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RESEARCH ARTICLE

Effect of planting techniques and irrigation levels on growth and yield of wheat (*Triticum aestivum* L.)

■ Lord Litan Debbarma, Dipak Nath and Dipankar Dey

SUMMARY

The experiment was conducted at Rampur Research Farm Rampur, Dehradun, Uttarakhand, India during Nov., 2013 to April, 2014 to study the effect of planting techniques and irrigation levels on growth and yield of wheat (UP-2584). Irrigation was scheduled as per treatment based on IW (Irrigation Water): CPE (Cumulative Pan Evaporation) ratio and on critical growth stages (CGS). The treatments comprising three irrigation scheduling *i.e.* I_1 (irrigation at IW: CPE 0.90), I_2 (irrigation at IW: CPE1.20) and I_3 (irrigation at Critical Growth Stages) and five planting techniques *i.e.* Flat bed (Conventional). Raised bed, top 45 cm with two rows (RB 45/15). Broadcast seeding then making raised bed, top 45 cm (MRB 45/25). Broadcast seeding then making raised bed, top 60 cm (MRB 60/25). Broadcast seeding then making raised bed, top 80 cm (MRB 80/25). Data on agronomic traits like germination, numbers of tillers per m^2, numbers of active leaves, dry matter accumulation, plant height, grain weight, 1000-grain weight, grain number/ear, number of fertile and sterile spikelet's/spike, grain yield, straw yield, biological yield and harvest index was recorded. Result showed that irrigation schedule at IW: CPE 1.20 recorded significantly highest grain yield (48.3 quintal/ha), respectively compared to rest of treatment. Consumptive water use efficiency was recorded in IW: CPE 0.90 significantly highest (28.4 kg/ ha-cm), respectively as compared to IW: CPE 1.20 and CGS. Numbers of tillers/m^2, dry matter accumulation (g/m^2), root weight density, 1000-grain weight in CGS levels was significantly highest over rest of the treatments.

Key Words : Wheat, Planting techniques, Irrigation levels, Growth, Yield

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Wheat is the second most important cereal after rice in India and rank 3rd in the world's cereal crops production. It is a staple food for 1/3rd of the world's population, thus, primary food security concerns are focused on improving and sustaining its productivity. In India, wheat is grown in 29.8 m ha area with a total production of 94.0 mt, contributing 13.15 per cent to the total food grain production in the country, with a productivity level of 26.02 q/ha (Anonymous, 2011-12). As per an estimate, India would need 109 mt, wheat by 2020, which can be achieved by its assured annual growth rate of 4.1 per cent (Nagarajan, 2005). Food

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security dilemma is the major problem of the future for countries like India, where resources are getting stretched to the limits. There is no doubt that intensive agriculture in irrigated areas has brought out substantial enhancement in food grain production but has also threatened the environmental safety and accelerated the degradation and inefficient use of basic resources and production inputs. In the present situation, the only option left is to sift towards eco-friendly advance and efficient utilization of production resource especially soil, water and nutrients. Amongst the various agronomic practices, proper crop establishment method may considerably increase the efficiency of inputs/ productivity of wheat. It is also well known fact that water management is one of the major factors responsible for achieving better harvest in crop establishment method (Maurya and Singh, 2008). In many parts of the country, the availability of irrigation water is decreasing as both ground and surface water are being over exploited. Flat bed planting is the most common and popular wheat establishment practice all over the country but consumes unrealistically high amount of irrigation water resulting into low water use efficiency. Therefore, there is need to find out the alternative water efficient planting method. The efficiency of available irrigation water can be increased by resorting to raised bed planting as in this method the application of irrigation water is restricted to furrows only, made between two parallel beds. The moisture to crop root zone is made available through lateral movement of water. Apart from this, such configurations have also been found useful in trapping the rain water for soil moisture augmentation. The piling up of fertile top soil in the form of bed also helps in vigorous root system, enabling the plant to explore more soil volume and resist against lodging. The raised bed planting system with furrow irrigation has been found to give higher water use efficiency and also resulted 30 per cent saving in irrigation water over conventional flat planting with flood irrigation (Wang *et al.*, 2004). The added advantage observed with former has been the reduced crust problem on the soil surface and improved soil physical health. Asif *et al.* (2003) reported that bed furrow method consumed about 35.6 per cent less irrigation water as compared to flat border irrigation method. Also germination count and yield components were considerably improved under bed furrow irrigation technique leading to 13.4 per cent higher grain yield. In the recent years, the furrow irrigation raised bed system has proved to be one of the important components of low cost sustainable production system. This planning system facilitates mechanical weed control, increase water use efficiency, reduces crop lodging and has lower seed requirement (Sayre, 2000 and Yadav *et al.*, 2002). In bed planting, some area remains unsown in the form of furrows and crop is planted and the top of the beds only. The yield compensation or advantage is assumed due to border / edge effect, which may vary depending upon the soil type and actual area sown. In this respect, bed which may play significant role in determining the wheat as well as water productivity. Sayre *et al.* (1997) found a bed width of 75-80 cm as optimum for wheat in water scarce areas for achieving higher water use efficiency. Akbar *et al.* (2010) reported higher wheat (15%) and maize (26%) yields on wide (180 cm) beds that the flat bed system. Irrigation water is one of the most crucial inputs for wheat growth, development yield expression. Maintaining adequate soil moisture in the crop root zone is the prime aim of irrigation application. However, the time of irrigation application is governed by type of the soil (texture), stage of the crop as well as evaporative demand of the atmosphere. Improper scheduling of irrigation results not only in wastage of water, but also decreases crop yield. In flat bed planting, irrigation water is applied to the entire field, while in raised bed system; it is restricted to furrows only, resulting in reduced quantity of applied of irrigation water. Therefore, crop likely to respond differently to variable irrigation applications under different methods of establishment and bed sizes. Kakar (2003) reported notable variations in yield of wheat under raised beds and flat bed planting, when subjected to variable supply of irrigation water. For seeding wheat on raised bed, machines are available for large, uniform fields of plain areas. However, in resource poor areas (small plot size, terraced fields, high gravel content etc.), the availability and operation ability of such devices is still limited. Therefore, in the present study efforts were made to make raised bed using the local tool spade to offer an alternative for such areas. In view of above facts, the present investigation entitled Effect of planting techniques and irrigation levels on growth and yield of wheat (*Triticum aestivum* L.).

MATERIAL AND METHODS

A field experiment was carried out during the winter (*Rabi*) season (November - April) of 2013-2014 at Research Farm Rampur, Dehradun (30°21' North, latitude of 71°52' East longitude and at an altitude of 516.5 meters above the sea level), Uttarakhand. The soil was sandy loam having bulk density 1.48 g/cc, pH 7.3. The soil was high organic carbon (0.89%), medium available nitrogen (245.0 kg/ ha), low available phosphorus (32.8 kg/ha) and medium in potassium (178.3 kg/ ha). The experiment was laid out in Factorial Randomized Block Design with three replications. The treatments comprising three irrigation scheduling *i.e.* I_1 (irrigation at IW: CPE 0.90), I_2 (irrigation at IW: CPE 1.20) and I_3 (irrigation at Critical Growth Stages) CGS and five planting techniques *i.e.* Flat bed (Conventional). Raised bed, top 45 cm with two rows (RB 45/15). Broadcast seeding then making raised bed, top 45 cm (MRB 45/25). Broadcast seeding then making raised bed, top 60 cm (MRB 60/25). Broadcast seeding then making raised bed, top 80 cm (MRB 80/ 25). "UP 2584" was used as experimental material. Seeds were sown on 3rd November during 2013 and on harvesting at 15th April during 2014, respectively. Seeds were sown @100 kg/ ha at a distance of 20 cm in flat beds. In case of raised bed 45/15 with two rows, seeds were sown at a spacing of 22.5 cm whereas in raised bed (top 45, 60, 80 cm) seeds were broadcast in leveled plots and beds were made using a space as per treatment. Crop was raised with recommended package of practices of weed management, *viz.*, chlodinophop 15 per cent and metsulfuron methyl (MSM) 1% W.P. @ 60 g/ ha as post emergence at 32 days after sowing was sprayed to control the weeds. The experiment had a total of 45 plots (experimental units) of 4.2m x 4.0 meter were separated. All the plots were provided with 0.80 meter wide buffer space around it. The gross area of every plot was 16.8 m². Irrigation applied as per treatment on the basis of IW: CPE ratio approach using 6 cm depth of irrigation water. Irrigation applied on five irrigations in I_1 (irrigation at Critical Growth Stages), two irrigations in I_2 (irrigation at IW: CPE 0.90) and three irrigations in I_3 (irrigation at IW: CPE 1.20). The crop was fertilized at 120 kg N, 60 kg P_2O_5 and 40 K_2O per hectare. Nitrogen, phosphorus and potassium were applied through NPK mixture (12: 32: 16) and remaining nitrogen was applied through urea. Full quantity of phosphorus and potassium and one third of nitrogen was applied just before sowing and incorporated. Remaining two-third nitrogen was top dressed through urea in two equal splits, respectively. The farm yard manure (FYM) was applied two weeks before sowing and vermin-compost just before sowing as per treatment. The observation data recorded included germination, number of tillers per m², number of active leaves, dry matter accumulation, plant height, numbers of ears/m², grain weight, weight of 1000-grain, grain number/ear, number of fertile and sterile spikelet's/spike, grain yield, straw yield, biological yield and harvest index. Grain and straw yield was determined from the each plot and the yield quintal per hectare calculated. The crop was harvested manually when grain almost matured and spikes turned yellow. The biological yield was obtained by sun-dried bundled and labeled and expressed in quintal per hectare. The straw yield was obtained by subtracting the grain yield from the biological yield. Soil moisture content was determined for different depths taking samples from the respective depths with the help of screw augur. Then the samples were dried in oven at 105°C ± 2° C till they attain constant weight.

Moisture content was determined by:

$$P_w = \frac{W_1 - W_2}{W_2} \times 100$$

Consumptive use of water was determined by using the formula and then was calculating water use efficiency.

$$WUE = \frac{Y}{U}$$

Harvest index was calculated using the formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

The data were analyzed using the 'analysis of variance technique' for Factorial Randomized Block Design as per the procedure given by Rangaswamy (2006). Wherever, the effect exhibited significance at 5 per cent level of significance, the critical difference (CD) was calculated for comparison of treatment effect.

RESULTS AND DISCUSSION

The emergence count was affected significantly due to planting techniques only. The higher emergence count/ m² was found in flat bed sown (651/m²) as compared to all raised bed sown wheat plots and the lowest emergence (548/m²) was observed in treatment MRB 80/25. Irrigation applied at IW: CPE 1.20 was the highest emergence (592/m²) and the lowest of CGS (576/m²). The interaction effect between planting techniques and irrigation levels on emergence count was found to be non-significant. The data on number of tillers/m² of wheat showed major variation at different DAS due to different irrigation levels. At both 45 and 90 DAS, maximum number of tillers found flat bed sown (1201/m² and 791/

m^2) than all raised bed treatments. Application of irrigation at CGS was the highest tillers (1018/m^2 and 653/m^2) than IW: CPE 0.90 and IW: CPE 1.20. The interaction effect between planting techniques and irrigation levels on number of tillers/m^2 was found to be non-significant at 45 DAS and Significant at 90 DAS. The maximum and significantly higher number of active leaves was flat bed sown (4350/m^2 and 3078/m^2). The lowest number of active leaves RB 45/15 (3070/m^2) at 45 DAS and MRB 45/25 (2685/m^2). Irrigation treatments showed statistically significant highest number of active leaves/m^2 in IW: CPE 1.20 (3953/m^2) at 45 DAS and CGS (2892/m^2) at 90 DAS. The lowest number of active leaves/m^2 in IW: CPE 0.90 (3645/m^2) at 45 DAS and IW: CPE 1.20 (2771/m^2) at 90 DAS. The interaction effect between planting techniques and irrigation levels on number of active leaves/m^2 was found to be non-significant at 45 DAS and Significant at 90 DAS. The data pertaining to dry matter accumulation at both 45 and 90 DAS, the dry matter accumulation was affected significantly due to planting techniques. At both stages maximum and significantly dry matter content was found in flat bed (1286 g/m^2) wheat sown than all the raised bed treatments and the lowest and significantly dry matter content MRB 45/25 (956 g/m^2). At 45 DAS, irrigation level IW: CPE 1.20 (62 g/m^2) recorded the maximum and significantly higher dry matter and IW: CPE 0.90 (954 g/m^2) recorded the lowest. At 90 DAS, CGS recorded significantly higher (1175 g/m^2) and IW: CPE 1.20 (1079 g/m^2). The interaction effect between planting techniques and irrigation levels on dry matter accumulation was found to be non-significant. The data observed on plant height at 45 and 90 DAS. At 45 DAS, the plant height ranged from (25 cm) RB 45/15 to (28.1 cm) MRB 60/25. At the 90 DAS, MRB 60/25 (77.2 cm) recorded significantly taller and flat bed (71.2 cm) lower plant height. At 45 DAS, IW: CPE 0.90 recorded the highest (27.6 cm) and IW: CPE 1.20 recorded the lowest plant height. At 90 DAS, IW: CPE 1.20 recorded was highest (77.7 cm) plant height and the lowest plant height CGS (72.9 cm). The data on at harvest, among the planting techniques the plant height ranged from (78.0 cm) flat bed to (81.6 cm) MRB 60/25. Irrigation levels at IW: CPE 1.20 recorded the highest plant height (80.5 cm) and IW: CPE 0.90 was the lowest plant height. The interaction effect between planting techniques and irrigation levels on plant height was found to be non-significant The observed data on days taken to 50 per cent heading among the planting techniques ranged from 99 (MRB 60/25) to 103 (flat). Irrigation applied at CGS and IW: CPE 1.20 (102) than IW: CPE 0.90 (98) to attain the 50 per cent heading stages. Data on days taken to maturity among the planting techniques was the maximum (137 days) in flat bed sown, while RB 45/15 (134 days) took the minimum time to attain the maturity. Irrigation at CGS took significantly higher (137 days) than IW: CPE

Table 1: Grain yield, straw yield and biological yield and harvest index as influenced by planting techniques and irrigation levels

Treatment	Yield (q/ha)			Harvest index (%)
	Grain	Straw	Biological	
Planting techniques				
Flat	48.3	69.7	119.0	40.9
RB 45/15	47.6	67.8	115.4	41.3
MRB 45/25	47.5	70.9	118.4	40.1
MRB 60/25	47.5	65.5	113.0	42.0
MRB 80/25	46.0	67.4	113.4	40.6
S.E.±	1.1	2.1	3.5	1.0
C.D .(P=0.05)	NS	NS	NS	NS
Irrigation level				
IW: CPE 0.90	46.6	65.5	111.9	41.6
IW: CPE 1.20	48.2	67.0	115.2	41.8
CGS	47.4	72.3	119.7	39.6
S.E.±	0.8	1.6	2.7	0.7
C.D. (P=0.05)	NS	4.7	NS	2.2
Interaction	NS	NS	NS	NS

NS= Non-significant

0.90 (133 days). The interaction effect planting techniques and irrigation levels on days taken to maturity was found to be non-significant. Data on numbers of ears per m^2 in flat bed recorded the maximum and significantly higher (723/m^2) and treatment MRB 45/25 recorded the lowest number of ears (512/m^2). Irrigation applied at CGS, recorded significantly higher number of ears (632/m^2) than IW: CPE 0.90 (533/m^2). The interaction effect planting techniques and irrigation levels on ears/m^2 was found to be non-significant. The observed data on grain weight / ear ranged from 1.29g (flat) to 1.34g (MRB 60/25). Irrigation levels, the grain weight / ear did not differ much and ranged from 1.31g (CGS) to 1.32g (IW: CPE 1.20 and IW: CPE 0.90). The interaction effect planting techniques and irrigation levels on grain weight /ear was found to be non-significant. The statistically observed data on 1000-grain weight ranged from 40.3g (flat) to 41.4g (MRB 45/25). Irrigation applied at CGS recorded the highest 1000-grain weight (41.3 g) and at IW: CPE 0.90 was the lowest of 1000-grain weight. The interaction effect planting techniques and irrigation levels on 1000-grain weight was found to be non-significant. The data on grain number /ear among planting techniques MRB 80/25 (33) was recorded higher and the lower of flat (30). Irrigation at CGS and IW: CPE 1.20 recorded the same number of grains /ear which was higher than IW: CPE 0.90. The interaction effect planting techniques and irrigation levels on grain number /ear was found to be significant. Data on number of fertile spikelets per spike was not affected significantly both due to planting techniques and irrigation levels. Among the planting techniques, the number of fertile spikelet's per spike ranged from 14.4 (flat and RB 45/15) to 15.5 (MRB 60/25). Irrigation levels, at IW: CPE 1.20 and CGS recorded similar number of fertile spikelet's per spike (15.1), which decreased at IW: CPE 0.90 (14.8). The observed data on number of sterile spikelet's per spike among planting techniques MRB 60/25 (2.33) recorded significantly higher than the rest of planting techniques. Irrigation at IW: CPE 0.90 recorded significantly higher (1.80) and CGS (1.73) recorded the lower. The interaction effect planting techniques and irrigation levels on numbers of sterile spikelets was found to be significant. The data on grain among planting techniques, ranged from 46.0 q/ ha (MRB 80/25) to 48.3 q/ha (flat). Irrigation levels at IW: CPE 1.20 recorded the highest grain yield (48.2 q/ha) and the lowest at IW: CPE 0.90 (46.6 q/ha). The interaction effect planting techniques and irrigation levels on grain yield was found to be non-significant. The data on straw yield among planting techniques, ranged from 65.5 q/ha (MRB 60/25) to 70.9 q/ha (MRB 45/25). Irrigation applied at CGS recorded the maximum straw yield (72.3 q/ha) which was statically at par treatments. The interaction effect planting techniques and irrigation levels on straw yield was found to be non-significant. The data on biological yield among planting techniques, ranged from 113.0 q/ha (MRB 60/25 and RB 45/15) to 119.0 q/ha (flat). Irrigation levels, at CGS (119.7 q/ha) was the highest and IW: CPE 0.90 (111.9 q/ha) recorded the lowest biological yield. The observed data on harvest index (%) was the highest of 42.0 (MRB 60/25) and the lowest 40.6 (MRB 80/25). The irrigation levels at IW: CPE 1.20 (41.8) was the highest and the lowest of CGS (39.6). Consumptive water use efficiency was recorded in IW: CPE 0.90 significantly highest (28.4 kg/ ha -cm), respectively as compared to IW: CPE 1.20 and CGS.

Higher number of active leaves/m^2 and dry matter production/m^2 in flat bed may be ascribed to more plant population per unit area. Among raised beds plots, MRB 80/25 had higher value of these parameters, especially at later stage (90 DAS). Irrigation at IW: CPE 1.20 and CGS produced higher active leaves and dry matter over IW: CPE 0.90. Increase in dry matter production with increase in irrigation frequency has also been reported by Pal *et al.* (2000) and Shivani *et al.* (2003). Taller plants were observed in raised beds plots than the flat bed. The better soil environment in the form of raised bed might have caused the enhancement in plant height. Better soil conditions in turn plant growth conditions in raised bed techniques have also been reported by Kumar *et al.* (2008). The medium texture (sandy loam soil) of study area probably did not cause any impedance in the root development under flat sown condition, thus, resulting in non-significant variation in root growth between flat and raised bed plots. Irrigation levels at IW: CPE 1.20 and CGS (4 irrigations) improved the root growth over IW: CPE 0.90 (2 irrigations) at 90 DAS. This may be credited to regular supply of soil moisture. Better root growths under higher soil moisture regime are in accordance with Bandopadhay and Mallick (2003). Moisture stress under IW: CPE 0.90 (2 irrigations) as compared to IW: CPE 1.20 and CGS (4 irrigations), might have advanced the crop maturity in the former treatment. The yield attributes except ears per m^2, were favoured by raised bed planting techniques. Higher ears per m^2 in flat bed sown plots could be attributed to larger net sown area and more tiller per m^2. Improvement in the remaining yield attributes under raised beds plots may be due to better plant growth as evidenced from plant height under these treatments. Sterile spikelet's/ spike were higher in raised beds plots, which may be ascribed to more moisture loss, resulting in low moisture availability, leading to poor translocation of photosynthesis. The results corroborated with the findings of Kumar *et al.* (2007). More frequent irrigation at IW: CPE 1.20 and at critical growth stages resulted in higher values of yield attributes than IW: CPE 0.90. Variable availability of soil moisture under variable soil moisture regimes might have caused such variation. More number of sterile spikelet's/ spike in IW: CPE 0.90 indicates that under this treatments, wheat might have experienced some moisture stress. Lower values of yield attributes at less frequent irrigations are in line with Shivani *et al.* (2003). Among the planting techniques flat bed sown wheat crop recorded higher (48.3 q/ ha) grain yield but did not differ significantly with other planting techniques, comprising of varying sizes of raised beds. Buttar *et al.* (2006) also did not find significant variation in the wheat grain yield due to planting techniques. Several other workers have also reported non-significant variations in yields between raised bed and flat bed sown crop (Mishra *et al.*, 1994; Singh *et al.*, 2006; Kumar *et al.*, 2007; Singh *et al.*, 2009; Pal *et al.* 2000 and Kukal *et al.*, 2009). The grain yield did not increase significantly with increase in number of irrigation *i.e.* from (2 irrigations) in IW: CPE 0.90 and irrigation applied at critical stages. During the crop season, 74.4 mm rainfall was received, which was probably good enough to fulfill the water requirement of the wheat crop along with 2 irrigations applied at IW: CPE 0.90. Some enhancement was found in wheat yield with increase number of irrigation at IW: CPE 1.20 and CGS, but increase was not enough to become significant. Almost similar trend was observed in straw and biological yield. Almost similar trend was observed in straw and biological yield. Similar findings also have been reported by Pal *et al.* (2000).

Conclusion:

Planting technique and irrigation played a vital role for the growth and yield of wheat. Different planting techniques and irrigation levels showed significant difference on yield and yield contributing characters of wheat plant. The interaction effect of different planting techniques and irrigation levels also showed the significant variation on yield contributing characters. Wheat yield was found the maximum flat bed sown and three irrigation levels at different growth stages.

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