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Effect of sowing windows and irrigations on growth and yield of wheat

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Abstract
A field experiment conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2020-21 to evaluate the effect of sowing windows and irrigations on growth and yield of wheat. The experiment was laid out in Split Plot Design with 12 treatment combinations replicated thrice. The treatments consisted of four sowing dates i.e., 48 MW – 26 Nov. to 2 Dec. (S_1), 49 MW – 3 Dec. to 9 Dec. (S_2), 50 MW – 10 Dec to 16 Dec (S_3) and 51 MW – 17 Dec. to 23 Dec. (S_4) combined with three irrigation levels at different growth stages *viz*., four irrigation (CRI, late tillering, late jointing, and flowering) (I_1), five irrigation (CRI, late tillering, late jointing, flowering and milking stage) (I_2) and six irrigation (CRI, late tillering, late jointing, flowering, milking and dough stage) (I_3). Results revealed that, sowing of wheat in 48 MW (S_1) recorded significantly higher growth *viz*. length of spike (7.18 cm), number of grains spike^{-1} (36.19), grain weight plant^{-1} (6.49 g) and test weight (38.87 g) along with grain, straw yield (3154 and 3973 kg ha^{-1}) of wheat. Growth characters *viz*. length of spike (7.29 cm), number of grains spike^{-1} (34.60), grain weight plant^{-1} (6.59 g) and test weight (38.93) along with grain, straw yield (2966 and 3905 kg ha^{-1}) of wheat were also significantly higher with application of six irrigations (I_3) at harvest compared to rest of the number of irrigations. Combination of sowing 48 MW (S_1) with six irrigations (I_3) recorded significantly highest grain yield of wheat.

Keywords: wheat, irrigations, sowing, windows, growth, yield

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world. India stands second in wheat production next to China. It contributes about 25% of the total food grain production of the country. Nearly 55 percent of the world population depends on wheat for intake of about 20 percent of food calories. It is preferable than rice for its higher seed protein content. It ranks 1st both in acreage and production among the grain crops of the world (FAO, 2008) [4]. Wheat grain is rich in food value containing 12 percent protein, 1.72 percent fat, 69.60 percent carbohydrates and 27.20 percent minerals BARI (2006) [2]. Wheat occupies an area of 309.60 lakh ha. with total production of 98.38 lakh tons and productivity 31.72 qt ha-1. In Maharashtra state, it occupies 12.72 lakh ha. area with 22.14 lakh tons production and productivity 17.40 qt ha^{-1}. In Vidarbha, area under wheat production is 4.72 lakh ha. with production 7.31 lakh tons and productivity 15.59 qt-1. (Anonymous). Maharashtra contributes about 1.51 percent of the total wheat production of the country. Wheat is a *rabi* season crop. In Maharashtra (Vidarbha) sowing of wheat is generally done after harvesting of *kharif* crop i.e., soybean. Due to climate change harvesting of *kharif* is late which cause the delay in wheat sowing. Among various agronomic practices, wheat is highly reactive to sowing time and irrigation levels. Time of sowing affect the wheat yield most. It's germinative, vegetative and reproductive stage required the optimum temperature range and proper moisture availability too. The reason of low productivity of wheat in Maharashtra is late sowing, short duration, lack of resources, low fertility status, inadequate irrigation, improper selection of varieties, sub- optimal seed rate, poor plant protection measures etc. Wheat crop is very much responsive to irrigation. According to food and Agriculture Organization (FAO) of united Nation, in addition to pre- irrigation, one irrigation during early vegetative period, two irrigations – one during early vegetative period and one just prior to head emergence through flowering period; three irrigations- during early vegetative period, just prior to head development through flowering period and early grain formation period; four irrigations- during early vegetative, late vegetative, flowering and grain formation periods are required by spring wheat in India.

Due to adverse effect of climate change, sowing of wheat is delay and there will be reduction in potential yield of wheat, if use to sown early sown wheat variety during late sown condition. May be there will be increase in yield of wheat by using late sown wheat variety. Also, the wheat requires the almost six to seven irrigations during its growth and development period. But in some areas, there is limited irrigation water source. However, it is possible to obtained the maximum yield from wheat under limited irrigation water by applying irrigation at most water sensitive growth stages in wheat. Both the problems i.e., climate change and deficit irrigation water can be mitigated by using the practice of shifting of date of wheat sowing and follow the proper irrigation schedule.

Materials and Methods

The investigation entitled "Effect of sowing windows and irrigations on growth and yield of wheat" was conducted during *rabi* season of 2020-21 at Agronomy Farm, College of Agriculture, Nagpur. The experiment was laid out in SPD with combination of sowing dates and number of irrigations. Treatment comprised sowing dates in main plot *viz.* 1st sowing in 48 MW (S_1), 2nd sowing in 49 MW (S_2), 3rd sowing in 50 MW (S_3) and 4th sowing in 51 MW (S_4) and three irrigation level in sub plot *viz.* four irrigations (I_1) at (CRI, late tillering, late jointing, and flowering), five irrigations (I_2) at (CRI, late tillering, late jointing, flowering and milking stage) and six irrigations (I_3) at (CRI, late tillering, late jointing, flowering, milking and dough stage). Thus, there were twelve treatment combinations, replicated thrice. The soil of the experimental field was vertisol, clayey in texture. It was low in available nitrogen, very low in available phosphorus and medium in organic carbon, very high in available potassium and slightly alkaline in reaction. Nagpur is located in Central Vidarbha zone of Maharashtra. The land was prepared by two cross wise harrowing followed by stubble picking and levelling. A light pre-sowing irrigation was applied a week before sowing and when it attended field capacity. Wheat variety AKAW-4627 was used in present investigation. Seed rate used for sowing was 150 kg ha-1. The seed was drilled with a spacing of 22.5 cm between rows. The nutrients (100:50:50 kg N:P: K ha^{-1}) were applied through urea, single super phosphate and muriate of potash. Half of the nitrogen and full dose of phosphorus and potash was applied at the time of sowing as basal dose to all the treatments. Remaining half of the nitrogen was applied as top dressing at 30 days after sowing. Total crop was harvested for 4 consecutive dates. Crop was harvested in different days as they attain mature stage which also varied as per sowing time of this study. The observations were recorded on growth, yield attributes and yields of crop and the data was analyzed statistically.

Results and Discussion

Effect of sowing windows and irrigations on growth and yield characters of wheat

Effect of sowing windows

The yield attributes of wheat was significantly influenced due to various sowing dates. At harvest sowing on 48 MW (S_1) recorded significantly highest length of spike (6.68 cm) as compared to sowing on 50 MW (S_3) and 51 MW (S_4) i.e., 6.19 and 5.98 cm respectively but it was at par with sowing on 49 MW (S_2) i.e., 6.43 cm. Highest spike length at early sowing might be due to longer and favorable period of ear formation resulting more spikelet's development and greater chances of producing long ears containing a large number of grains as confirmed by Jat *et al.* (2013) [5]. At harvest sowing on 48 MW (S_1) recorded significantly highest number of grains $spike^{-1}$ (36.19) as compared to sowing on 50 MW (S_3) and 51 MW (S_4) i.e., 33.51 and 29.98 respectively but it was at par with sowing on 49 MW (S_2) i.e., 35.06. The reduction in number of grains $spike^{-1}$ might be due to very low temperature in late- sown conditions during vegetative growth stages which slow the cell- division and cell expansion as reported by Raju *et al.* (2016) [10]. At harvest sowing in 48 MW (S_1) recorded significantly highest grain weight $plant^{-1}$ (6.49 g) as compared to sowing in 50 MW (S_3) and 51 MW (S_4) i.e., 5.56 and 5.08 g, respectively but it was at par with sowing in 49 MW (S_2) i.e., 5.82 g. Effect of late sowing on yield attributes characters like grains $spike^{-1}$, spike weight can be attributed to sharp rise in temperature accompanied by hot winds adversely affecting the grain development and resulted in immature and shriveled grains in the late sown crop, which was in the milk stage during that period similar findings were reported by Dar *et al.* (2018) [3]. At harvest sowing in 48 MW (S_1) recorded significantly highest test weight (38.87 g) as compared to sowing in 50 MW (S_3) and 51 MW (S_4) i.e., 37.35 and 37.19 g respectively, but it was at par with sowing in 49 MW (S_2) i.e., 38.15 g. Higher 1000 grain weight with full irrigations might be due to the more translocation of photosynthates towards grain due to the sufficient amount of water in root zone. In another hand plants having limited supply of water had produced lighter grain which might be due to the less availability of nutrients from soil solution as recorded by Sarwar *et al.* (2010) [11].

Effect of irrigations

Yield attributes was significantly influenced due to number of irrigations at all growth stages. At harvest six irrigation to wheat (I_3) recorded significantly highest length of spike (6.79 cm) as compared to length of spike (5.96 cm) obtained with four irrigations (I_1). However, length of spike of wheat with five irrigations (6.48 cm) and six irrigations (6.79 cm) was significantly at par with each other. This may be due to cause that sufficient moisture in the soil profile under six scheduling of irrigation levels, plant nutrients particularly nitrogen, phosphorus and potassium were also more available and might have translocated to produce more dry matter. Secondly, higher levels of irrigation might play key role in root development by dropping mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant as reported by Singh *et al.* (2020) [13]. At harvest six irrigation to wheat (I_3) recorded significantly highest number of grains spike-1 (34.60) as compared to number of grains $spike^{-1}$ (32.74) obtained with four irrigations (I_1). However, number of grains spike-1 of wheat with five irrigations (33.81) and six irrigations (34.60) was significantly at par with each other. The lesser competition and greater availability of water and nutrients resulted in more number of spike bearing tillers as well as number of grains spike-1 in wheat as reported by Mitra and Das (2015) [8]. At harvest six irrigation to wheat (I_3) recorded significantly highest grain weight plant-1 (6.59 g) as compared to grain weight plant-1 (4.93 g) obtained with four irrigations (I_1). However, Grain weight $plant^{-1}$ of wheat with five irrigations (5.98 g) and six irrigations (6.59 g) was at par with each other. The reduction in grain weight $plant^{-1}$ might

be due to the moisture stress at grain filling stage hinders the translocation of photosynthates from leaves to ear and thus affecting the seed size as confirmed by Ahmad and Kumar (2015) [1]. At harvest six irrigation to wheat (I_3) recorded significantly highest test weight (38.93 g) as compared to test weight (37.00 g) obtained with four irrigations (I_1). However, test weight of wheat with five irrigations (38.03 g) and six irrigations (38.93) was significantly at par with each other. Singh *et al.* (2020) [13] reported that, higher 1000 grain weight may be due to cause that sufficient moisture in the soil profile under three scheduling of irrigation levels, plant nutrients particularly nitrogen, phosphorus and potassium were more available and might have translocated to produce more dry matter. Secondly, higher levels of irrigation might be due to its key role in root development by dropping mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant.

Effect of sowing windows and irrigations on yield of wheat

Effect of sowing windows

The grain and straw yield (kg ha-^{1}) of wheat was significantly influenced due to various sowing dates. Sowing in 48 MW (S_1) recorded significantly highest grain yield (3154 kg ha-^{1}) as compared to sowing in 50 MW (2888 kg ha-1) and 51 MW (S_4) (2738 kg ha^{-1}). However, it was at par with sowing in 49 MW (S_2) i.e., 2937 kg ha^{-1}. Lower grain yield in late - sown wheat could be due to less favorable period for maturity. High temperature and hot winds forced maturity of the crop and maturation period is shortened as recorded by Jat *et al.* (2013) [5]. Sowing in 48 MW (S_1) recorded significantly highest straw yield (3973 kg ha^{-1}) as compared to sowing in 50 MW (S_3) (3745 kg ha^{-1}) and 51 MW (S_4) (3736 kg ha^{-1}) but it was at par with sowing in 49 MW (S_2) and i.e., 3872 kg ha^{-1}. The higher grain and straw yield were observed on date of sowing 15th November (Timely), which might be due to the fact that timely (15th November) sowing of wheat mitigated the heat stress and simultaneously, the wheat crop had enjoyed better and congenial weather parameters with, better development of growth and yield attributes which in turn resulted in higher yield as reported by Patel *et al.* (2018) [9].

Effect of irrigations

Grain and straw yield (kg ha-1) was significantly influenced due to number of irrigations. Six irrigations to wheat (I_3) recorded significantly highest grain yield (2966 kg ha-1) as compared to grain yield (2851 kg ha-1) obtained with four irrigations (I_1). However, grain yield of wheat with five irrigations (2911 kg ha-1) and six irrigations (2966 kg ha-1) was significantly at par with each other. Singh *et al.* (2018) [12] reported that, this might be due to adequate moisture availability, which contributed to better growth parameters and yield attributes. Productivity of crop collectively determined by vigour of the vegetative growth and yield attributes. Better vegetative growth coupled with higher yield attributes resulted in higher grain and straw yield. Six irrigations to wheat (I_3) recorded significantly highest straw yield (3905 kg ha-1) as compared to straw yield (3794 kg ha-1) obtained with four irrigations (I_1). However, straw yield of wheat with five irrigations (3843 kg ha-1) and six irrigations (3905 kg ha-1) was at par with each other. The increase in straw yield may be due to cause that sufficient moisture in the soil profile under six scheduling of irrigation levels, plant nutrients particularly nitrogen, phosphorus and potassium were more available and might have translocated to produce more dry matter. Secondly, higher levels of irrigation might be due to its key role in root development by dropping mechanical resistance of soil, higher transpiration, greater nutrient uptake and more photosynthesis due to metabolic activities in plant as reported by Singh *et al.* (2020) [13].

Interaction effects of sowing windows and irrigations on yield of wheat

The interaction effect of sowing dates and number of irrigations in number of grains spike^{-1} and yield of wheat was found to be significant. Significantly highest number of grains spike-1 was obtained from sowing in 48 MW and six irrigations (S_1I_3) i.e., 37.03 and it was at par with S_1I_2, S_2I_2 and S_2I_3. Number of grains spike-1 were less due to less production of photosynthates due to shorter growing period. The optimum sowing resulted in better development of the grain due to good growing period as reported by Kumar *et al.* (2017) [7]. Significantly highest grain yield was obtained from sowing in 48 MW (S_1) with six irrigations (S_1I_3) i.e., 3137 kg ha^{-1} and it was at par with five irrigations in 48 MW and 49 MW i.e. S_1I_2, S_2I_2 and S_2I_3. Kumar *et al.* (2017) [7] found that, the interaction effect of date of sowing, varieties and irrigation schedule on grain yield was also found significant. Lower grain yield in late sowing was mainly due to lower germination count, less number of tillers, less number of grains per spike and lower 1000-grain weight. Late sowing resulted in less grain yield per hectare. Higher grain yield was mainly due to higher number of tillers and higher 1000-grain weight. Grain yield of wheat crop is the result of combined effect of various yield contributing components. Significantly highest straw yield was obtained from sowing in 48 MW (S_1) with six irrigations (I_3) i.e., 4078 kg ha^{-1} and it was at par with S_1I_2, S_2I_2, S_2I_3. The highest straw yield was observed with six irrigations. Increased straw yield with increase in irrigation was attributed mainly due to increase in plant height and tillers plant-1 (Kabir *et al.*, 2009) [6].

Table 1: Growth, yield attributes and yield of wheat as influenced by various treatments

Treatments	Length of spike (cm)	Number of grains spikes^{-1}	Grain weight plant^{-1} (g)	Test weight (g)	Grain Yield (kg ha-1)	Straw yield (kg ha-1)	Harvest index (%)
Main plot treatments- Sowing windows							
S_1 – 48 MW	7.18	36.19	6.49	38.87	3154	3973	43.45
S_2 – 49 MW	6.93	35.06	5.82	38.15	2937	3872	43.13
S_3 – 50 MW	6.69	33.51	5.56	37.35	2888	3745	43.09
S_4 – 51 MW	6.48	29.98	5.08	37.19	2738	3736	42.55
SE (m) ±	0.08	0.34	0.20	0.40	68	61	-
CD at 5%	0.27	1.17	0.69	1.38	234	210	-
Sub-plot treatments - Irrigations							
I_1 - Four irrigations	6.46	32.74	4.93	37.00	2851	3794	42.89
I_2 - Five irrigations	6.98	33.81	5.98	38.03	2911	3843	43.09
I_3 - Six irrigations	7.29	34.60	6.59	38.93	2966	3905	43.18
SE (m) ±	0.13	0.29	0.21	0.56	30	32	-
CD at 5%	0.39	0.89	0.64	1.73	91	96	-
Interaction Effect of sowing windows and irrigations							
SE (m) ±	0.14	0.32	0.45	1.74	37	50	-
CD at 5%	NS	0.97	NS	NS	113	150	-
GM	6.43	33.68	5.89	38.35	2910	3847	43.06

Table 2: Number of grains spike-1 as influenced by S × I interaction effect

S × I	Number of grains spike^{-1}		
	I_1	I_2	I_3
S_1	35.30	36.23	37.03
S_2	34.30	36.19	36.30
S_3	31.70	33.53	35.30
S_4	29.60	30.03	30.26
SE(m) ±	0.32		
CD at 5%	0.97		

Table 3: Grain yield (kg ha-1) as influenced by S × I interaction effect

S × I	Grain yield (kg ha^{-1})		
	I_1	I_2	I_3
S_1	2934	3087	3137
S_2	2858	3025	3071
S_3	2776	2905	2961
S_4	2669	2745	2886
SE(m) ±	37		
CD at 5%	113		

Table 4: Straw yield (kg ha-1) as influenced by S × I interaction effect

S × I	Straw yield (kg ha^{-1})		
	I_1	I_2	I_3
S_1	3998	4012	4078
S_2	3844	3852	3891
S_3	3692	3761	3877
S_4	3629	3701	3843
SE(m) ±	50		
CD at 5%	150		

Conclusions

Sowing in 48 MW (S_1) and application of six irrigations (I_3) improved the yield attributes *viz.* length of spike, number of grains spike-1, grain weight plant-1 and test weight along with grain and straw yield of wheat, significantly over S_3 and S_4 respectively and it was at par with S_2. Sowing in 48 MW (S_1) combined with six irrigations (I_3) recorded highest grain yield of wheat.

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