of biological yield. This results obtained by Bastia and Rout (2000) [3]. Plant growth and yield are governed by the combined effects of inherited genetic potential and environment in which plants are grown. The significant difference was not found is the initial plant population among the varieties. While significant differences in plant height, number of shoot m^{-2}, LAI and dry matter accumulation were recorded with variety PBW 343 at all the growth stage of crops while differences at 30 DAS was recorded non significant. Similarly another growth characteristics and yield attributing characters showed the significant differences among the varieties. The variation in growth development and yield of varieties might be due to their genetic characteristics. Similar finding in respect to varieties were also reported by Brij Kishor (1998) [5]. Growth and yield components were determined at the time of physiological maturity. Late sowing of wheat crop drastically decreased the crop development attributes (days taken to booting, heading, anthesis, physiological maturity), growth attributes (germination count m^{-2}, No. of shoots m^{-2} and plant height) and yield attribute (number of grains $spike^{-1}$, test weight, grain yield). The crop growth, yield and yield attributing characters in terms of number of effective tillers/m^2, number of grains/spick, number, test weight, straw yield, biological yield and grain yields of wheat crop were recorded significantly. Among the various sowing dates, wheat sown on 15th Nov. provided best results as compared to other sowing dates (25th Nov. and 05 Dec.). Similar results were obtained by Haider (2002) [7] and Mohsen *et al.* (2013) [11].

Table 2: Effect of moisture regime and different sowing dates on plant height of wheat varieties

Treatments	Plant Height (cm)													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime														
I_1 (Critical stages)	18.3	18.2	32.6	32.5	43.4	44.1	66.4	67.5	88.5	90.0	91.3	92.9	95.3	96.9
I_2 (0.6 IW: CPE)	17.3	17.2	28.5	28.4	38.0	38.6	56.6	57.6	75.5	76.7	79.8	81.2	83.4	84.8
I_3 (0.8 IW: CPE)	17.2	17.1	29.8	29.7	39.7	40.4	59.3	60.2	79.0	80.3	83.6	85.0	87.3	88.7
I_4 (1.0 IW: CPE)	17.5	17.9	31.3	32.1	41.7	42.3	62.2	63.1	83.0	86.1	87.8	91.2	91.7	95.2
S.Em±	0.40	0.39	0.48	0.72	0.64	0.66	1.31	0.96	1.74	1.71	1.35	1.84	1.41	2.12
CD at 5%	NS	NS	1.66	2.48	2.21	2.27	4.52	3.32	6.03	5.93	4.66	6.36	4.86	7.35
Variety														
PBW-343	17.6	17.8	31.7	31.6	42.2	42.8	63.7	64.7	85.0	86.2	88.8	90.1	92.7	94.0
HD-2733	17.5	17.7	29.4	29.7	39.2	39.9	58.5	59.5	78.0	80.3	82.5	85.0	86.1	88.8
S.Em+	0.27	0.27	0.57	0.48	0.76	0.79	0.94	1.18	1.25	1.29	1.60	1.35	1.67	1.43
CD at 5%	NS	NS	1.86	1.55	2.48	2.57	3.05	3.86	4.07	4.21	5.23	4.42	5.46	4.65
Date of sowing														
15 Nov.	18.1	18.3	31.4	31.6	41.9	42.6	63.7	64.7	85.0	86.3	88.2	89.5	92.0	93.5
25 Nov.	17.5	17.9	30.9	31.6	41.2	41.9	61.5	62.5	82.0	84.9	86.7	89.8	90.5	93.8
05 Dec.	17.0	16.9	29.2	29.1	39.0	39.6	58.1	59.0	77.5	78.7	82.0	83.3	85.6	86.9
S.Em+	0.38	0.38	0.52	0.65	0.70	0.71	1.50	1.06	2.01	1.87	1.47	1.98	1.53	1.94
CD at 5%	NS	NS	1.51	1.89	2.01	2.04	4.33	3.05	5.78	5.39	4.23	5.69	4.41	5.58

Table 3: Effect of moisture regime and different sowing dates on leaf area index of wheat varieties

Treatments	Leaf area index (LAI)													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime														
I_1 (Critical stages)	1.8	1.8	2.4	2.4	4.0	4.1	4.0	4.1	4.1	4.2	3.4	3.5	2.0	2.1
I_2 (0.6 IW: CPE)	1.7	1.7	2.1	2.1	3.5	3.6	3.4	3.5	3.5	3.6	2.9	3.0	1.7	1.7
I_3 (0.8 IW: CPE)	1.7	1.7	2.2	2.2	3.7	3.8	3.6	3.6	3.7	3.7	3.0	3.1	1.8	1.8
I_4 (1.0 IW: CPE)	1.7	1.7	2.3	2.4	3.9	3.9	3.7	3.9	3.9	3.9	3.2	3.3	1.9	2.0
S.Em±	0.04	0.04	0.03	0.05	0.06	0.06	0.08	0.08	0.08	0.06	0.07	0.07	0.04	0.04
CD at 5%	NS	NS	0.12	0.17	0.21	0.20	0.27	0.27	0.28	0.20	0.23	0.23	0.14	0.14
Variety														
PBW-343	1.7	1.7	2.3	2.3	3.9	4.0	3.8	3.9	4.0	4.0	3.3	3.3	1.9	2.0
HD-2733	1.7	1.7	2.1	2.2	3.7	3.7	3.5	3.6	3.6	3.7	3.0	3.1	1.8	1.8
S.Em+	0.03	0.03	0.04	0.04	0.07	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.03	0.03
CD at 5%	NS	NS	0.13	0.12	0.23	0.18	0.18	0.20	0.19	0.18	0.16	0.17	0.09	0.10
Date of sowing														
15 Nov.	1.7	1.8	2.3	2.3	3.9	4.0	3.8	3.9	4.0	4.0	3.3	3.3	1.9	2.0
25 Nov.	1.7	1.8	2.2	2.3	3.8	3.9	3.7	3.8	3.8	3.9	3.2	3.3	1.9	1.9
05 Dec.	1.6	1.7	2.1	2.2	3.6	3.7	3.5	3.5	3.6	3.7	3.0	3.0	1.8	1.8
S.Em+	0.04	0.04	0.04	0.05	0.06	0.05	0.09	0.09	0.09	0.05	0.08	0.08	0.05	0.04
CD at 5%	NS	NS	0.11	0.15	0.19	0.14	0.27	0.14	0.26	0.25	0.22	0.22	0.13	0.13

Table 4: Effect of moisture regime and different sowing dates on dry matter accumulation of wheat varieties.

Treatments	Dry matter accumulation (g/m^2)													
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime														
I_1 (Critical stages)	56.1	56.0	122.7	122.4	245.4	249.6	567.7	577.2	788.1	801.4	915.3	930.7	1017.0	1034.1
I_2 (0.6 IW: CPE)	53.0	52.8	107.3	107.0	214.6	218.3	496.4	504.9	689.1	700.9	800.4	814.1	889.3	904.5
I_3 (0.8 IW: CPE)	52.8	52.6	112.4	111.9	224.7	228.4	519.7	528.2	721.5	733.3	838.0	851.7	931.1	946.3
I_4 (1.0 IW: CPE)	53.6	53.7	118.0	118.1	236.0	239.4	545.8	553.6	757.8	768.5	880.1	892.6	977.9	991.8
S.Em±	1.23	0.93	1.81	2.02	3.62	4.09	7.81	9.47	10.84	13.14	12.59	15.26	13.99	16.96
CD at 5%	NS	NS	6.26	6.99	12.52	14.16	27.01	32.75	37.50	45.47	43.56	52.81	48.40	58.68
Variety														
PBW-343	54.1	54.0	119.3	119.0	238.6	242.1	551.8	560.0	766.0	777.4	889.7	902.9	988.5	1003.2
HD-2733	53.7	53.6	110.9	110.7	221.8	225.7	513.0	522.0	712.2	724.7	827.2	841.7	919.1	935.2
S.Em+	0.82	0.82	2.15	1.76	4.31	3.60	7.72	8.32	10.72	11.55	12.45	13.42	13.84	14.91
CD at 5%	NS	NS	7.02	5.76	14.05	11.73	25.18	27.13	34.96	37.67	40.60	43.75	45.11	48.61
Date of sowing														
15 Nov.	55.7	55.5	118.5	118.2	237.0	240.7	548.1	556.7	761.0	772.8	883.8	897.6	982.0	997.3
25 Nov.	53.9	54.0	116.6	116.9	233.1	237.1	539.2	548.5	748.5	761.4	869.4	884.4	966.0	982.6
05 Dec.	52.1	51.8	110.2	109.5	220.5	223.9	509.9	517.8	707.9	718.8	822.2	834.9	913.5	927.6
S.Em+	1.16	0.81	1.97	1.72	3.95	3.48	6.89	8.06	9.56	11.19	11.11	12.99	12.34	14.44
CD at 5%	NS	NS	5.68	4.95	11.36	10.04	19.84	23.21	27.54	32.22	31.99	37.42	35.54	41.58

Table 5: Effect of moisture regime and different sowing dates on yield attributes of wheat varieties

Treatments	Effective Tillers m^{-2}		Length of Spike (cm)		Number of Grains Spike^{-1}		Test Weight (g)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime								
I_1 (Critical stages)	445.4	452.9	12.5	12.7	46.6	47.4	41.8	41.7
I_2 (0.6 IW: CPE)	331.9	337.6	10.5	10.7	39.4	40.0	35.2	35.1
I_3 (0.8 IW: CPE)	389.6	396.0	11.2	11.4	41.9	42.6	37.5	37.4
I_4 (1.0 IW: CPE)	430.0	436.1	11.9	12.4	44.5	45.1	39.8	39.9
S.Em±	5.66	7.99	0.24	0.25	0.91	0.84	0.82	0.74
CD at 5%	19.59	27.64	0.85	0.86	3.16	2.89	2.83	2.55
Variety								
PBW 343	411.4	417.5	11.7	11.9	43.7	44.4	39.2	39.1
HD 2733	387.1	393.8	11.4	11.7	42.4	43.2	38.0	37.9
S.Em±	5.74	6.54	0.18	0.19	0.66	0.75	0.59	0.66
CD at 5%	18.70	21.31	NS	NS	NS	NS	NS	NS
Date of Sowing								
15thNov.	428.0	434.7	12.0	12.2	44.7	45.4	40.0	39.9
25 Nov.	419.3	426.5	11.6	12.1	43.5	44.2	38.9	39.0
05 Dec.	350.3	355.8	11.0	11.2	41.1	41.7	36.8	36.6

S.Em±	5.18	6.58	0.28	0.29	1.06	0.70	0.95	0.62
CD at 5%	14.91	18.95	0.82	0.82	3.04	2.03	2.72	1.79

Table 6: Effect of moisture regime and different sowing dates on yield attributes of wheat varieties**.**

Treatments	Grain yield (q/ha)		Straw yield (q /ha)		Harvest index (%)	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
Moisture Regime						
I_1 (Critical stage)	52.3	53.2	65.8	66.9	45.4	46.2
I_2 (0.6 IW: CPE)	45.8	46.5	57.5	58.5	39.7	40.4
I_3 (0.8 IW: CPE)	47.9	48.7	60.2	61.2	41.6	42.2
I_4 (1.0 IW: CPE)	51.2	51.9	64.4	65.3	44.4	45.0
Variety						
PBW 343	51.3	52.1	64.5	65.5	44.5	45.2
HD 2733	47.3	48.1	59.5	60.5	41.0	41.7
Date of Sowing						
15th Nov.	51.2	52.0	64.4	65.4	44.4	41.6
25th Nov.	49.7	50.6	62.5	63.6	43.1	41.2
05th Dec.	47.0	47.7	59.1	60.0	40.8	40.6

Conclusion

The following conclusions can be drawn from the present study: Late in sowing of wheat can cause reduction in crop growth and yield attributes. Wheat sown on 15th Nov. appeared to be most desirable sowing time to produce maximum yield. The suitable irrigation schedule for wheat crop was found under I_1 (critical stages) treatment produced significantly the highest yield. Timely sown wheat variety PBW-343 recorded highest grain yield followed by HD-2733.

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