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Response of yield performance of wheat to irrigation regime and sowing time

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Abstract

The experiment was conducted during the period from November 2014 to March 2015 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of irrigation under varying sowing times on yield performance of wheat. The experiment comprised of two factors; Factors A: Irrigation (3 levels): I_1: Irrigation up to field capacity; I_2: Irrigation upto 1/2 of field capacity and I_3: Irrigation upto1/4th of field capacity (at crown root initiation, flowering and grain filling stage); Factor B: Sowing time (4 levels at 10 days interval): S_1: Sowing at 10 November; S_2: Sowing at 20 November; S_3: Sowing at 30 November and S_4: Sowing at 10 December. The experiment was laid out in Split Plot Design with three replications. Irrigation was assigned in the main plot and sowing time was assigned in the sub-plot. The highest days to maturity was recorded from I_1 while the lowest days to maturity was observed from I_3. The highest days to maturity was observed from S_1 while lowest days to maturity S_4. I_1 recorded the highest spike length, number of spike lets spike^{-1}, number of grains spike^{-1}, 1000 grain weight, grain yield, straw yield, biological yield and harvest index respectively compared to I_3. S_2 produced the highest results than that of S_1 in spike length, number of spike lets spike^{-1}, number of grains spike^{-1}, 1000 grain weight, grain yield, straw yield, biological yield and harvest index respectively. Better grain yield performance of wheat was obtained from irrigation upto field capacity with sowing at 20 November.

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops all over the world. It is rich in various nutrients compared to other food crops. Wheat grain is rich in food value containing 12% protein, 1.72% fat, 69.60% carbohydrate and 27.20% minerals (BARI, 2006). Wheat has the umpteen potentiality in yield among other crops grown in Bangladesh. Wheat is grown all over Bangladesh but wheat grows more in Dhaka, Faridpur, Mymensingh, Rangpur, Dinajpur, Comilla districts.

Wheat production in Bangladesh is lower than other wheat growing countries in the world due to various problems. But major problems are delayed sowing after the harvest of transplanted aman rice and no or limited irrigation facilities. Irrigation plays an imperative role for optimum growth and development of wheat. Irrigation requirement is the quantity of water needed above the existing moisture level. Water supplied at booting to heading stages promoted both spike and grain development (Zhang-Xu Cheng *et al.*, 2011). Grain yield and its components of wheat declined when exposed to drought stress condition (Fang *et al.* 2006). Too early sowing makes plant weak having poor root system. In late sowing condition, wheat crop experiences high temperature stress. Late sowing checked the yield, caused by decline in the yield contributing traits like number of grains spike^{-1} and grain yield (Ansary *et al.,* 1989). Normal sowing gave higher grain yield than late sowing (Rajput and Verma, 1994).

In Bangladesh the wheat growing season (November-March) is in the driest period of the year. Wheat yield was declined by 50% owing to soil moisture stress (Islam and Islam, 1991). In Bangladesh best time of sowing of spring wheat ranges from15 to 30 November. Farmers can't sow seeds in optimum time as they cultivate wheat in winter season after harvesting of transplanted (T) aman rice. So, it is necessary to detect amount of irrigation water and accurate sowing time in a bid to enhancement of satisfactory yield. There is a lack of adequate information on the amount of irrigation water and the precise sowing time of wheat in relation to climate change that limits wheat production in Bangladesh. That's why, such type of research related to find out the amount of irrigation and optimum sowing time in addition to the relationship between irrigation and sowing time will generate yield of wheat to a large extent.

Materials and methods

The field experiment was designed to achieve the objectives of the study and executed following standard procedures and methods. The experiment was conducted at experimental field of Sher-e-Bangla Agricultural University, Bangladesh during the period from November 2014 to March 2015. The experiment was carried out at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 during the Rabi season of 2014. The land area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level. The farm belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system.

The experiment was laid in a split-plot design with three replications. Each replication was first divided into three main plots on which the irrigation treatments were assigned. Each of the main plots was then subdivided into four unit plots to accommodate the sowing time. Thus the total number of unit plots was 3×3×4=36. The size of the unit plot was 2.75m × 1.8m. The distance maintained between two unit plots was 0.5m and between blocks was 1m. The treatments were randomly assigned to the plots within each replication. The following treatments were included in this experiment (A) Irrigation: 3 (I_1=Irrigation upto field capacity, I_2 =Irrigation upto 1/2 of the field capacity,I_3=Irrigation upto1/4th of the field capacity at crown root initiation, flowering and grain filling stages and (B) Sowing time: 4 (S_1=10 November, S_2=20 November, S_3=30 November, andS_4 =10 December.

There were on the whole 12(3×4) treatment combinations such as I_1S_1,I_1S_2,I_1S_3,I_1S_4,I_2S_1,I_2S_2,I_2S_3, I_2S_4,I_3S_1,I_3S_2,I_3S_3 and I_3S_4.

Determination of Field Capacity (FC)

The field capacity (FC) is the amount of water remaining in the soil after having been wetted and after free drainage has ceased. The matric potential at this soil moisture condition is around - 1/10 to – 1/3 bar. The moisture available in a soil is the difference of moisture contents at the permanent wilting point (PWP) and FC. The permanent wilting point (pwp) is the water content of a soil when plants growing in that soil wilt and fail to recover their turgor upon rewetting. The matric potential at this soil moisture condition is commonly estimated at -15 bar. Field capacity was determined for 1m² area in my research field. Two canes of water were required to obtain field capacity of 1m² area. According to this, 10 canes of water were required to have field capacity for each plot having 4.95m². As such, 5 canes of water were given for having 1/2 of field capacity and 2.5 canes of water were given for having 1/4 of field capacity.

A water cane contains 8.5 L of water. For field capacity, water required was 85 L for 4.95m².Similarly, for 1/2 of the field capacity, water required was 42.5 L. For 1/4th of the field capacity, water required was 21.25 L.

Urea, TSP, MP and Gypsum and cow dung were applied respectively at the rate of 220kg,180kg, 50kg,120kg and 10 ton per hectare. The whole amount of TSP, MP and Gypsum, 2/3rd of urea were applied at the time of the final land preparation. Rest of urea was top dressed after first irrigation (BARI, 2006). Two third of urea, the entire amounts of triple super phosphate, muriate of potash and gypsum were applied at final land preparation as a basal dose. Seeds of BARI Gam-26 (Hashi) were sown. Yield contributing characters and yield characters were recorded as days to flowering, days to maturity, spike length (cm), number of spike lets spike^{-1}, number of grains spike^{-1}, weight of 1000 grains (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield and harvest index (%).

Biological yield (t ha^{-1})

Biological yield of a crop is defined as the sum of grain yield and straw yield. The biological yield of wheat was measured for each plot and express in t/ha. The biological yield was estimated with the following formula: Biological yield = Grain yield + Straw yield

Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with the following formula. (Gardner *et al.*, 1985).

$$\text{HI (\%)} = \frac{\text{Economic yield (Grain weight)}}{\text{Biological yield}} \times 100$$

Data analysis

Collected data on different parameters were statistically analyzed with split plot design using the MSTAT computer package program developed. Least Significant Difference (LSD) technique at 5% and 1% level of significance was used by Duncan's Multiple Range Test (DMRT) to compare the mean differences among the treatments (Gomez and Gomez, 1984).

Results and discussion

Effect of irrigation on days to flowering and maturity

Days to flowering

Days to flowering of wheat showed statistically significant variation due to different amount of irrigation under the present trial (Table 1).

The highest days to flowering (56.25) was recorded from I_1. 53.50 days to flowering were obtained from I_2. The lowest days to flowering (50.83) was observed from I_3.The lower amount of irrigation tends to early flowering.

Days to maturity

Statistically significant variation was recorded in terms of days to maturity of wheat due to different amount of irrigation (Table 1). The highest days to maturity (105.70) was recorded from I_1while the lowest days to maturity (100.60) was observed from I_3. On the other hand, 103days to maturity was observed from I_2. But Atikulla (2013) reported that irrigation hastened the maturity period of wheat.

Table 1. Effect of irrigation on days to flowering and days to maturity of wheat.

Irrigation	Days to flowering	Days to maturity
I_1	56.25 a	105.70 a
I_2	53.50 b	103.00 b
I_3	50.83 c	100.60 c
SE	0.221	0.587
Level of significance	**	**
CV (%)	1.40	1.96

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter (s) differ significantly at 1% level of probability. Here, I_1 =Irrigation upto field capacity, I_2 = Irrigation upto 1/2 of the field capacity, I_3 = Irrigation upto $1/4^{th}$ of the field capacity.

Effect of sowing time on days to flowering and maturity

Days to flowering

Statistically significant variation from days to flowering of wheat was observed due to different sowing times (Table 2). The highest days to flowering (60) was observed from S_1 while the lowest days to flowering (49.67) was recorded from S_4. Due to high temperature stress days to flowering were shortened on 10 December sowing (S_4). Hakim *et al.* (2012) showed that all genotypes of wheat were significantly influenced by high temperature stress in late and very late sowing conditions shortening days to heading. Spink *et al.* (1993) also found that delayed sowing curtails the duration of each development phase due to increase in temperature.

Days to maturity

Different sowing times showed statistically significant variation for days to maturity of wheat (Table 2). The highest days (111.8) to maturity was observed from the treatment $S_1$and 106.20 days required from S_2. But the lowest days to maturity S_4 (96.22) which was statistically similar to S_3 (98.11). High temperature stress was responsible for reducing maturity period. Hakim *et al.* (2012) showed that all genotypes of wheat were significantly influenced by high temperature stress in late and very late sowing conditions shortening days to maturity.

Table 2. Effect of sowing time on days to flowering and days to maturity of wheat.

Sowing time	Days to flowering	Days to maturity
S_1	60.00 a	111.8a
S_2	53.78 b	106.20
S_3	50.67 c	98.11c
S_4	49.67 d	96.22
SE	0.250	0.674
Level of significance	**	**
CV (%)	1.40	1.96

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% level of probability. Here, S1= 10 November, S2 = 20 November, S3 = 30 November, S4 = 10 December.

Spike length (cm)

Effect of irrigation

Statistically significant variation was recorded for spike length of wheat due to different amount of irrigation (Table 3). The highest spike length (30.20cm) was recorded from I_1 while the lowest spike length (15.14cm) was observed from I_3 which was statistically similar with I_2 (15.40cm). Ample irrigation was responsible for boosting up spike length.

Effect of sowing time

Spike length of wheat showed statistically significant variation due to varying sowing times (Table 4). The highest spike length (22.67cm) was observed in S_2, which was statistically similar to S_3 (22.39cm) and closely followed by S_4 (21.38cm). The lowest spike length (14.57cm) was recorded from S_1. Spike length was reduced in early sowing, S_1 (10 November).

But, Chowdhury (2002) conducted an experiment with four sowing dates and reported that spike length decreased with delay in sowing date from November 15 and the lowest spike length were recorded in December 15 sown plants.

Table 3. Effect of irrigation on yield contributing characters and yield of wheat.

Irrigation	Spike No. of spikelet	No. of grains 1000 grain	Biological	Harvest	length (cm) spike^{-1}spike^{-1}wt	Yield (t ha^{-1}) index (%)
I_1	30.20 a	16.93 a	49.92 a	49.65 a	7.16a	47.09a
I_2	15.40 b	16.53 b	45.92 b	47.99 b	6.75b	46.25b

Irrigation	Spike No. of spikelet	No. of grains 1000 grain	Biological	Harvest	length (cm) spike^{-1}spike^{-1}wt	Yield (t ha^{-1}) index (%)
I_3	15.14 b	16.25 c	42.78 c	45.81 c	6.25c	45.56b
SE	0.335	0.027	0.513	0.212	0.049	0.181
Level of significance	**	**	**	**	**	**
CV (%)	5.68	0.52	3.72	1.53	2.24	1.58

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% level of probability. Here, I_1 =Irrigation upto field capacity, I_2 = Irrigation upto1/2 of the field capacity, I_3 = Irrigation upto1/4thof the field capacity.

Table 4. Effect of sowing time on yield contributing and yield characters of wheat.

Sowing time	Spike No. of spikelet	No. of grains 1000 grain	Biological	Harvest	length (cm) spike^{-1}spike^{-1}wt	Yield (t ha^{-1}) index (%)
S_1	14.57c	15.60d	38.29d	42.96d	5.64d	45.42c
s_2	22.67a	17.20a	51.00a	53.30a	7.63a	47.21a
s_3	22.39ab	17.02b	49.18b	48.41b	7.16b	46.43b
S_4	21.38b	16.47c	46.36c	46.59c	6.46c	46.15b
SE	0.384	0.028	0.572	0.244	0.051	0.244
Level of significance	**	**	**	**	**	**
CV (%)	5.68	0.52	3.72	1.53	2.24	1.58

** = Significant at 1% level of probability. In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% level of probability. Here, S_1= 10 November, S_2 = 20 November, S_3 = 30 November, S_4 = 10 December

Number of spike lets spike-1

Effect of irrigation

Different amount of irrigation showed statistically significant variation in terms of number of spike lets spike^{-1} of wheat under the present trial (Table 3). The highest number of spike lets spike^{-1} (16.93) obtained from I_1.16.53 numbers of spikeletsspike^{-1}were obtained from I_2. The lowest numbers of spike lets spike^{-1} (16.25) was observed in I_3.The higher amount of irrigation at grain filling stage increased number of spike lets spike^{-1}.

Effect of sowing time

Significant variation was found for number of spike lets spike^{-1} of wheat due to varying sowing times (Table 4). The highest numbers of spike lets spike^{-1} (17.20) was observed in S_2.In case of S3, numbers of spike lets spike-1were 17.02 andS4produced 16.47 numbers of spike lets spike^{-1}. The lowest numbers of spike lets spike^{-1} (15.60) was recorded from S_1. In order to sowing early (10 November), S1produced lowest numbers of spike lets spike-^{1}compared to late sowing (10 December), S_4. But Shafiq (2004) revealed that early sowing increased spike lets per spike compared to late sowing.

Number of grains spike-1

Effect of irrigation

Number of grains spike^{-1} of wheat showed significant variation due to different amount of irrigation (Table 3). The highest numbers of grains spike^{-1} (49.92) were recorded from I_1. I_2 produced 45.92 numbers of grains per spike. The lowest numbers (42.78) were recorded from I3. Numbers of grains spike^{-1} were enhanced owing to applying irrigation upto field capacity (I_1). Razi-us-Shams (1996) observed that irrigation increased number of grains per panicle over the control in wheat.

Effect of sowing time

Statistically significant variation was recorded for number of grains spike^{-1} of wheat under varying sowing times (Table 4). The highest numbers of grains spike^{-1} (51) was obtained from S_2 whereas the lowest numbers of grains spike^{-1} (38.29) were recorded from S_1. S_3 produced 49.18 numbers of grains spike^{-1} and S_4 produced 46.36 numbers of grains spike^{-1}.Owing to early sowing (10 November), S_1 produced lowest numbers of grains spike.$^{-1}$ But Shafiq (2004) revealed that early sowing increased grains spike^{-1}compared to late sowing.

Weight of 1000-grain (g)

Effect of irrigation

It was found that weight of 1000-grain of wheat varied significantly due to different amount of irrigation under the present trial (Table 3). The treatment I_1 produced the highest 1000-grain weight of 49.65g whereas the treatment I_3 produced lowest 1000-grain weight of 45.81g. The treatment I_2produced 47.99g wt. of 1000 grain of wheat. Weight of 1000-grain was increased due to applying irrigation upto field capacity (I_1). But Islam (1996) observed that irrigation had no influence of 1000-grain weight.

Effect of sowing time

Statistically significant variation was recorded for weight of 1000-grain of wheat due to varying sowing times (Table 4). The treatment S_2 produced significantly the highest 1000 grain weight of 53.30g while S_1 produced significantly the lowest 1000-grain weight of 42.96g.

The treatment S3 produced 48.41g weight of 1000 grain and 46.59g was found in S_4. Due to early sowing (10 November), lowest 1000 grain weight was recorded from S_1 compared to S_4 (late sowing, 10 December). But Shafiq (2004) revealed that early sowing increased 1000-grain weight compared to late sowing.

Yield characters

Effect of irrigation on grain and straw yield (t ha^{-1})

Grain yield

Grain yield of wheat ha^{-1} significantly differed from different levels of amount of irrigation (Fig.1). Grain yield was significantly influenced by different irrigation treatments. It was observed that the highest grain yield (3.380tha^{-1}) was obtained from I_1.

On the other hand, the lowest grain yield (2.858tha^{-1}) was obtained from I3. Maximum grain yield was obtained due to applying irrigation upto field capacity (I_1). Rasol, H. O. A. (2003) stated that the high yields were obtained from 500 and 600mm whereas the lowest was obtained from the 300mm irrigation treatment.

Straw yield

Straw yield of wheat showed statistically significant variation due to different levels of irrigation (Fig. 1). The highest straw yield of 3.787tha^{-1} was recorded from I_1. On the other hand, the lowest straw yield 3.402tha^{-1} was observed from I_3. Straw yield became maximum when irrigation applied upto field capacity (I_1) rather than 1/4th of field capacity (I_3). Razi-us-Shams (1996) observed that irrigation increased the straw yields over the control.

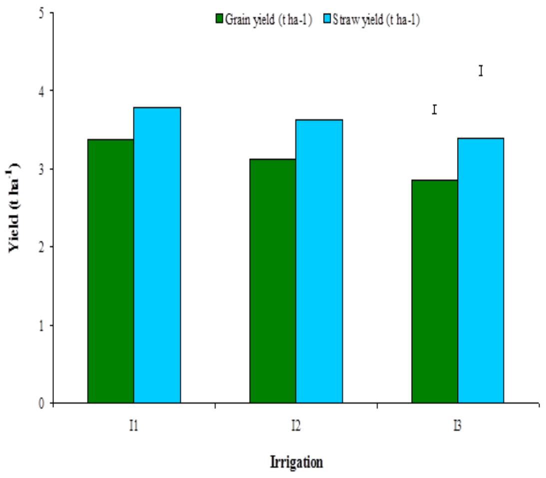
Effect of sowing time on grain and straw yield (t ha^{-1})

Grain yield of wheat showed statistically significant variation due to different sowing date (Fig. 1). The highest grain yield (3.607tha^{-1}) was observed from the treatment of S_2 and the lowest grain yield 2.567tha^{-1} observed from S_1 was statistically similar to 3.07tha^{-1} recorded from S_2.

Maximum grain yield was obtained from S_2 (20 November) compared to S_1 (10 November). Hossain *et al.* (2011) observed that highest yield was obtained wheat sown in November 22 to December 20 compared to November 08, 15 and December 27.

Significant variation was recorded for straw yield of wheat due to different sowing time under the present trial (Fig. 1). The highest straw yield as 4.027tha^{-1} was observed from S_2 and the lowest straw yield 3.079tha^{-1} was recorded from S_1. S_3 produced 3.834tha-1 and S_4produced 3.480tha^{-1}. Lowest straw yield was obtained from early sowing, S_1 (10 November) compared to late sowing, S_4 (10 December).

Ahmed *et al.* (2006) found that the highest straw yield (4.28tha^{-1}) produced due to early sowing (30 November), whereas the lowest straw yield (3.21tha^{-1}) was obtained from delay sowing.



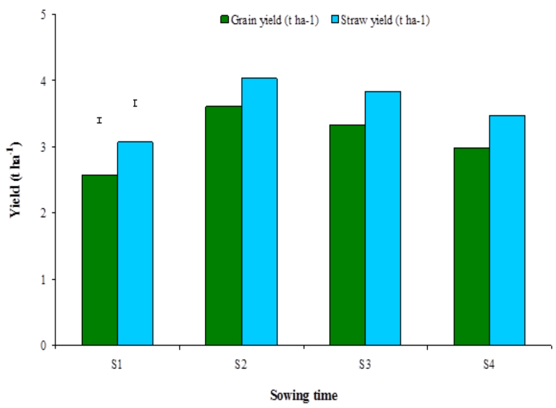


Fig. 1. Effect of irrigation and sowing time on grain and straw yield.

Here,

I_1 = Irrigation upto field capacity, I_2 = Irrigation upto 1/2 of the field capacity, I_3 = Irrigation upto1/4th of the field capacity and Here, S1= 10 November, S2 = 20 November, S3 = 30 November,S4 = 10 December.

Effect of irrigation and sowing time on biological yield and harvest index of wheat Biological yield (t ha^{-1})

It was revealed from the experiment that biological yield of wheat showed statistically significant variation due to different levels of irrigation under the present trial (Table 3). The highest biological yield (7.168tha^{-1}) was recorded from I_1. 6.753tha^{-1} recorded from I_2. On the other hand, the lowest biological yield 6.259tha^{-1} was observed from I_3. Shortage of irrigation reduced biological yield.

Statistically significant variation was recorded for biological yield of wheat due to varying sowing times (Table 4). The highest biological yield (7.633tha^{-1}) was obtained from S_2, while the lowest biological yield (5.646tha^{-1}) was recorded from S_1. S_3 produced 7.161tha^{-1} and S4 produced 6.467tha^{-1}. Atikulla (2013) observed that the highest biological yield (8.94tha^{-1}) obtained from November 19, 2012 (S_1), while the lowest biological yield (8.25tha^{-1}) was recorded from December 9 sowing date (S_3).

Harvest index (%)

Harvest index of wheat showed statistically non-significant variation due to different amount of irrigation under the present trial (Table 3). Numerically, the highest harvest index (47.09%) was recorded from I1 and the lowest harvest index was 45.56% was observed from I3 which was statistically similar to I2 (46.25%). Ngwako *et al.* (2013) showed that irrigation throughout the growth stages increased harvest index by 16.71% over no irrigation.

Data revealed that there was significant variation for harvest index of wheat due to varying sowing times (Table 4). The highest harvest index (47.21%) was observed from S_2 and the lowest 45.42% was from S_1. Harvest index (46.43%) was observed from S_3 which was statistically similar to S_4 (46.15%). Ehdaie *et al.* (2001) stated that harvest index was reduced by early sowing.

Interaction of different levels of irrigation and sowing time on yield characters of wheat

Data revealed that interaction effect of different amount of irrigation and sowing times showed significant differences on grain yield ha^{-1} of wheat (Table 5). The highest grain yield ha^{-1} of wheat (3.970tha^{-1}) was obtained from the treatment combination of irrigation upto field capacity with 20 November, 2014 sowing time (I_1S_2) and the lowest grain yield of wheat ha^{-1} (2.3tha^{-1}) was obtained from the treatment combination of irrigation upto 1/4th of field capacity with 10 November, 2014 (I_3S_1).

Interaction effect of amount of irrigation and sowing time showed significant differences on straw yield of wheat (Table 5).

The highest straw yield (4.310tha^{-1}) was observed from I_1S_2, while the lowest straw yield (2.867tha^{-1}) was recorded from I_3S_1. Amount of irrigation and sowing time showed significant differences on biological yield of wheat due to interaction effect (Table 5). The highest biological yield (8.280tha^{-1}) was observed from I_1S_2, while the lowest biological yield (5.167tha^{-1}).

Was recorded from I_3S_1. There were no significant differences on interaction effect of different amount of irrigation and sowing time on harvest index of wheat (Table 5). Numerically, the highest harvest index (47.93%) was observed from I_1S_2, while the lowest harvest index (44.66%) was recorded from I_3S_1.

Table 5. Interaction effect of irrigation and sowing time on yield characters of wheat.

Irrigation x Sowing time	Grain yield (%) (tha-1)	Straw yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
I_1S_1	2.75 e	3.17g	5.92f	46.42
I_1S_2	3.97 a	4.31a	8.28a	47.93
I_1S_3	3.55 b	4.00b	7.55b	47.02
I_1S_4	3.25 c	3.67e	6.92cd	46.97
I_2S_1	2.65 e	3.20g	5.85f	45.30
I_2S_2	3.53 b	3.97bc	7.50b	47.07
I_2S_3	3.33 c	3.83cd	7.16c	46.38
I_2S_4	3.00 d	3.50f	6.50e	46.15
I_3S_1	2.30 f	2.86h	5.16g	44.66
I_3S_2	3.32 c	3.80de	7.12c	46.63
I_3S_3	3.10 d	3.67e	6.77d	45.79
I_3S_4	2.71 e	3.27g	5.98f	45.32
SE	0.041	0.048	0.08	80.422
Level of significance	*	*	*	NS
CV (%)	2.36	2.30	2.24	1.58

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant. In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 1% and 5% level of probability.

Conclusion

The highest grain yield ha^{-1} (3.380t) and highest straw yield ha^{-1} (3.787t) were obtained by the treatment I_1 and the respective lowest grain yield ha-^{1} (2.858t) and straw yield ha-^{1} (3.402t) were obtained by the treatment I_3. In case of biological yield I_1 obtained the highest value of 7.168tha^{-1} which was significantly higher than each of the respective values obtained by the rest irrigation treatments and highest harvest index (47.09%) was obtained from I_1 compared to other irrigation treatments.

The highest grain yield (3.607tha^{-1}), straw yield (4.027tha^{-1}) and biological yield (7.633tah^{-1}) and harvest index (47.21%) were also recorded in November 20 sowing (S_2) and all the lowest values of all these parameters were recorded on November 10 sowing (S_1). Irrigation upto field capacity (I_1) in combination with November 20 sowing (I_1S_2) recorded the highest grain yield (3.97tha^{-1}), straw yield (4.310tha^{-1}) and biological yield (8.280tha^{-1}) and harvest index (47.93%) respectively.

The respective lowest yield 2.300tha^{-1}, 2.867tha^{-1}, 5.167tha^{-1} 44.66% were obtained in the treatment combination of I_3S_1. It may be concluded that yield attributes and yield of wheat were significantly affected with irrigation and sowing time.

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