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# Effect of sowing windows and irrigations on yield and economics of wheat

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**Abstract**
A field experiment entitled "Effect of sowing windows and irrigations on yield and economics of wheat" was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2020-21. The experiment was laid out in Split Plot Design with 12 treatment combinations and replicated thrice. The treatments consisted of four sowing dates *viz*., 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 i.e., 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 grain and straw yield (3154 and 3973 kg $ha^{-1}$) of wheat. Grain and 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 ($I_3$) gave significantly highest grain yield of wheat. Gross monetary returns and net monetary returns were significantly higher with sowing in 48 MW ($S_1$) with six irrigations ($I_3$) after harvest over rest of the respective treatments.

**Keywords:** wheat, sowing windows, irrigations, yield, economics

## 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) [3]. In India, 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. 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 yield and economics 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. The land was prepared by two cross wise harrowing. It was 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. The crop was harvested manually depending upon the maturity of plant from each plot and the 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 yields of crop. Economics of treatments was worked out on the basis of market process of different inputs and crop produce and the data was analyzed statistically.

## Result and Discussion

### 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. 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) [10].

### 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. 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 translocate 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) [12].

### 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 photosynthetic 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) [6]. 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.* (2015) [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) [5].

**Effect of sowing windows and irrigations on economics of wheat**

**Effect of sowing windows**

Economics of wheat were significantly influenced due to various sowing dates. Sowing in 48 MW ($S_1$) recorded significantly highest gross monetary returns (80760 Rs. ha$^{-1}$) as compared to sowing in 50 MW ($S_3$) and 51 MW ($S_4$) i.e., 76297 and 73403 Rs. ha$^{-1}$ respectively but it was at par with sowing in 49 MW ($S_2$) i.e., 77802 Rs. ha$^{-1}$. Gross returns were higher in timely sown crop than early, moderately late, late and very late sowing due to higher grain yield and straw yield with the same input cost in timely sown condition which decreased with delay in sowing as concluded by Shabnam *et al.* (2018) [11]. Sowing in 48 MW ($S_1$) recorded significantly highest net monetary returns (48495 Rs. ha$^{-1}$) as compared to sowing in 50 MW ($S_3$) and 51 MW ($S_4$) i.e., 44032 and 41138 Rs. ha$^{-1}$, respectively but it was at par with sowing in 49 MW ($S_2$) i.e., 45537 Rs. ha$^{-1}$. This confirmed the findings of Alam *et al.* (2013) [1], Bachhao *et al.* (2018) [2], Patel *et al.* (2018) [10], Shabnam *et al.* (2018) [11] and Yusuf *et al.* (2019) [13]. The B:C ratio of wheat was influenced due to various sowing dates. Sowing in 48 MW ($S_1$) recorded highest B:C ratio (2.7) as compared to sowing in 49 MW ($S_2$), 50 MW ($S_3$) and 51 MW ($S_4$) i.e., 2.6, 2.5 and 2.4 respectively. Similar results were also reported by Alam *et al.* (2013) [1], Bachhao *et al.* (2018) [2], Patel *et al.* (2018) [10], Shabnam *et al.* (2018) [11] and Yusuf *et al.* (2019) [13].

**Effect of irrigations**

Economics was significantly influenced due to number of irrigations at all growth stages.Six irrigations to wheat ($I_3$) recorded significantly highest gross monetary returns (78543 Rs. ha$^{-1}$) as compared to gross monetary returns (75552 Rs. ha$^{-1}$) obtained with four irrigations ($I_1$). However gross monetary returns of wheat with five irrigations (77102 Rs. ha$^{-1}$) and six irrigations (78543 Rs. ha$^{-1}$) was significantly at par with each other. These results are in agreement with Kumar *et al.* (2015) [7] and Mitra and Das (2015) [9]. Six irrigations to wheat ($I_3$) recorded significantly highest net monetary returns (45778 Rs. ha$^{-1}$) as compared to net monetary returns (43787 Rs. ha$^{-1}$) obtained with four irrigations ($I_1$). However, net monetary returns of wheat with five irrigations (44837 Rs. ha$^{-1}$) and six irrigations (45778 Rs. ha$^{-1}$) was significantly at par with each other. Similar results were also reported by Kumar *et al.* (2015) [7] and Mitra and Das (2015) [9]. Six irrigations to wheat ($I_3$) recorded highest B:C ratio (2.6) as compared to B:C ratio (2.5) obtained with five irrigations ($I_2$) and four irrigations ($I_1$). Results are in accordance with the result recorded earlier by Kumar *et al.* (2015) [7] and Mitra and Das (2015) [9].

**Interaction effect of sowing windows and irrigations on economics of wheat:** Interaction effect between sowing dates and number of irrigations (S×I) was found to influence the gross monetary returns (Rs. ha$^{-1}$) of wheat. Significantly higher gross monetary returns were obtained from sowing in 48 MW with six irrigations ($S_1$I3) i.e., 82989 Rs. ha$^{-1}$ over all other treatment combination and it was at par with $S_1I_2$, $S_2I_2$ and $S_2I_3$. Significantly higher net monetary returns were obtained from sowing in 48 MW with six irrigations ($S_1I_3$) i.e., 50724 Rs. ha$^{-1}$ than all other treatment combination and it was at par with $S_1I_2$, $S_2I_2$ and $S_2I_3$. The results are in close agreement with the findings of Meena *et al.* (2015) [8].

**Table 1:** Yield and economics of wheat as influenced by various treatments

| Treatments | Grain Yield (kg ha$^{-1}$) | Straw Yield (kg ha$^{-1}$) | GMR Rs. ha$^{-1}$ | NMR Rs. ha$^{-1}$ | B:C Ratio |
|---|---|---|---|---|---|
| **Main plot treatments- Sowing Windows** | | | | | |
| $S_1$ – 48 MW | 3154 | 3973 | 80760 | 48495 | 2.7 |
| $S_2$ – 49 MW | 2937 | 3872 | 77802 | 45537 | 2.6 |
| $S_3$ – 50 MW | 2888 | 3745 | 76297 | 44032 | 2.5 |
| $S_4$ – 51 MW | 2738 | 3736 | 73403 | 41138 | 2.4 |
| SE (m) ± | 68 | 61 | 1231 | 1231 | - |
| CD at 5% | 234 | 210 | 4259 | 4259 | - |
| **Sub-plot treatments- Irrigations** | | | | | |
| $I_1$ - Four irrigations | 2851 | 3794 | 75552 | 43787 | 2.5 |
| $I_2$ - Five irrigations | 2911 | 3843 | 77102 | 44837 | 2.6 |
| $I_3$ - Six irrigations | 2966 | 3905 | 78543 | 45778 | 2.6 |
| SE (m) ± | 30 | 32 | 502 | 502 | - |
| CD at 5% | 91 | 96 | 1505 | 1505 | - |
| **Interaction Effect (SxI)** | | | | | |
| SE (m) ± | 37 | 50 | 1004 | 1004 | - |
| CD at 5% | 113 | 150 | 3011 | 3011 | - |
| GM | 2910 | 3847 | 77066 | 44801 | 2.5 |

**Table 2:** 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 3:** 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 | | |

**Table 4:** Gross monetary returns (Rs. ha$^{-1}$) as influenced by S × I interaction

| S × I | Gross monetary returns (Rs. ha$^{-1}$) | | |
|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ |
| $S_1$ | 80153 | 81644 | 82989 |
| $S_2$ | 76937 | 79980 | 80097 |
| $S_3$ | 73558 | 76538 | 77591 |
| $S_4$ | 70850 | 75663 | 76538 |
| SE(m) ± | 1004 | | |
| CD at 5% | 3011 | | |

**Table 5:** Net monetary returns (Rs. ha$^{-1}$) as influenced by S × I interaction

| S × I | Net monetary returns (Rs. ha$^{-1}$) | | |
|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ |
| $S_1$ | 45884 | 48879 | 50724 |
| $S_2$ | 43398 | 47715 | 47832 |
| $S_3$ | 41793 | 44672 | 45632 |
| $S_4$ | 39085 | 40556 | 43773 |
| SE(m) ± | 1004 | | |
| CD at 5% | 3011 | | |

## Conclusion

Sowing in 48 MW ($S_1$), recorded significantly yield, gross and net monetary returns and highest B:C ratio over $S_2$, $S_3$ and $S_4$, respectively. Application of six irrigations ($I_3$) resulted significantly highest yield, gross and net monetary returns and highest B:C ratio over remaining irrigation levels. Sowing in 48 MW combined with six irrigations ($S_1I_3$) observed highest yield, gross monetary returns and net monetary returns.

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