Vol. 38, No. 3, pp 194-198, 2010
Indian Journal of Soil Conservation
Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home

Irrigation scheduling in zero-till and bed-planted wheat (*Triticum aestivum*)

Avtar Singh, J. S. Kang, Maninder Kaur and Ashu Goyal

Department of Agronomy, Punjab Agricultural University, Ludhiana-141 004
E-mail: avtar_bimbraw@yahoo.com

ARTICLE INFO

Article history :
Received : February 2010
Revised : August 2010
Accepted : August 2010

Key words :
Bed planting
Conventional tillage
Irrigation
IW/CPE, WUE
Zero tillage

www.IndianJournals.com
Members Copy, Not for Commercial Sale
Downloaded From IP - 203.100.75.43 on dated 25-Mar-2011

ABSTRACT

Field experiments were conducted at Department of Agronomy, Punjab Agricultural University, Ludhiana during 2004-05 to 2006-07 with planting wheat in three patterns namely, flat planting (zero) conventional tillage, bed planting and, three time of first irrigation at 2, 3and 4 weeks after planting and three subsequent irrigation at 1.2, 1.0 and 0.8 IW:CPE ratio. Bed planted wheat had lower water consumption, higher water use efficiency and grain yield than conventional and zero tillage The higher water use was recorded where first irrigation was applied at 2 weeks than that of 3 and 4 weeks after planting. However, the highest yield and water use efficiency was recorded when irrigation was applied at 3 weeks after planting. The highest water consumption and water use efficiency was observed when subsequent irrigation were applied at1.2 IW:CPE ratio. In 0-15cm soil layer, bulk density and infiltration rate under zero tillage were higher than conventional and bed planting. Lowest root density was recorded under zero tillage than conventional and bed planting. Soil water content in profile under zero tillage was higher followed by bed planting at all stages of growth. Water content in soil increased with the reducing interval of first irrigation and with the increasing of IW:CPE ratio from 0.8 to 1.2.

1. INTRODUCTION

Wheat crop is planted on preparing good tilth with 4-8 tillage operations after rice crop. The land preparation requires high input energy and increase cost of cultivation. Secondly, wheat sown with conventional tillage system also requires irrigation of 7.5 cm depth. To cope the problems of high cost of cultivation, fast depleting ground water resource and to sustain the productivity of rice-wheat cropping system, the adoption of new tillage and crop establishment technologies like zero tillage, bed planting (Furrow irrigated raised beds) direct seeded rice, crop residue recycling and crop diversification could answer the major constraints to the sustainability issues of rice-wheat cropping (Gupta *et al*.,2006). Zero tillage reduces cost of cultivation, saves fuel, energy, facilitate timely planting of crop, reduces weed population and wear and tear of tractor. Bed planting system reduces herbicide dependence through intercultural tillage, and saves inputs like water and seed (Fahong *et al.,*2004). Optimizing irrigation schedule and timely application of water play an important role in obtaining maximum yield. However, such as information is lacking about schedule of first and subsequent irrigations to zero till and bed planted wheat. With this background, present study was undertaken to workout the irrigation schedule for zero- till and bed planted wheat with the objectives to know the optimum time of first and subsequent irrigation in zero till and bed planted wheat.

2. MATERIAL AND METHODS

Field experiments on wheat were conducted over three growing seasons (2004-05 to 2006-07) at Punjab Agricultural University, Ludhiana. The soil of experimental field was loamy sand in texture with pH 8.3, low in available N (185 kg ha^{-1}), medium in available P (13.25 kg ha^{-1}) and

available K (247.5 kg ha^{-1}). Initial bulk density was 1.56, 1.62 and 1.57 (gcm^{-3}) in the soil layers of 0-15, 15-30 and 30-60 cm, moisture content at planting was 38.0, 33.8 and 35.0 cm under zero tillage, conventional tillage and bed planting, respectively. The experiment was comprised of planting wheat in three pattern with zero tillage (ZT), conventional tillage (CT), bed planting (BP) in the main plots, three timing of first irrigation at 2,3 and 4 weeks after planting of irrigation was in sub plots; and three subsequent irrigations at IW:CPE ratio of 1.2, 1.0, 0,8 in sub-subplots with three replications in split plot design. The width of the bed was 67.5 cm and rows to row distance in all the methods was 20 cm. The wheat '*PBW 343*' was planted and the irrigation was applied as per treatment. The depth of irrigation water was 7.5 cm for zero and conventional tillage and 5 cm for bed planted treatments. The wheat was planted on 9 November in all years using seed rate of 100 $kgha^{-1}$ in zero tillage and conventional tillage and 75 kg ha^{-1} in bed planting. The crop was raised with recommended package of practices. The rainfall was 145.1, 50.2 and 143.5 mm during the season in 2004-05, 2005-06 and 2006-07, respectively. Average number of irrigation was applied 4.7, 4.3 and 3.0; 4.3, 3.7 and 3.3; 4.3, 4.0 and 3.0 to bed planting, 4.0, 3.2 and 3.0; 3.7,3.3 and 2.7; 3.7, 4.0 and 2.3 to the zero and conventional tillage at 1.2, 1.0 and 0.8 IW:CPE ratio including first irrigation at 2,3 and 4 weeks after sowing during 2004-05, 2005-06 and 2006-07, respectively. Soil water content was measured gravimetrically in 0-180 cm soil profile at 15cm increments for first two layers, and subsequently at 30 cm. The root mass of a wheat plant was measured at the milk stage with a core sampler of 8.6 cm diameter up to 180 cm profile at depth increments of 30 cm.

3. RESULTS AND DISCUSSION

Growth Parameters

The average plant height at maturity did not vary with planting pattern, time of first irrigation and subsequent irrigation treatments and it varies from 79.4 to 81.7 cm under all the treatments (Table 1). The average dry matter accumulation at maturity were not significantly affected by plating pattern, time of first irrigation and subsequent irrigation treatments. The average aboveground dry matter of the bed planting was higher (11.6 t ha^{-1}) followed by conventional tillage (11.6 t ha^{-1}) and zero tillage (11.3 t ha^{-1}) but the differences were non-significant (Table 1) due to the same plant height attained by the plants under all the treatments. It also could be due to better environment for growth and development, where water was used more efficiently and caused an increase in photosynthetic potential (Wang *et al*., 2004). Among the time of first irrigation, higher dry matter accumulation was obtained when first irrigation was applied at 2 weeks after planting (11.8 t ha^{-1}) than that of obtained from the irrigation was applied 3weeks (11.4 t ha^{-1}) and 4 weeks (11.4 t ha^{-1}) after planting**.** This might be due to better availability of soil water content from the root initiation stage up to the maturity**.** Among the subsequent irrigation levels, the higher IW:CPE ratio of 1.2 produced the highest average aboveground dry matter (11.6 t ha^{-1}).

The bed planted wheat had significantly higher average

www.IndianJournals.com
Members Copy, Not for Commercial Sale
Downloaded From IP - 203.100.75.43 on dated 25-Mar-2011

Table 1
Effect of different treatment on grain yield, growth and yield component of wheat (average of 3 years)

Treatment	Above ground dry matter at maturity (t ha^{-1})	LAI at 120 days after planting	Effective tillers (No m^{-1})	Ear length (cm)	No. of grains per ear	1000-grain weight (g)	Grain yield (t ha^{-1})			Mean (t ha^{-1})
							2004-05	2005-06	2006-07	
Planting pattern										
ZT	11.3	2.6	95.4	9.4	34.8	41.4	4.38	3.84	4.90	4.37
CT	11.6	2.5	95.3	9.2	35.3	42.2	4.47	3.87	4.91	4.42
BP	11.6	3.1	100.0	9.6	35.1	40.1	4.52	4.19	5.02	4.50
CD (p=.05)	NS	0.2	NS	NS	NS	NS	NS	NS	NS	-
Time of first irrigation (Weeks after planting)										
2	11.8	2.9	95.6	9.3	34.2	41.2	4.52	3.93	4.95	4.47
3	11.4	2.7	98.4	9.5	37.0	41.8	4.50	4.09	4.96	4.52
4	11.4	2.5	96.8	9.4	33.8	39.6	4.35	3.89	4.91	4.38
CD (p=.05)	NS	0.1	NS	NS	NS	NS	0.12	NS	NS	-
Subsequent irrigation level (IW:CPE ratio)										
1.2	11.6	2.9	99.7	9.5	35.6	41.1	4.56	4.15	5.01	4.57
1.0	11.5	2.8	97.7	9.4	35.0	41.4	4.42	3.99	4.92	4.44
0.8	11.4	2.2	94.5	9.4	34.4	40.2	4.40	3.75	4.90	4.35
CD (p=.05)	NS	0.2	NS	NS	NS	NS	NS	0.23	NS	-

ZT: Zero tillage CT: Conventional tillage BP: Bed planting

leaf area index (3.1) than zero (2.6) and conventional flat (2.5) sown wheat. First irrigation at 2 weeks after planting resulted in significantly higher leaf area index of 2.9 than at 4 weeks (2.5) and was at par with first irrigation was applied at 3 weeks (2.7) after planting. Subsequent irrigation applied at IW:CPE ratio of 1.2 produced significantly higher leaf area index (2.9) than IW:CPE ratio of 0.8 (2.2)and at par with IW:CPE ratio of 1.0 (2.8).

Yield Attributes

Yield attributes *viz;* average effective tillers per meter row length, ear length, number of grains per ear, 1000- grain weight were not significantly affected by different planting patterns (Table 1).The wheat sown with bed planting gave the average highest grain yield (4.50 tha^{-1}) than those obtained with conventional (4.42 tha^{-1}) and zero tillage (4.37 tha^{-1}). Higher yield might be due to better growth and yield parameters such as effective tillers per meter row length, ear length and leaf area index (Dhillon *et al*. 2004). The different time of first irrigation had significant effect on grain yield in the first year but not in the second and third year could be due to the production of significantly same yield attributes. The significant differences in the grain yield were recorded in the treatment where irrigation was applied at 2 weeks (4.52 t ha^{-1}) than 4 weeks (4.35 t ha^{-1}) and at par with 3 weeks (4.50 t ha^{-1}) after planting of wheat during 2004-05. The average grain yield was recorded highest with the application of first irrigation at 3 weeks which was due to the more number of effective tillers, ear length, number of grains per ear and 1000-grain weight. Subsequent irrigation treatments were produced statistically similar grain yield in the first and third years. In the second year, maximum grain yield was obtained when irrigation was applied at IW:CPE ratio of 1.2 (4.15 t ha^{-1}) which was significantly higher than that of 0.8 IW:CPE ratio (3.75 t ha^{-1}) and was at par with IW:CPE ratio of 1.0 (3.99 t ha^{-1}).However, the average higher grain yield was also recorded under the treatments where irrigation was applied at IW:CPE ratio of 1.2.

Bulk Density

The average bulk density values of three years at harvest increased from 0-15 (1.57, 1.49 and 1.48 g cm^{-3}) to 30-40 (1.61, 1.63 and 1.63 g cm^{-3}) and decreased at 30-60 cm (1.56, 1.54 and 1.58 g cm^{-3}) in the layer of soil under zero tillage, conventional and bed planting at harvest, respectively (Table 2). However, the bulk density values were higher in 0-15 cm soil layer under zero tillage (1.54 g cm^{-3}) than conventional tillage (1.49 g cm^{-3}) and bed planting (1.48 g cm^{-3}). The average of three years cumulative intake of water at 3 hr was higher under zero tillage (18.50 cm) followed by bed planting (16.79 cm) and conventional tillage (16.26 cm). The higher infiltration rate under zero tillage might be due to greater continuity of pores and dead root channels**.**

Total Root Density

Average total root density of three years was varied under different planting patterns and irrigation treatments (Table 3)**.** Lowest root density was recorded under zero tillage (2358.9 gm^{-3}) as compared to conventional (2400.2 gm^{-3}) and bed planting (2716.9 gm^{-3}). It could be due to the higher bulk density at the top surface which restricted the proliferation of roots at the upper surface. However, the highest root density was recorded under the bed planting followed by conventional tillage. It could be due to lower penetration resistance in soil layers. Singh *et al.* (2002) reported higher root density under bed planting than that of conventional tillage. The differences in rooting behavior under different tillage levels could be attributed to bulk density variation in the soil profile. Total root density was not much varied with the time of first irrigation and highest was observed where irrigation was applied at 3 weeks (2384.9 g m^{-3}) than 2weeks (2371.2 g m^{-3}) and 4 weeks (2373.0 g m^{-3}) after planting. It indicated that rooting density reduced when irrigation was applied before and after the initiation of crown root stage. The crop received irrigation at IW:CPE ratio of 1.2 had the higher root density (2704.9 g m^{-3}) as compared to 1.0 (2528.4 g m^{-3}) and 0.8 IW:CPE

Table 2
Effect of planting pattern on bulk density at different depth(cm) and cumulative infiltration rate at harvest of wheat (average of 3 years)

Treatment	Bulk density at harvest (gcm^3)			Cumulative infiltration rate at 3hr at harvest(cm)
	0-15 cm	15-30cm	30-60 cm	
Planting pattern				
ZT	1.57	1.61	1.56	18.50
CT	1.49	1.63	1.54	16.26
BP	1.48	1.63	1.58	16.79

ZT: Zero tillage CT: Conventional tillage BP: Bed planting

www.IndianJournals.com
Members Copy, Not for Commercial Sale
Downloaded From IP - 203.100.75.43 on dated 25-Mar-2011

ratio (2517.8 g m^{-3}). Singh (2001) reported that root density increased with increase in IW:CPE ratio from 0.65 to 1.1 at 103 days after sowing.

Soil Water Content

Soil water content (cm) in profile under zero tillage (34.4, 28.6, 31.1 and 16.4 cm) was higher at 60, 90, 120 days after planting and at maturity of crop except at 30 days (30.3 cm) after planting (Table 3). Among the conventional and bed planting pattern, it was higher in bed planting (33.7, 31.7, 25.4 28.7 and 14.7 cm, respectively) at 30, 60, 90, 120 days after planting and at maturity of crop. Mahey *et al.* (2002) reported that soil water content in profile under zero tillage was higher than conventional and bed planting. At 30 and 90 days after planting, higher water content (33. 7, 34.7 cm, respectively) was recorded when first irrigation was applied at 4 weeks after planting. At 60 and 120 days after planting and at maturity, higher water content (34.8, 32.1 and 17.2 cm, respectively) was recorded when first irrigation was applied at 2 weeks after planting, respectively. Among subsequent irrigation levels, at 30, 60 and 90 days after planting higher water content (35.6, 35.2, 28. 4 cm, respectively) was recorded when irrigation applied at IW:CPE of 1.2, 0.8 and 1.0, respectively. However, higher water content was recorded when irrigation was applied at IW:CPE of 0.8 and 1.2 after 120 days of planting (30.4 and 30.4 cm, respectively) and at harvest of wheat it was maximum at IW:CPE of 1.2.

Consumptive Use of Water

The average (3 years) consumptive use of water by the crop was maximum under zero tillage (468.0 mm) followed by conventional tillage (462.8 mm) and bed planting (460.8 mm) due to the well distributed rainfall in the growing seasons and less irrigation frequency (Table 3). The decrease in water consumption in the bed planted wheat was due to the changing from flood irrigation to furrow irrigation which decreased irrigation amount and lowered evaporation from topsoil (Wang *et. al*., 2004 and Zhang *et al*., 2007). The higher water-use was recorded where first irrigation was applied at 2 weeks (476.6 mm) after planting followed by 3 (459.0 mm) and 4 weeks (456.9 mm) after planting. This could be due to the better availability of soil water content under higher frequency of irrigation. Singh (2000) reported higher water-use where first irrigation was applied at 14 days after sowing as compared to irrigation applied at 21 and 28 days after sowing**.** A progressive increase in consumptive use (453.9 to 474.9 mm) of water was recorded with increasing IW:CPE ratio from 0.8 to 1.2. It could be due to better availability of soil water content and more aboveground dry matter under higher frequency of irrigation. Parihar and Tiwari (2003) reported that consumptive use of water by the wheat crop increased with the increase in IW:CPE ratio from 0.6 to 1.2.

Water Use Efficiency

The average water use efficiency (WUE) was higher in the bed planting (9.91 kg ha-mm^{-1}) followed by conventional (9.50 kg ha-mm^{-1}) and zero tillage (9.34 kg ha-mm^{-1}) might be due to the less consumptive use of water resulted in higher WUE. Fahong *et. al.* (2004) reported higher WUE in bed

www.IndianJournals.com
Members Copy, Not for Commercial Sale
Downloaded From IP - 203.100.75.43 on dated 25-Mar-2011

Table 3
Effect of different treatment on root density, soil water content, consumptive water use and water use efficiency (average data of 3 years)

Treatment	Root density (gm^{-3})	Soil water content (cm) Days after planting 30	60	90	120	At harvest	Consumptive water use (mm)	Water-use efficiency (kg ha-mm^{-1})
Planting pattern								
ZT	2358.9	30.3	34.4	28.6	31.1	16.4	468.0	9.34
CP	2400.2	27.7	31.2	25.9	29.2	13.9	464.8	9.50
BP	2716.9	33.7	31.7	25.4	28.7	14.7	460.8	9.91
Time of first irrigation (weeks after planting)								
2	2371.2	28.0	34.8	25.1	32.1	17.2	476.6	9.36
3	2384.9	30.0	29.6	30.4	28.2	13.2	459.0	9.83
4	2373.0	33.7	32.7	34.7	28.8	15.0	456.9	9.57
Subsequent irrigation levels (IW: CPE)								
1.2	2704.9	35.6	32.8	26.6	30.4	16.4	474.9	9.62
1.0	2528.4	30.4	29.4	28.4	30.1	12.9	465.8	9.53
0.8	2517.8	25.0	35.2	24.2	30.4	15.9	453.9	9.58

ZT: Zero tillage CT: Conventional tillage BP: Bed planting

planting as compared to flat planting. The highest WUE by the crop was recorded where irrigation was applied at 3 weeks (9.83) than 2 weeks (9.36) and 4 weeks (9.57 kg ha-mm^{-1}) after planting due to the less consumption of water by the crop. Similarly, the highest WUE recorded when first irrigation was applied at 21 days after sowing (Singh 2000). The maximum WUE was observed where irrigation was applied at IW:CPE ratio of 1.2 (9.62 kg ha-mm^{-1}) than IW:CPE ratio of 0.8 (9.58) and 1.0 IW:CPE ratio (9.53) could be due to the prolonged availability of soil water content resulted in higher grain yield. Bandyopadhyay (1997) reported that highest WUE was obtained with IW:CPE ratio of 1.2 and WUE decreased with the decrease in frequency of irrigation.

4. CONCLUSIONS

This study showed that first irrigation at 3 weeks after sowing and subsequent irrigation at 1.2 IW:CPE ratio to be applied in zero tillage and bed planted to obtain the higher grain yield of wheat in comparison to conventional tillage.

REFERENCES

Bandyopadhyay, P. K. 1997. Effect of irrigation schedule on evapo-transpiration and water use efficiency of winter wheat (*Triticum aestivum*). *Indian J. Agron.* 42(1): 90-93.

Dhillon, S. S., Prashar, A. and Thaman ,S. 2004. Studies on bed planted wheat (*Triticum aestivum* L.) under different nitrogen levels and tillage methods. *Curr. Sci.* 5(1): 253-256.

Fahong, W., Xuqing, W. and Sayre, K. 2004. Comparison of conventional, flood irrigated, flat planting with furrow irrigated, raised bed planting for winter in China. *Field Crops Res.* 87: 35-42.

Gupta, R. K., Jat, M. L. and Gill, M. S. 2006. Alternate tillage and crop establishment options for resource conservation in Indo-Gangetic plains of India. *In: Proceedings National Symposium on Conservation Agriculture and Environment*, October 26-28, BHU, Varanasi, U.P. India. *pp* 3-7.

Mahey, R. K., Singh, O., Singh, A., Brar, S. S., Virk, A. S. and Singh, J. 2002. Influence of first and subsequent irrigations under varying tillage levels on weed control and grain yield of wheat. *Crop Res.* 23(1): 7-11.

Parihar, S. S. and Tiwari, R. B. 2003. Effect of irrigation and nitrogen levels on yield, nutrient uptake and water use of late-sown wheat (*Triticum aestivum*). *Indian J. Agron.* 48(2): 103-07.

Singh, M. 2000. Studies on seed rate requirement and time of first irrigation in no-till wheat following rice. *M.Sc. Thesis* , Punjab Agricultural University, Ludhiana. *pp* 67-69.

Singh, S. 2001. Studies on irrigation, fertilizer and plant population on growth, yield and water use in bed planted wheat (*Triticum aestivum L.*). *Ph.D. dissertation*, PAU, Ludhiana. *pp* 52-55.

Singh, S., Yadav, A., Malik ,R.K. and Singh, H. 2002. Furrow-irrigated raised bed planting system-A resource conservation technology for increasing wheat productivity in rice-wheat sequence. *In: Proceedings International Symposium Herbicide Resistance Management and Zero Tillage in Rice-Wheat Cropping System.* March 4-6 at CCS HAU, Hisar, India. *pp* 198-200.

Wang, F.H., Wang, X.Q. and Sayre, K. 2004. Conventional, flood irrigated, flat planting with furrow irrigated, raised bed planting for winter wheat in China. *Field Crop Res*., 87: 35-42.

Zhang Jiyang, Sun Jingsheng, Duan Aiwang, Wang Jinglei, Shen Xiaojun and Liu Xiaofei. 2007. Effects of different planting patterns on water use and yield performance of winter wheat in the Huang-Huai-Hai plain of China. *Agric. Water Manage.* 92: 41-47.

www.IndianJournals.com
Members Copy, Not for Commercial Sale
Downloaded From IP - 203.100.75.43 on dated 25-Mar-2011