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Influence of moisture regimes on growth parameter, yield attributes, and yield with sowing methods of wheat (*Triticum aestivum* L.) cultivar

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Abstract
A field experiment was conduct at Agronomy Research farm, Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.) during Rabi season of two combined year of 2017-18 and 2018-19 with an objective of to find out the suitable wheat two varieties with moisture regime and different sowing method system. Eighteen treatment combination consisted of two wheat variety (PBW-343 and HUW-234) and three moisture regimes (irrigation at 0.8 IW/CPE, 1.0 IW/CPE ratio and irrigation at CRI late jointing and flowering stage allotted in main plots and three sowing methods system (Broad casting, seed drill and FRIB) in sub-plots. The experiment was conducted in split plot design (SPD) with 3 replication on silty loam soil having low organic carbon (0.33% and 0.32%) and available nitrogen (137.60 kg ha^{-1} and 136.82 kg ha^{-1}) medium in phosphorus (15.20 kg ha^{-1} and 14.70 kg ha^{-1}) and available potassium (249.30 kg ha^{-1} and 248.32 kg ha^{-1}) and soil pH is high (8.30 and 8.20). The crop was show on November 25 in the first and second both years, respectively using a seed rate of 125 kg ha^{-1} with row sowing of 22.5 (cm) apart. The crop was harvest on April 17 and April 19 during 2018 and 2019 respectively. The growth parameters character like plant height (cm), dry matter accumulation (gm^{-2}), LAI as well as attributing are spike length (cm), number of grain $Spike^{-1}$, test weight (g) were found significantly high with variety PBW-343along with moisture regime 1.0 IW/CPE and wheat sown by FIRB (Furrow irrigation raised bed) method over rest of the treatments during both year. The biological yield were also followed the same trend as of growth and yield attributes during both the year. The highest gross income (₹ 125203.80 and 134785.75 ha^{-1}), net return (₹ 91728.80 and 98485.75 ha^{-1}) and benefit: cost ratio (2.74 and 2.71 $₹^{-1}$ invested) was obtained with the PBW-343 and Irrigation at 1.0 IW/CPE ratio along with furrow irrigated raised bed method during 2017-18 and 2018-19, respectively.

Keywords: Moisture regimes, cultivar, growth parameters, yield attributes, sowing method, wheat

Introduction
Wheat (*Triticum aestivum* L.) belongs to family poaceae. It is the most important food crop of the world, which occupied the largest crop area and has greater production than any other crop. It provides food to 36% of the global population. It contains about 12% protein, 2% total fat, 55% carbohydrates (Kumar *et al.*, 2011) [13, 14-18, 23, 24, 26, 41]. About 80 to 85% of wheat grains are used for human food. Its straw is mainly used as fodder for livestock. Wheat is a winter season crop widely grown in between November-December& harvested between March & April. In India, current estimate indicates that wheat crop grown on around 13.5 m ha^{-1} in India is affected by heat stress (Sareen *et al.*, 2012) [30]. However, during the last few years, there is stagnation in wheat productivity and environmental issues are still posing challenge to the researchers and extension agencies. There is a need to diversify the area under different wheat varieties. The magnitude of environmental variance was relatively lower than the genotypic variation. It indicated that there was not considerable effect of environment on the genotypic coefficient of variability. Highest magnitude of genotypic and phenotypic coefficient of variation was observed for 1000 seed weight, day to maturity and plant height (Mehta *et al.*, 2013 and Kumar *et al.*, 2014) [13, 14-18, 20, 23, 24, 26, 41]. The large area occupied by PBW-343 is a major concern and other varieties need to be popularized for better production and profitability. The quality of grains put of timely sown varieties of wheat refers to the bold and plump kernels. While the shriveled and sunken seeds are highly recorded in late sown wheat

which is unfit for seed production due to low germination percentage is recorded (Tahir *et al.,* 2000). Number of tillers per plant is found to be associated with yield attributes of wheat. The highest number of a productive tillers ware reported in timely sown varieties (Alam *et al.,* 2018) [1]. The late sown wheat occupies now a sizeable area in Uttar Pradesh either due to late harvesting of preceding crop or due to excessive moisture in the field as a result of prolonged monsoon rains (Kaur 2017) [12, 37, 38]. Therefore, selection of proper variety and their fertility and irrigation management play important roles in maintaining the productivity. The reduction in the optimum growth period caused by a rise in temperature leads to leaf senescence resulting in a photosynthetic rate that is too low to meet plant (Sharma-Natu *et al.,* 2006) [29, 32-34, 41]. As per result, it affects two important yield parameters, *i.e*., the number of grains per spike and grain weight (Ugarte *et al.,* 2007) [40]. It is mostly due to shorter growth period available to late sown wheat coupled with high temperature and hot winds during reproductive growth period, which leads to forced maturity and ultimately poor grain yield. The huge reduction in yield due to delayed sowing prompted us to evaluate optimum time of sowing for different varieties for maximum production. Among the various agronomic factors, sowing of wheat is considered to be prime importance for proper distribution of plants over cultivated area, thereby better utilization of available soil and atmospheric resources. In FIRB planting system, generally, two to three rows of wheat are planted on the top of bed 70 cm wide and irrigation is done through furrows. It has been reported that wheat crop under FIRB system produced higher grain yield compared to conventional sowing. Besides yield advantage, no lodging was observed in any of the varieties. It also provides an opportunity of mechanical weeding in furrows and on the top of beds (Anonymous, 1996) [2, 3]. Water is a precious and scare input plays a vital role in assured crop production since it is essential for the maintenance to turgidity, absorption of nutrients and the metabolic process of the plants. Therefore, it becomes imperative to develop an optimum irrigation schedule to maintain the sufficient available soil moisture throughout the crop period for best exploitation of crop yield potential. Among the several recognized criteria of irrigation scheduling, climatologically approach is very scientific and widely accepted among the scientists and research workers throughout the world. It is well known that evapotranspiration by a full crop cover is closely associated with the evaporation from an open pan (Dastane, 1972) [6]. Parihar *et al.,* (1976) [27] suggested a relatively more practical meteorological approach of IW/CPE which is a ratio between fixed amount of irrigation water and cumulative pan evaporation minus rains. This IW/CPE approach merits on account of its simplicity of operation and high water use efficiency. Therefore, the climatologically approach of scheduling irrigation by evaluating different IW/CPE ratios in wheat crop has been proposed in this study. It is an established fact that in future, less and less of water will be available for agriculture on account of increasing water demand for domestic, industrial and other purposes. It is estimated that even after achieving the full irrigation potential, nearly 50% of the total cultivated area will remain rainfed (Anonymous, 2020) [2, 3]. Irrigation increases the availability of water and nutrients through the establishment of relatively favorable moisture conditions around root zone of the crop (Zhelev, 1975) [42]. However, the research work done on irrigation scheduling of wheat crop raised under different methods of sowing is very negligible, hence there is need to work out irrigation requirement of wheat crop. The importance of irrigation management has further increase with the introduction of the dwarf wheat cultivars throughout the country, for achieving the maximum yield of different wheat varieties. Efficient input management along with varietal improvement is the basic aspects that can help in achieving the sufficient production but also enhances the water productivity; it must achieve the water economy such that the demand of climate is balanced by the supply, available to it. Since water is very scare and costly input, so it must be used very judiciously by adopting an appropriate technique *i.e.* IW/CPE ratio or critical stages and plating system. It is highest water use efficiency (WUE) 11.3 kg/ha mm (Limon *et al.,* 2000) [19].

Materials and Methods

A field investigation was conducted during Rabi season of two consecutive 2017-18 and 2018-19 on the Agronomy Research Farm, Achariya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, (U.P.). Geographically, experimental site falls under the sub-tropical climate of Indo-Gangatic alluvial plains zone (IGP) having alluvial calcareous soil and located at 26°47' N latitude and 82°12’ E longitude with an altitude of 113 m above the mean sea level. The total average rainfall received during crop season was 1.0 mm and 71.5 mm during 2017-18 and 2018-19, respectively. The weekly mean maximum temperature ranged from 14.5^{0}C to 39.3^{0}C with an average of 26.8^{0}C during 2017-18 and from 20.6^{0}C to 40.5^{0}C with an average of 30.5^{0}C during 2018-19. A relative humidity average of 64.4 and 64.3 percent during 2017-18 and 2018-19. The soil of the field may be classified as silty loam in texture. The soil was slightly alkaline in reaction, low in organic carbon (0.33 and 0.32), available nitrogen (137.60 and 136.82 kg ha^{-1}), medium available phosphorus (15.20 and 14.70 kg ha^{-1}), available potassium (249.30 and 248.32 kg ha^{-1}) and medium in fertility during 2017-18 and 2018-19. The experiment was constituted with 18 treatment combinations involving two varieties (PBW-343 and HUW-234) and three moisture regimes (Irrigation at 0.8 IW/CPE ratio, 1.0 IW/CPE ratio and irrigation at CRI, late jointing & flowering stage) in main plots and three sowing methods (Broad casting, seed drill and furrow irrigated raised bed) in sub-plots was laid out in split plot design (SPD) with three replications. A plot size is 3.6 x 5 (m) and size of ridge 0.5 (m) were made between replication and individual plots to check the out flow of nutrient and reduce the border effect. Varieties PBW-343 and HUW-234 was sown at row spacing 22.5 (cm) with line sowing of seed. The techniques used for recording observations on growth parameters (plant height (cm), dry matter accumulation (gm^{-2}), and LAI), yield attributes (No. of spike (m^{-2}), No. of grain $spike^{-1}$, test weight (g) and yield.

Result and Discussion

Growth parameters

The growth in terms of plant height, dry matter accumulation and leaf area index at 60 DAS are given in Table-1 showed that maximum plant height was recorded with cultivar PBW-343 and minimum plant height was recorded in cultivar HUW-234 at all the crop growth stages. Variation in plant height among cultivars might also be probably due to their genetic makeup of plant reported by Nainwal and Singh (2000) [22], Jat and Singh (2004) [9-11], Singh (2005) [1, 9, 21, 23, 26, 30, 32, 33, 35, 38]. The maximum taller plants were recorded under irrigation at1.0 IW/CPE ratio. This might be due to increasing the irrigation levels, which maintained various metabolic processes. Significant reduction in plant height due to decrease in irrigation levels was also reported by Singh *et al.* (2003) [1, 9, 21, 23, 26, 30, 32, 33, 35, 38], Saren *et al.* (2004) [1, 9, 21, 23, 26, 30, 32, 33, 35, 38], Brahma *et al.* (2007) [5], Kumar *et al.* (2012) [13, 14-18, 23, 24, 26, 41] and Kumar *et al.* (2016) [13, 14-18, 23, 24, 26, 41]. The maximum plant height was recorded furrow irrigated raised bed (FIRB) method of sowing as compared to other sowing methods at all the stages of crop growth during both the year of experimentation. The similar result was reported by Jat (2002) [9-11], Singh and Kaur (2019) [12, 37, 38].

The maximum dry matter accumulation was recorded with the variety of PBW-343 followed by HUW-234. Similar findings were reported by Sardana *et al.* (1999) [29]. Dry matter accumulation increased with the advancement in age of the wheat crop reported by Sharma *et al.* (2015) [29, 32-34, 41], Bachhao *et al.* (2018) [4]. The highest dry matter accumulation was recorded under 1.0 IW/CPE ratio which was significantly superior over irrigation at 0.8 IW/CPE ratio and CRI, late jointing and flowering stage. This might be due to adequate supply of moisture regimes increase in plant height, size of leaves, number of leaves etc. All these factors contributed for full turgidity and opened leaves, which increased the photosynthetic activity of crops, resulting in higher dry matter accumulation was similar finding by Nand *et al.* (2014) [14, 23].

The maximum leaf area index was noted with the variety of PBW-343 followed by HUW-234. This might be probably due to genetic makeup of plant, moisture, nutrients availability of crop *etc*. These similar finding given by Sharma *et al.* (2000) [29, 32-34, 41], Bachhao *et al.* (2018) [4]. The maximum LAI was recorded with application of irrigation at 1.0 IW/CPE was significantly higher over rest of treatments. This might be due to fact that moisture and nutrient supply contributed to more number of green leaves, size of leaves *etc*., led to higher leaf area and leaf area index. The results were in close proximity to those of Ahmad and Kumar (2015) [13, 14-18, 23, 24, 26, 41], Kumar *et al.* (2016) [13, 14-18, 23, 24, 26, 41] and Singh *et al.* (2018) [1, 9, 21, 23, 26, 30, 32, 33, 35, 38]. Leaf area index was significantly influenced by sowing methods. The maximum leaf area index was noted under furrow irrigated raised bed method of sowing and minimum with broad casting method. Similar results have been reported by Jain (2012) [8], Singh and Kaur (2019) [12, 37, 38].

Yield attributes The variety PBW-343 gave higher number of spike m^{-2}, number of grain $spike^{-1}$ and 1000 grains weight than HUW-234. The results were in conformity with those of Mishra *et al.* (2003) [21], Haider (2004) [7]. Number of spikes m^{-2}, number of grains $spike^{-1}$and test weight (g) were obtained highest with Irrigation at1.0 IW/CPE ratio, which was followed by 0.8 IW/CPE ratio and CRI, late jointing and flowering milking stage. However, the test weight was not significantly affected by moisture regimes. Thus, under maximum moisture level was obtained with 1.0 IW/CPE ratio, which was favourable for vegetative growth and development resulted into higher number of yield attributes. This result is in close proximity to those obtained Nayak *et al.* (2015) [24] and Verma *et al.* (2017) [17, 21, 41]. Among the sowing methods was observed that greater number of spikes m^{-2}, number of grains $spike^{-1}$ and 1000 grains weight were recorded in furrow irrigated raised bed than other method of sowing. Similar result were obtained by Jat *et al.* (2003) [9-11], Suthar (2006) [39], Pandey and Dwivedi (2007) [26, 26].

Yield

Grain and straw yield was significantly influenced by different varieties. The highest Grain and straw yield was obtained in cultivar of PBW-343 followed by HUW-234 (Table-3). Minimum Grain and straw yield were recorded with cultivar of HUW-234. This might be due to less number of spike bearing tillers, small length of spike and less number of grains $spike^{-1}$ and poor grain development. Similar findings were obtained by Pandey *et al.* (2017) [25, 26] and Bachhao *et al.* (2018) [4], Patel *et al.* (2018) [24, 28]. Grain and straw yield was influenced significantly by different moisture regimes. Highest grain yield was recorded under 1.0 IW/CPE ratio. Similar finding were reported by Kumar *et al.* (2017) [13, 14-18, 23, 24, 26, 41], Sharma *et al.* (2018) [29, 32-34, 41]. The maximum yield was recorded under furrow irrigated raised bed method than broad casting. Therefore was more suited for furrow irrigated raised bed planting system than broad casting. Similar findings were reported by Singh and Kaur (2019) [12, 37, 38]. Harvest index speaks the conversion efficiency of dry matter to grain portion. All the moisture regimes and sowing methods on late and timely sown varieties of wheat did not differ significantly on harvest index. Highest harvest index were noticed under PBW-343 and lowest in HUW-234 (Table-3). Similar finding were reported by Mohan *et al.* (2018).

Table 1: Growth parameters on influenced by moisture regimes, sowing methods and cultivar of wheat

Treatments	Growth parameters at 60 DAS					
	Plant height		Dry matter accumulation		LAI	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
(A) Varieties						
(i) PBW-343	65.30	66.61	495.11	502.28	4.90	5.00
(ii) HUW-234	58.10	59.26	445.39	446.40	4.50	4.59
S.Em +	0.94	0.95	5.96	7.19	0.07	0.07
CD at 5%	2.81	2.86	17.86	21.57	0.21	0.22
(B) Moisture regimes						
(i) Irrigation at 0.8 IW/CPE ratio	60.00	61.20	467.24	474.90	4.75	4.85
(ii) Irrigation at 1.0 IW/CPE ratio	68.50	69.87	502.94	508.45	4.95	5.05
(iii) Irrigation at CRI, late jointing & flowering stage	56.60	57.73	440.57	439.66	4.40	4.49
S.Em +	0.94	0.95	5.96	7.19	0.07	0.07
CD at 5%	2.81	2.86	17.86	21.57	0.21	0.22
(C) Sowing methods						
(i) Broad casting	55.00	56.10	446.82	452.32	4.44	4.53
(ii) Seed drill	63.00	64.26	468.09	470.32	4.76	4.86
(iii) FIRB	67.10	68.44	495.84	500.37	4.90	5.00
S.Em +	0.71	0.73	5.13	5.54	0.05	0.05
CD at 5%	2.05	2.09	14.73	15.89	0.16	0.16

Table 2: Yield attributes on influenced by moisture regimes, sowing methods and cultivar of wheat

Treatments	No. of spike m^{-2}		No. of grain $spike^{-1}$		Test weight	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
(A) Varieties						
(i) PBW-343	245.00	249.90	47.20	48.14	38.41	38.80
(ii) HUW-234	231.00	235.62	45.32	46.23	37.25	37.62
S.Em +	3.571	3.642	0.882	0.702	0.560	0.565
CD at 5%	10.706	10.920	NS	NS	NS	NS
(B) Moisture regimes						
(i) Irrigation at 0.8 IW/CPE ratio	240.00	244.80	46.65	47.58	37.87	38.24
(ii) Irrigation at 1.0 IW/CPE ratio	246.00	250.92	49.02	50.00	37.94	38.31
(iii) Irrigation at CRI, late jointing & flowering stage	228.00	232.56	43.12	43.98	37.69	38.07
S.Em +	3.571	3.642	0.882	0.702	0.560	0.565
CD at 5%	10.706	10.920	2.645	2.106	NS	NS
(C) Sowing methods						
(i) Broad casting	229.00	233.58	44.43	45.32	37.79	38.16
(ii) Seed drill	239.00	243.78	46.38	47.31	37.82	38.20
(iii) FIRB	246.00	250.92	47.97	48.93	37.89	38.27
S.Em +	2.889	2.947	0.456	0.568	0.475	0.480
CD at 5%	8.285	8.451	1.308	1.630	NS	NS

Table 3: Yield on influenced by moisture regimes, sowing methods and cultivar of wheat

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Harvest index (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
(A) Varieties						
(i) PBW-343	43.32	44.18	59.26	59.41	42.23	42.64
(ii) HUW-234	37.91	38.67	52.77	52.91	41.80	42.22
S.Em +	0.76	0.64	0.86	0.86	0.618	0.624
CD at 5%	2.28	1.91	2.58	2.58	NS	NS
(B) Moisture regimes						
(i) Irrigation at 0.8 IW/CPE ratio	40.71	41.53	56.03	56.18	42.07	42.50
(ii) Irrigation at 1.0 IW/CPE ratio	43.92	44.80	59.98	60.13	42.27	42.69
(iii) Irrigation at CRI, late jointing & flowering stage	37.22	37.96	52.03	52.17	41.70	42.11
S.Em +	0.93	0.78	0.86	1.05	0.618	0.536
CD at 5%	2.80	2.34	2.58	3.16	NS	NS
(C) Sowing methods						
(i) Broad casting	36.60	37.11	51.00	51.14	41.78	41.94
(ii) Seed drill	42.00	42.84	57.80	57.95	42.07	42.50
(iii) FIRB	43.24	44.10	59.24	59.39	42.19	42.60
S.Em +	0.49	0.78	0.80	0.81	0.531	0.536
CD at 5%	1.41	2.34	2.30	2.31	NS	NS

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