Research Article

Performance of Tillage and Irrigation Water on Growth, Yield Attributes and Yield of Wheat (*Triticum Aestivum* L.) In Uttar Pradesh

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Abstract

A field experiment was conducted during 2013-14 and 2014-15 at Meerut, Uttar Pradesh., The experiment consisting of five tillage in main plots and three treatments viz I_1 – IW/CPE 0.45, I_2 - IW/CPE 0.60, I_3 - IW/CPE 0.75 in sub-plots was laid out in split plot design with three replications. The plant height and dry matter accumulation among the yield attributes number of grain spike^{-1},test weight, spike length and number of spikelet's spike^{-1} were significantly higher with wheat sown on wide raised beds all other tillage practices except narrow raised beds zero tillage plots. Similarly furrow irrigated raised beds increased the grain yield of wheat significantly over rest of the plots during both the years.

Keywords: Tillage, Irrigation water, Yield attributes, Yield, Wheat

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Introduction

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is very important and remunerative *rabi* crop of North India. It is the second most important cereal crop after rice, grown under diverse agro-climatic conditions on 28 m ha area in India with a production of 84 m tonnes (Economic Survey, 2010-11). The North West India, which serves as India's food basket, may become food-insecure in the near future. Therefore, there is an urgent need to develop innovative alternative strategies for the future transformation of the irrigated wheat system toward improved practices, ones that (1)are more resource-use-efficient,(2) lead to food security, and (3) are economically sustainable. Conservation agriculture (CA)–based resource-conserving technologies (RCTs) include many new technologies (more efficient implements; reduced or minimal tillage; soil, water, and crop management practices) that are more efficient, use less inputs, improve production and income, and attempt to overcome emerging problems [1]. Alternative methods have been proven effective to sustain soil health and reduce water demand in the wheat crop in on-station trials in different agro-ecological regions by many scientists. But the applications of these new tillage and crop establishment methods need to be tested on a wider scale for water, labour, and energy efficiency on farm managed trials [2].There is a need to develop technologies and management practices that can simultaneously enhance production, preserve the natural resource base, and reduce poverty. In today's so stem, it is necessary to reduce the cost of production and to increase the productivity of wheat in order to compete in the international market. It has been well established that the zero tillage system reduces the cost of cultivation due to single tractor pass [3]. Water is an important input for realizing high wheat productivity; however, it is becoming the most limiting factor for crop production in most of the north western parts of India [4]. As water for irrigation is a scarce resource, its optimum use optimization is fundamental to water resource use. It permits better utilization of all other production factors and thus leads to increased yields per unit area and time. Efficient water management requires a thorough study of plant water relationship, climate, agronomic practices and economic assessment. In cultivation of high yielding wheat varieties, irrigation assumes greater importance because during growing season of crop (October to April) weather remains relatively dry. The judicial application of water calls for immediate attention and this is possible only by following some scientific basis for water application to the crop. Various agronomic practices have been developed to conserve rain or irrigation water. Proper utilization of conserved moisture is an effort towards increasing crop yield per unit amount of water used. Most of these practices increase the duration of moisture availability through an increase in the amount of available moisture in the soil. To increase the duration of moisture availability with the existing available moisture, the losses of it from plants (transpiration) and soil (evaporation) have to be reduced. Proper scheduling of irrigation (amount and timing) crops is an important component of water saving techniques. There are numerous ways to schedule irrigations and estimate the required depth of water application [5, 6]. All irrigation scheduling methods consist of monitoring indicators that determine the need for irrigation [7]. Suggested a simple approach based on meteorological parameters to schedule irrigation of crops based on the ratio between fixed depth (75 mm) of irrigation water (IW) and net cumulative pan evaporation since previous irrigation (PAN-E minus rainfall).Being the prime natural resource for assured crop production, water has to be used judiciously and in a scientific manner.

Materials and Methods

The experiment was conducted at Crop Research Centre (CRC) of the University situated in Indo-Genetic plains of western Uttar Pradesh in Western Plains Zone. It's geographically located at 29° 05' 19" N latitude, 77° 41' 50" E longitudes and at an elevation of 237 metres above the sea level during *rabi* 2013-14 and 2014-15 at a same site in both the years. The climate of this region is semi-arid and sub-tropical with extremes hot weather in summer and cold weather in winter season. There is gradual decrease in mean daily temperature in January reaching as low as 5.6^0C and further a gradual increase is registered reaching as high as 36.6 ^{0}C in months of April. Occasionally, frost does occur during the months of December and January. The maximum temperature was highest in fourth week of April during both the years. Rainfall was occurred 177.0 mm and 203.3 mm during crop period in 2013-14 and 2014-15. The mean weekly weather data for the crop period of 2013-14 and 2014-15. The soil was sandy loam with pH 8.0 and 7.9 (1:2.5 soil to water). The top soil of the experimental site was sandy loam overlying silty clay, with an abrupt change to sandy loam at about 90 cm. Bulk density was 1.51and 1.56 g/cm in the top-soil. Organic carbon 0.50 and 0.51%, available N 242.7 and 244.5 kg ha^{-1} available P 12.0 and 12.3 kg ha^{-1} and available K 201.3 and 202.2 kg ha^{-1} at the start of the experiment in 0 to 15 cm soil layer during 2013-14 and 2014-15, respectively. The treatments consists of five tillage practices (T1, Wide raised beds, T2, Narrow raised beds, T3, Conventional tillage, T4, Reduced tillage, T5, Zero tillage) and three irrigation schedules (I_1 – IW/CPE 0.45, I_2 - IW/CPE 0.60, I_3 - IW/CPE 0.75). The study was made in split plot design with three replications. In FIRBS, 15 cm high and 45 cm broad bed with a furrow width of 25 cm between the beds was prepared with planting three rows of wheat in rows 15 cm apart [8]. Half dose of N and full dose of P and K through urea, single super phosphate and muriate of potash, respectively, were applied at sowing and remaining N was applied after first irrigation. Wheat DBW-17 was sown on15 November and 22 November 2013 and 2014 and harvested on 15 April and 20 April, in 2014 and 2015, respectively. Other management practices were adopted as per recommendations of the crop under irrigated conditions. The nutrient uptake by the crops was obtained as product of nutrient concentration and yield. Two years data was pooled and statistically analyzed. Soil moisture content was measured at seeding, and before and after each irrigation on the top of the ridge and furrow in furrow irrigated raised bed planting system, between the 2 rows in flat planting by gravimetric method. Water saving (WS) was calculated as:

$$WS = (Q_F - Q_B)/Q_F \times 100,$$

Where, Q_F and Q_B are quantity of water applied in flat planting and furrow irrigated raised bed planting system, respectively. The soil moisture data will be utilized to calculate the consumptive use.

Results and Discussion

Plant height increased rapidly with advancement of age and reached maximum at harvest under T1 during both the years. Due to tillage method and irrigation water, the improvement in moisture supply. The difference in plant height between T_2 and T_5 were at par during the years of experimentation. Treatments T_4 and T_5 were at par, respectively. Similar trends were also observed, respectively. Among water regimes, I_3 was taller than I_2 treatments. The pattern of plant height at different stage between irrigation water were I_3>I_2 and I_1 during the experimental years. Similar rustles by [9, 10].

Tillers m^{-1}

The data revealed that tiller number decreased with advancement in crop age (**Table 1**). Wheat sown on wide raised beds produced more tillers followed by sowing on narrow raised beds method. Sowing wheat on wide raised beds (T_1) recorded maximum tillering was significantly more than other methods of establishment but statistically at par with sowing wheat on narrow raised beds (T_2) however, the differences among T_3 and T_5 treatments during the years of experimentation. Irrigation water application had significant effect on number of tillers m^{-1} throughout the crop growth period. During 2013-14, IW/CPE 0.75 (I_3) treatment recorded significantly higher tillers m^{-1} over all other treatments but it was statistically at par with I_2 treatment. Similarly during 2014-15 also, IW/CPE 0.75 (I_3) treatment gave significantly more tillers m^{-1} over all other treatment. [11, 12]

Table 1 Plant height, number of tillers and dry matter accumulation (g m^{-1} row length) at different stages of crop growth as influenced by tillage and irrigation water

Treatment	Plant height (cm)		Number of tillers (m^{-1})		Dry matter accumulation (g m^{-1})	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Tillage						
T_1	86.4	82.2	122	117	337.25	324.27
T_2	86.1	81.8	114	108	331.64	312.79
T_3	83.5	78.5	75	72	245.37	231.24
T_4	84.0	79.4	97	93	282.94	263.52
T_5	84.8	80.1	88	82	264.17	243.63
SEm(±)	*0.25*	*1.00*	*2.86*	*2.63*	*2.56*	*2.45*
C.D. (P=0.05)	*0.82*	*NS*	*9.31*	*8.56*	*8.33*	*7.98*
Irrigation water						
I_1	84.2	79.7	87	78	270.9	253.7
I_2	84.8	80.2	96	92	290.1	272.9
I_3	85.9	81.3	114	113	315.9	293.7
SEm(±)	*0.20*	*0.58*	*1.36*	*1.28*	*2.36*	*2.35*
C.D. (P=0.05)	*0.59*	*NS*	*4.00*	*3.18*	*6.95*	*6.94*
Interaction I × T	NS	NS	Sig	Sig	NS	NS

It is to mention here that the interaction effect of tillage practices crop and water regimes was statistically significant during both the years. A close scan of the data reveals that the water regime IW/CPE 0.75 (I_3) responded significantly to T_1 tillage practices.

Dry matter accumulation

Dry matter accumulation by crop is an important index indicating the photosynthetic efficiency of crop and photosynthetic left behind after respiration which ultimately influences the crop yield. So it is the best indicator of growth of a crop. The dry matter accumulation increased progressively with advancement of the crop age as presented in (Table 1). Differences due to tillage treatments were found to be significant. In general, dry matter accumulation kept on increasing with age and reached maximum in both the years of study. The dry matter accumulation meter^{-1} row length decreased during second year than first year. Wheat sown on wide raised beds (T_1 maximum dry matter accumulation (337.25 and 324.27g) was obtained under T_1 plots.

Wheat produced statistically similar dry matter at all the growth stages during the years of study with application of IW/CPE 0.75, with different intervals of irrigation at 22, 65 and 105 DAS, respectively. Treatment I_3 produced significantly more dry matter production over all other treatments but was statistically at par with I_2 and I_1 during the years of study. Irrigation water IW/CPE 0.60 and IW/CPE 0.75 treatments increased dry matter accumulation significantly over IW/CPE 0.45 (I_1) [11, 13].

Yield attributes

Spike length

Spike length is directly related to the number of spikelet and grains spike^{-1} and hence this is an important determinant of grain yield. Spike length may also serve as one of the criteria for assessing the grain yield in cereal crops. The scrutiny of data as presented in (**Table 2**) revealed that T_2 treatment significantly increased spike length over T_3 and T_4 treatments but at par with T_1 treatment during the years of study. However, T_2 treatment produced significantly increased spike length as compared toT_3 and $T_{4,}$ respectively.

The perusal of data as presented in Table 2 showed that spike length increased with the increase in irrigation water during the experimental years. Significantly longer spike were obtained with I_2 and I_3 as compared to I_1 this level Influence of water regime of IW/CPE 0.60 and IW/CPE 0.75 was at par on spike length when compared among different treatments of irrigation water. The interaction was found to be non-significant.

Spikelet's spike^{-1}

Table 2 indicates that the maximum number of spikelet's spike^{-1} was recorded significantly superior in T_1 treatment as compared to all other treatments except T_2 in both the years. T_4 and T_5 were at par with each other; however, they recorded significantly more number of spikelet over T_3 treatment which recorded minimum number of spikelet's spike^{-1} (17.1 and 16.7) during 2013-14 and 2014-15.

Water regime differences with respect to the average number of spikelet's spike^{-1} were also found to be significant. I_2 and I_3 produced significantly higher average number of spikelet's spike^{-1} (10.8, 10.0 and 10.1, 11.3) as compare to I_1 rest of the varieties during both the years of study.

Table 2 Effect of tillage and irrigation water on yield attributes of wheat

Treatment	Spike length(cm)		No. of Spikelet's spike^{-1}		No. of grains spike^{-1}		Test weight (g)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Tillage								
T_1	11.3	10.9	22.0	21.5	55.9	54.7	46.7	45.7
T_2	12.1	11.7	21.3	21.0	53.8	53.1	46.3	45.6
T_3	8.3	8.2	17.1	16.7	43.0	41.9	44.0	43.2
T_4	9.2	9.1	18.6	18.5	47.7	46.6	44.2	43.6
T_5	10.8	10.4	19.3	19.2	50.6	48.9	45.2	44.7
SEm(±)	*0.16*	*0.15*	*0.25*	*0.23*	*0.88*	*0.73*	*0.38*	*0.35*
C.D. (P=0.05)	*0.54*	*0.50*	*0.81*	*0.75*	*2.85*	*2.36*	*1.25*	*1.13*
Irrigation water								
I_1	9.7	9.4	19.0	18.7	46.2	44.8	44.3	43.8
I_2	10.3	10.0	19.6	19.2	50.4	49.0	45.1	44.5
I_3	11.1	10.8	20.4	20.1	54.0	52.7	46.4	45.3
SEm(±)	*0.11*	*0.10*	*0.17*	*0.15*	*0.52*	*0.48*	*0.42*	*0.38*
C.D. (P=0.05)	*0.32*	*0.29*	*0.50*	*0.46*	*1.52*	*1.42*	*1.25*	*1.12*
Interaction I × T	NS	NS	Sig	Sig	Sig	Sig	NS	NS

Grains spike^{-1}

The grain is fertilized; fully ripened ovule of spikelet in a spike that ultimately contributes to grain yield. This excludes sterile spikelet's spike^{-1}. The data on number of grains spike^{-1} depicted in Table 2 that sowing of wheat on wide raised beds (T_1) planting techniques produced significantly more grains spike^{-1} during the years of study over all other treatments but was statistically at par with sowing of wheat on narrow raised beds (T_2), respectively. The differences in number of grains spike^{-1} among the treatments T_4 and T_5 were non-significant but significantly superior over T_3 in both the years. The maximum number of grains spike^{-1} (55.9 and 54.7) (T_1) and the minimum (43.0 and 41.9) were recorded under T_3 treatments during 2013-14 and 2014-15, respectively. It can be seen from the data that IW/CPE 0.60 irrigation application and IW/CPE 0.75 irrigation application significantly increased number of grains spike^{-1} over IW/CPE 0.45 (I_1). However; treatments I_2 and I_3 of water regime were statistically at par among themselves during the years of study.

1000 grain weight (g)

The weight of individual grain calculated from 1000 grain weight (test weight) is an important yield attribute which provides information regarding the efficiency with grain filling process took place. Thousand grain weight (1000 grain weight), as it is called the test weight of the desired output, is referred to be considered as one of the most significant agronomic parameters ever trusted that contributes in having a reconnaissance over the possible production of a lot (grain yield). Data pertaining to the 1000 grain weight are presented in (Table 2) revealed that T_1 treatment of planting techniques significantly increased 1000 grain weight over all other treatments but were statistically at par with T_2 and T_5 treatments during the years of study. However, T_5 treatment produced significantly higher grain weight as compared to T_3 and T_4, respectively.

All treatments of water regime IW/CPE 0.60 application and IW/CPE 0.75 application were statistically at par among themselves in respect of thousand grain weights during 2013-14 and 2014-15. However, water regime IW/CPE 0.60 application to wheat significantly increased thousand grain weights over IW/CPE 0.45 "I_1". The interaction effects were non-significant. Interaction effects between tillage practices and water regime in respect to average number of spikelet's spike^{-1} and number of grain were significant. It indicated that the crop response to tillage crop establishment was modified by the irrigation scheduling [14, 15].

Yield

Grain yield (q ha^{-1})

Grain yield is a function of various parameters like crop dry matter accumulation, number of tillers, number of grains spike^{-1} and grain weight etc. Grain yield is the most important criteria for evaluating the effects of applied treatments. Crop productivity is the rate at which a crop accumulate biomass which depends primarily on the photosynthesis and conversion of light energy into chemical energy by green plants. The data on grain yield is presented in (**Table 3**) revealed that grain yield increased with each increment in moisture retention level.

Table 3 Effect of tillage and irrigation water on grain, straw, biological yield and harvest index of wheat

Treatment	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})		Harvest index (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Tillage								
T_1	48.96	48.19	62.78	61.55	111.74	109.74	43.81	43.83
T_2	47.01	46.17	58.51	57.55	105.52	103.72	44.54	44.05
T_3	42.34	41.45	51.47	50.57	93.81	92.02	45.14	44.59
T_4	44.54	42.81	53.17	51.95	97.71	94.76	42.97	44.11
T_5	45.07	43.90	59.12	56.81	104.19	100.71	45.88	45.77
SEm(±)	*0.77*	*0.82*	*1.33*	*1.67*	*2.07*	*2.24*	-	-
C.D. (P=0.05)	*2.51*	*2.69*	*4.35*	*4.79*	*6.74*	*7.31*	-	-
Irrigation water								
I_1	40.95	39.87	51.19	49.84	92.13	89.71	44.46	44.29
I_2	45.78	44.70	57.31	55.96	103.08	100.66	44.46	44.65
I_3	50.02	48.94	62.54	61.26	112.56	110.20	44.48	44.47
SEm(±)	*0.50*	*0.54*	*0.64*	*0.67*	*1.13*	*1.21*	-	-
C.D. (P=0.05)	*1.48*	*1.60*	*1.88*	*1.97*	*3.34*	*3.57*	-	-
Interaction I ×T	Sig	Sig	Sig	Sig	Sig	Sig	-	-

The variations in grain yield due to main effects of various treatments were statistically significant during both the years. In general, the grains yield was higher during 2013-14 and 2014-15.Tillage influenced the grain yield significantly during both the years of study. During 2013-14 T_1 (wheat sown on wide raised beds) recorded the maximum grains yield (48.96 q ha^{-1}) and T_2 (wheat sown on narrow raised beds) (47.01 q ha^{-1}) remained statistically at par with it. The reduction in grain yield due to more tillage i.e. traditional practices with was 3.06, 2.43 and 3.25 % compared to T_1 (wide raised beds), T_2 (narrow raised beds) and T_5 (zero tillage) practices, respectively. However, wheat sown on wide raised beds registered 11.79 and 11.32 % a significant yield improvement over conventional practices. There was yield improvement due to tillage in wide raised beds and narrow raised beds, respectively over conventional tillage. Similar trends were observed during 2014-15.

Grain yield was significantly influenced by irrigation water as well as application of IW/CPE 0.75. Significantly higher grain yield of (50.02 and 48.94 q ha^{-1}) was obtained in I_3 treatment which remained statistically at par with I_2 treatment. I_1 "conventional tillage" treatment recorded minimum grain yield (40.95 and 39.87 q ha^{-1}) during the years of study, respectively.

Straw yield (q ha^{-1})

Table 3 clearly showed that average straw yield was lower during the second year as compared to that in first year. It is evident from the data that the main effect of different modes of tillage and interaction effect of irrigation water was significant for straw.

During 2013-14, the significantly highest straw yield (62.78 q ha^{-1}) was recorded due to moisture retention along with wheat sown on wide raised beds (T_1) over remaining treatments except wheat sown on narrow raised beds (T_2) and zero tillage modes (T_5). The differences in the straw yield due to conservation tillage treatments proved significant. The straw yield increased significantly with the every successive increase in moisture supply by moisture retention and bed configuration. T_2 and T_5 were at par with each other, however, they recorded significantly higher straw yield over rest of the treatments. Treatment T_3 (conventional tillage) recorded minimum straw yield 51.47 and 50.57 q ha^{-1} which was at par with T_4 during 2013-14 and 2014-15, respectively.

Irrigation water differences with respect to the straw yield per hectare also proved significant in both the years. Irrigation water (I_3) produced significantly higher straw yield (62.54 and 61.26 q ha^{-1}) as compared to all other water regime. I_2 was significantly superior to the remaining Irrigation water which recorded minimum straw yield (51.19 and 49.84 q ha^{-1}) in both the years.

Biological yield (q ha^{-1})

Total dry matter accumulation (Grain + straw) by crop is an important index indicating the photosynthetic efficiency of crop and photosynthates left behind after respiration which ultimately influences the crop yield (Table 3). Wheat sown on wide raised beds (T_1) being at par with wheat sown on narrow raised beds (T_2) in biomass production during both the year. Whereas, wheat sown by zero tillage technique (T_5) and wheat sown by reduced tillage (T_4) in second year produced significant increase in biological yield over conventional tillage (T_3), respectively.

Table 3 clearly showed that the differences among the irrigation levels were obtained to be significant. The increased number of irrigation up to 3 make significant improvement in biological yield compared to lower levels in both the years. Water Highest biological yield of wheat was produced with 3 irrigations at 22, 65 and 105 DAS (I_3) (112.56 and 110.20 q ha^{-1}) which were 92.13, 89.71 and 103.08, 100.66 q ha^{-1} higher as compared to I_1 and I_2 during first and second year, respectively. [16-18].

Harvest index (%)

Harvest index is an important parameter indicating the efficiency in partitioning of dry matter to the economic part of crop. Higher harvest index, means higher is the economic return of the crop. The data regarding harvest index have been presented in (Table 3). In the treatments of water management, all the treatments proved higher than one irrigation practice (I_1) during the years of study but all treatments were at par with each other, respectively. No definite trend with respect to the planting techniques on harvest index was observed. However, the highest harvest index was obtained under T_5 and lowest under T_3 treatment during the years of study. The interaction effects were non-significant.

Interaction

The interaction, tillage × irrigation water was significant for the number of tillers, grain, straw and biological yield. The magnitude of increase in straw yield due to improvement in moisture supply by tillage modes with wheat sown on raised beds was higher in I_3 as compared to other irrigation water.

Conclusion

Among the five tillage practices namely wide raised beds, narrow raised beds, conventional tillage, reduced tillage and zero tillage. Wide raised beds performed best with highest yield attributes and yield of 48.58 q ha^{-1} followed by narrow raised beds and zero tillage. The increased irrigation water increased the growth and yield significantly and it was highest in I_3 where 3 irrigation were applied at 22, 65 and 105 DAS.

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