Vol. 13, No. 2, pp. 126-132 (2013)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Crop Growth Behaviour and Yield Characteristics of Wheat (*Triticum aestivum* L.) in Two Different Agroclimatic Zones of Punjab

K.K. GILL*[1], NAVNEET KAUR[1] AND RITU BABUTA[2]

[1]*School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana - 141004*

[2]*Regional Station, Bathinda, Punjab Agricultural University, Ludhiana - 141004*

ABSTRACT

A field experiment was conducted during 2011-12 at the research farm, School of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana and Regional Station, Bathinda to determine the influence of sowing dates, irrigation levels and varieties on the growth and yield of wheat in two different agroclimatic zones of the state namely, central plains (Ludhiana) and western plains (Bathinda). Similar treatments comprised of 3 sowing dates (November 15 and 25, and December 5), 4 irrigation levels: I_1 (irrigation at CRI, jointing and milking), I_2 (at CRI, tillering, booting and milking), I_3 (at CRI, tillering, jointing, booting and milking) and I_4 (irrigation according to weather forecast) with 2 wheat varieties (PBW-343 and PBW-621) in split-split plot design were adopted at both the locations. The grain yield was higher in November 15 sowing (3.96 and 3.44 t ha^{-1}) both at Ludhiana and Bathinda as compared to other sowing dates. The variety PBW-621 performed better at both the locations (3.76 and 3.12 t ha^{-1} at Ludhiana and Bathinda, respectively). Among irrigation treatments, I_3 was better than other irrigation treatments (3.92 at Ludhiana and 3.35 t/ha in Bathinda) both at Ludhiana and Bathinda, respectively and it was at par with the I_4 treatment, where irrigation was applied based on weather forecast (3.84 and 3.33 t/ha at Ludhiana and Bathinda). Comparatively higher plant heights, number of effective tillers, ear length, number of grains ear^{-1} and 1000-grain weight and higher grain yields were recorded in I_3 and I_4 treatments as compared to others. Biological and straw yields in PBW-621 were also higher under November 15 sown crop with I_3. However, the interaction between dates of sowing and irrigation levels was non-significant.

Key words: Wheat, Sowing dates, Irrigation levels, Yield

Introduction

Wheat (*Triticum aestivum* L.) is the most important *rabi* cereal crop of Northern India. India is one of the largest wheat producing country contributing >30% in world wheat production. Among the wheat growing stats, Punjab contributes 50-70% to the central pool of wheat. Wheat is a thermo-sensitive crop, and therefore, choice of high yielding and disease resistant cultivars suitable to different sowing times is extremely important. Both sowing date and irrigation are interrelated for better productivity. The early sown crops mature earlier, but they require longer growing period and consequently, difference in harvest date between an early and a late sown variety becomes less than the difference in their planting dates. Timely sown wheat usually results in higher yields and is most likely to escape injury from drought, heat and diseases

*Corresponding author,
Email: kgill2002@gmail.com

which become more prevalent as the season advances. Late planting results in poor tillering and gets more chance of winter injury (Mass *et al.*, 2007). The sowing of irrigated wheat in Punjab starts in October and continues till as late as 1st week of December. Most of wheat is harvested in April-May and during the whole period, normal growth and development of the crop primarily depends upon available irrigation water. Irrigation consistently increases wheat yields (Rahim *et al.*, 2007), specifically when irrigation is applied at all definable growth stages (Wajid *et al.*, 2002). Sarwar *et al.* (2010) concluded that grain yields of different wheat cultivars significantly reduced by water stress at all critical growth stages and greatest reduction occurred through water stress during anthesis. The forecast of rainfall is much beneficial for wheat in northern India as western disturbances occur frequently and farmers are able to skip irrigation besides saving crop from damage during wind storms. Not much information is available to this effect under Punjab conditions. Therefore, the present study was planned to examine the effect of different sowing dates on growth, yield and yield attributes of wheat cultivars under two different agroclimatic conditions.

Materials and Methods

The field experiment comprised of 3 sowing dates as main plots (November 15 and 25; and December 5), 4 irrigation levels as sub-plots *viz.*, I_1 (irrigation at CRI, jointing and milking), I_2 (irrigation at CRI, tillering, booting and milking), I_3 (irrigation at CRI, tillering, jointing, booting and milking) and I_4 (irrigation according to weather forecast) and 2 wheat varieties as sub-sub-plots (PBW-343 and PBW-621) under split-split plot design at research farm of the Department of Agricultural Meteorology and Research Station, Bathinda, and Punjab Agricultural University, Ludhiana during the winter season of 2011-12.

Two different agroclimatic zones under the study represent central plains *i.e.*, Ludhiana (30°N 54°E and 75°N 48°E) and western plains *i.e.*, Bathinda (30°N 09°E and 74°N 55°E). The wheat crop was sown with seed @ 100 kg ha^{-1}. The seeds were sown in rows at a spacing of 20 cm and the fertilizers were applied as per recommendation (125, 62.5 and 30 kg N, P_2O_5 and K_2O ha^{-1} through urea, diammonium phosphate and muriate of potash, respectively). Entire doses of phosphorous and potassium and half of N were applied at sowing, and rest half N at first irrigation by top dressing. The tiller count was taken from the 1 m row length and plant heights were recorded as average from randomly selected 5 plants at different intervals. The ear length and effective tillers were recorded before harvesting. Data on 1000-grain weight and number of grains ear^{-1} were recorded after threshing. The grain yield and biomass were recorded after sun-drying and threshing of the produce. The harvest index was calculated as:

$$\text{Harvest index (HI)} = \frac{\text{Grain yield}}{\text{Biological yield}}$$

The statistical analysis was done as per the procedure given by Cheema and Singh (1991) using CPCS-I.

Results and Discussion

Plant heights

The crop sown on November 15 produced significantly higher plant height as compared to the delayed sowings at both Ludhiana and Bathinda (Table 1). The shorter heights of late-sown wheat could be attributed to plants having shorter growing periods. Mass *et al.* (2007) also reported decrease in plant height with delayed sowing. Among the irrigation treatments, I_3 produced significantly higher plant heights as compared to other irrigation treatments both at Ludhiana and Bathinda, but was at par with I_4 at Ludhiana and with the I_2 and I_4 at Bathinda. These results are similar to those of Thompson and Chase (1992), who also reported that irrigation treatments significantly influenced plant height. Among the varieties, PBW-621 produced significantly higher plant heights than PBW-343. This might be due to the genetic characters of the cultivars (Sarwar *et al.*, 2010; Shahzad *et al.*,

Table 1. Yield attributing characters of wheat at different dates of sowing and under irrigation levels (L=Ludhiana and B=Bathinda)

Treatments	Plant height (cm)		Effective tiller (no./m row length)		Ear length (cm)		No. of grains per ear		1000-grain weight(g)	
	L	B	L	B	L	B	L	B	L	B
Date of sowing										
November 15	11.46	83.18	176	130	10.27	9.10	46	45	61.99	44.22
November 25	11.16	81.55	153	122	9.65	8.45	43	41	59.21	41.83
December 5	10.90	80.03	147	112	8.27	8.43	38	39	56.79	39.77
C.D. (p=0.05)	2.34	1.84	12	5	0.47	0.49	4	2	3.72	0.85
Irrigation levels										
I_1	108.77	78.91	149.50	108.61	9.63	8.57	39.59	41.20	55.86	38.90
I_2	110.83	82.23	156.00	119.56	9.38	8.64	41.36	41.41	58.60	40.96
I_3	114.81	82.84	171.56	130.50	9.57	8.73	42.84	41.44	63.44	44.15
I_4	112.40	82.36	156.17	125.72	9.62	8.71	43.71	41.97	59.42	43.75
C.D. (P=0.05)	2.70	2.12	13.77	6.11	NS	NS	NS	NS	4.29	0.98
Varieties										
PBW-343	108.51	80.46	156.78	120.14	9.40	8.58	38.87	40.16	57.54	40.64
PBW-621	114.89	82.71	159.83	122.06	9.70	8.74	44.89	42.86	61.12	43.24
C.D. (P=0.05)	1.40	0.83	NS	NS	NS	NS	2.43	1.05	2.80	0.37

2007). The height of the crop was comparatively higher at Ludhiana compared to Bathinda. This might be due to more number of days taken by the crop to complete its phenology at Ludhiana than Bathinda.

Effective tillers

Numbers of effective tillers were significantly affected by sowing dates and irrigation levels (Table 1). Significantly higher number of effective tillers (176 and 130 at Ludhiana and Bathinda, respectively) was produced when sowing was done on November 15. Less number of effective tillers was produced when sowing was done on December 5, which was statistically at par with the November 25 sown crop at Ludhiana. The reduction in effective tillers with delayed sowing was also reported by Rout and Satapathy (1994). The I_3 treatment had significantly higher number of effective tillers compared to other irrigation treatments. The crop under I_1 resulted in minimum number of effective tillers, which was statistically at par with I_2 and I_4. Effective tiller numbers under I_1, I_2 and I_4 were statistically at par with each other at Ludhiana whereas the irrigation treatments I_3 and I_4 were at par in Bathinda. Sarwar *et al.* (2010) reported higher number of effective tillers under higher levels of irrigations. Effect of varieties, however was non-significant in both the sites.

Ear length

The sowing time significantly affected the ear length in wheat whereas the effect of irrigation levels and varieties were non-significant in both the places (Table 1). The maximum ear length (10.27 and 9.10 cm at Ludhiana and Bathinda, respectively) was recorded in November 15 sown crop. In other dates, the effect was non-significant. The ear length decreased with delay in sowing and was minimum (8.27 and 8.43 cm at Ludhiana and Bathinda, respectively) with December 5 sowing. Similar effect of delayed sowing on ear length of wheat was reported by Piech and Atankowski (1989). The irrigation had no effect on ear length of both the varieties.

Number of grains ear^{-1}

Number of grains ear^{-1} is an important yield contributing parameter in wheat (Table 1). Dates of sowing significantly affected the grain numbers

and were higher in November 15 sowing (46 and 45 at Ludhiana and Bathinda, respectively) whereas the delayed sown crop produced significantly low (38 and 39 at Ludhiana and Bathinda, respectively) number of grains ear^{-1}. Grain numbers were at par in crops sown on November 25 and December 5 at Ludhiana. Decrease in number of grains with delayed sowing has been reported by Shafiq (2004). However, all the irrigation treatments showed non-significant effect. The variety PBW-621 produced significantly higher number of grains ear^{-1} compared to PBW-343 in both Ludhiana and Bathinda.

1000-grain weight

The 1000-grain weights were significantly affected by sowing dates, irrigation levels and varieties both at Ludhiana and Bathinda. The crop sown on November 15 produced significantly higher 1000-grain weights (61.99 g at Ludhiana and 44.22 g at Bathinda). Gupta *et al.* (2010) also observed higher 1000-grain weight in normal sown wheat crop, which decreased with delay in sowing. The higher grain weight obtained with November 15 sowing was due to prevailing low temperature necessary for reproductive growth. Significantly higher 1000-grain weight was recorded under I_3 (63.44 g at Ludhiana and 44.15 g at Bathinda) as compared to I_1, I_2 and I_4 treatments. Higher grain weight in I_3 might be due to higher translocation of photosynthates toward grain due to sufficient amount of water present in root zone. The I_1, I_2 and I_4 treatments were at par. Wajid *et al* (2002) and Sarwar *et al.* (2010) also reported higher grain weight with the increasing levels of irrigation. Variety PBW-621 (61.12 and 43.24 g at Ludhiana and Bathinda) produced significantly higher grain weight than PBW-343 (57.54 g at Ludhiana and 40.64 g at Bathinda).

Biological yield

Biological yields were significantly affected by dates of sowing, irrigation treatments and the varieties at both Ludhiana and Bathinda (Table 2). The maximum biological yield was recorded for the crop sown on November 15 (14.35 t ha^{-1} - Ludhiana and 12.88 t ha^{-1} - Bathinda). Yield was reduced significantly with delay in sowing and was minimum for the crop sown on December 5. Our results are in agreement with Rajput and Verma (1994), who reported significant decrease in biological yield with delayed sowing. The highest yield was obtained in I_3 (14.57 and 12.12 t ha^{-1} at Ludhiana and Bathinda, respectively) that was significantly higher than I_1 and I_2, Similar yields were recorded with I_1 and I_2 at Ludhiana, while I_3 and I_4 effects were at par in Bathinda. Under I_4 at Ludhiana, irrigation was skipped in the month of January and February in 2011 and 2012, respectively. This implies that if weather forecast is taken account, irrigation water can be saved and cost of cultivation can be reduced, without any loss of crop yield. Increase in biological yield with increased levels of irrigation was reported earlier (Akram, 2011). The PBW-621 produced significantly higher yields (13.97 t ha^{-1} at Ludhiana and 11.85 t ha^{-1} at Bathinda) than PBW-343. The higher yields might be attributed to higher plant height, more number of effective tillers, grain numbers and 1000-grain weights in PBW 621.

Straw yield

Sowing dates significantly affected the straw yield (Table 2). Significantly higher straw yield was produced at November 15 sowing (10.38 t ha^{-1} at Ludhiana and 9.44 t ha^{-1} at Bathinda), whereas significantly lower yields were recorded in December 5 sown crop. The highest straw yield in November 15 could be attributed to higher vegetative growth, more tiller production due to low temperature prevailing during the vegetative growth. Lower straw yield in the late sown crop was due to poor vegetative growth and less number of tillers. Results are in conformity with Mavi *et al.* (1992) who reported that the straw yield reduced significantly with delay in sowing. The straw yield was also significantly affected by various irrigation levels and varieties. The I_3 treatment resulted in maximum straw yield (10.65 and 8.77 t ha^{-1} at Ludhiana and Bathinda, respectively) but was statistically similar with I_4. The I_1 and I_2 treatment were also statistically at par at Ludhiana. But the irrigation levels showed

Table 2. Biological, straw and grain yields, and harvest index of wheat on different sowing times and irrigation treatments (L=Ludhiana and B=Bathinda)

Treatments	Biological yield		Straw yield (t ha^{-1})		Grain yield		Harvest index (%)	
	L	B	L	B	L	B	L	B
Date of sowing								
November 15	14.35	12.88	10.38	9.44	3.97	3.45	27.67	26.79
November 25	13.39	11.33	9.70	8.16	3.70	3.17	27.63	27.98
December 5	11.79	10.09	8.35	7.45	3.44	2.64	29.18	26.16
C.D. (P=0.05)	8.58	7.86	8.24	9.62	2.33	4.06	NS	NS
Irrigation levels								
I_1	11.96	10.37	8.59	7.66	3.37	2.71	28.18	26.13
I_2	12.71	11.27	9.04	8.33	3.66	2.94	28.80	26.09
I_3	14.57	12.12	10.65	8.77	3.92	3.35	26.90	27.64
I_4	13.46	11.97	9.62	8.63	3.84	3.34	28.53	27.90
C.D. (P=0.05)	9.91	9.08	9.52	NS	2.69	4.69	NS	NS
Varieties								
PBW-343	12.38	11.01	8.74	7.97	3.64	3.04	29.40	27.61
PBW-621	13.93	11.85	10.21	8.73	3.76	3.12	26.99	26.33
C.D. (P=0.05)	4.68	4.70	4.24	4.46	NS	NS	0.10	NS

non-significant effect at Bathinda. The low straw yield under less irrigation conditions could be due to low dry matter accumulation in different plant parts under such conditions. Among the varieties, PBW-621 produced significantly higher straw yield (10.21 t ha^{-1} at Ludhiana and 8.73 t ha^{-1} at Bathinda) than PBW-343 at both the locations.

Grain yield

Similar to biological and straw yields, highest grain yields was also recorded in November 15 sowing at Ludhiana (3.97 t ha^{-1}) and Bathinda (3.45 t ha^{-1}). It was significantly higher than other dates of sowing (similar yields) at Ludhiana. The lower grain yield in delayed sowings might be due to reduced number of days to complete phenological stages, reduced radiation use efficiency, yield attributing characters like effective tillers, grains ear^{-1} and 1000-grain weight. Similar results were also reported by Jain *et al.* (1992) and Ram *et al.* (2012). The minimum grain yield was recorded in I_3 treatment where soil water stress occurred at tillering under both Ludhiana and Bathinda. The grain yield was higher in I_3 (3.92 and 3.35 t ha^{-1} at Ludhiana and Bathinda, respectively) but was at par with I_4 (3.84 and 3.3.4 t ha^{-1} at Ludhiana and Bathinda, respectively) as rainfall compensated the deficit irrigation in I_4. Our results are in agreement with those reported by Kang *et al.* (2002) and Pirdashti *et al.* (2004). Among the varieties, grain yield was marginally higher in PBW-621 (3.76 and 3.12 t ha^{-1} at Ludhiana and Bathinda, respectively).

Harvest index

The harvest index, a parameter to indicate degree of allocation of dry matter from leaves and stem to grains (sink) (Solanki, 2009).was affected by sowing dates, irrigation levels and varieties (Table 2). Effects of dates of sowing and irrigation treatments were non-significant. Similar results were reported by Mahmoud (1999) and Sharaan *et al.* (2000). The variety PBW-343 showed higher harvest index at Ludhiana, but at par with PBW-621 at Bathinda. Lower straw yield was associated with higher harvest index (Lathwal and Thakral, 1999).

Conclusions

The results showed that November 15 is the optimum time of sowing and it produced higher

plant height, number of effective tiller, ear length, number of grains per ear and 1000-grain weight, grain yield, biological yield in the central plain zone as compared to western plain zone of the state. This might be due to the synchronization of the crop growth stages with optimum temperature requirement under normal sowing at central plain zone. Irrigation at all critical stages resulted in higher grain yield and remained at par with the irrigation given based on weather forecast. Therefore, wheat grower must be careful about water stress on critical stage that can cause tremendous yield loss and can apply irrigation according to accurate weather forecast available during crop season. The application of water based on the weather forecast saves water and also protect the crop from moisture stress as well as from damage caused by wind storms at maturity. The moisture stress at different growth stages under I_1 and I_2 treatment caused low grain yield by reducing the yield attributes. It was found that the PBW-621 performed comparatively better than PBW-343 in the central plain zone than the western zone of Punjab in terms of yield production.

References

Akram, M. 2011. Growth and yield components of wheat under water stress of different growth stages. *Bangladesh J. Agric. Res.* **36**: 455-468.

Cheema, H.S. and Singh, B. 1991. *Software Statistical Package* CPCS-1. Department of Statistics, *Punjab Agricultural University*, Ludhiana, India.

Gupta, A., Gupta, M. and Bazaya, B.R. 2010. Effect of sowing dates and genotypes on growth and yield of durum wheat (*Triticum durum* L.). *J. Res. SKUAST* **9**: 164-168.

Jain, M.P., Dixit, J.P., Pillai, P.V.A. and Khan, R.A. 1992. Effect of sowing date on wheat varieties under late sown irrigated condition. *Indian J. Agric. Sci.* **62**: 669-671.

Kang, S., Zhang, L., Lian, Y. and Cai, H. 2002. Effect of limited irrigation on yield and water use efficiency of winter wheat on the loess plateau of China. Regional water and soil assessment for managing sustainable agriculture in China and Australia. *ACIAR Monograph No*. **84**: 105-116.

Lathwal, O.P. and Thakral, S.K. 1999. Performance of wheat varieties under rainfed conditions. *Crop Res.* **18**: 470-471.

Maas, A.L., Hanna, W.W. and Mullinix, B.G. 2007. Planting date and row spacing affects grain yield and height of pearl millet Tifgrain 102 in the Southeastern coastal plain of the United States. *J. SAT Agric. Res.* **5**:1-4.

Mahmoud, A.A.M. 1999. Effect of some agricultural practices on growth and yield of wheat. Ph.D. Thesis, Fac Agric, Mansoura Univ Egypt.

Mavi, H.S., Mahi, G.S., Mathauda, S.S., Jhorar, O.P. and Singh, G. 1992. Dynamic simulation of wheat growth and forecasting its fungal disease. DST Project Report, PAU, Ludhiana.

Piech, M. and Atankowski, S. 1989. Effect of sowing date and seed rate on yield and grain quality of winter wheat varieties. Biuletyn Institute Hodwoli-1-aklimaty Zacji Roslin *Field Crop Abstr.* **27**: 137-147.

Pirdashti, H., Sarvestani, Z.T., Nematzadch, G. and Ismail, A. 2004. Study of water stress effects in different growth stages on yield and yield components of different rice (*Oryza sativa* L.) cultivars.*4th Int Crop Sci. Cong.* pp 1-7.

Rahim, A., Abbassi, G.H., Rashid, M. and Ranjha, A.M. 2007. Methods of phosphorous application and irrigation schedule influencing wheat yield. *Pakistan J. Agric. Sci.* **44**: 420-423.

Ram, H., Singh, G., Mavi, G.S. and Sohu, C.V.S. 2012. Accumulated heat unit requirement and grain yied of irrigated wheat (*Triticum aestivum* L.) varieties under different crop growing environment in central Punjab. *J. Agrometeorol.* **14**: 147-153.

Rajput, R.L. and Verma, O.P. 1994. Effect of sowing dates on the yield of different varieties of wheat in Chambal Command Area of Madhya Pradesh Bharyiya Krishi Anusandhan Patrika. *Indian J. Agron.* **9**: 165-169.

Rout, D. and Satapathy, M.R. 1994. Effect of date of sowing on wheat (*Triticum aestivum*) varieties in Umerkote zone of Orissa. *Indian J. Agron.* **39**: 466-468.

Sarwar, N., Maqsood, M., Mubeen, K., Shehzad, M., Bhullar, M.S., Qamar, R. and Akbar, N. 2010. Effect of different levels of irrigation on yield

and yield components of wheat cultivars. *Pakistan J. Agric. Sci.* **47**: 371-374.

Sharaan, A.N., Abd El-Samie, F.S. and Abd El-Gawad, I.A. 2000. Response of wheat varieties (*Triticum aestivum* L.) to some environmental influences, II: Effect of planting date and drought at different plant stages on yield and its components. In Proc. 9th Conf. Agron. Minufiya Univ., 1-2 Spet., 2000. Egypt.

Shahzad, M.A., Din, W.U., Sahi, S.T., Khan, M.M., Ehsanullah and Ahmad, M. 2007. Effect of sowing dates and seed treatment on grain yield and quality of wheat. *Pak. J. Agric. Sci.* **44**: 581-583.

Shafiq, H.M. 2004. Modeling growth, radiation use efficiency and yield of wheat at different sowing dates and nitrogen levels under arid conditions of Bawalpur. M.Sc (Hons.) Thesis, Univ Agric, Faisalabad- Pakistan.

Solanki, P. 2009. Resopnse of wheat (*Triticum aestivum*) under varying weather environment. ISPRS Archives XXXVIII-8/W3 Workshop Proc. *Impact of Climate Change on Agriculture*, pp 58-61.

Thompson, J.A. and Chase, D.L. 1992. Effect of limited irrigation on growth and yield of semi dwarf wheat in southern New South Wales. *Aust. J. Exp. Agric.* **32**: 725-730.

Wajid, A., Hussain, A., Maqsood, M., Ahmad, A. and Awais, M. 2002. Influence of sowing date and irrigation levels on growth and grain yield of wheat. *Pak. J. Agric. Sci.* **39**: 22-24.

Received: 24 December 2012; Accepted: 28 September 2013