

RESEARCH PAPER

Influence of Sowing Environments and Varieties on Yield and Economics of Rainfed Wheat in Sub-Tropical Conditions of Jammu- India

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ABSTRACT

An experiment was conducted during the *Rabi* season of 2018-19 to study the effect of six dates of sowing (31st October, 15th November, 30th November, 15th December, 30th December and 14th January) on the yield and economics of two wheat varieties (PBW-175 and JAUW-598) in Jammu, India. The experiment was laid out in Factorial Randomized Block Design with three replications. Analysis of variance showed the significant variations that were observed for number of tillers/m², length of ear (cm), number of grains/earhead, 1000-grain weight, grain and straw yields due to varietal variations and changing dates of sowing. However, wheat variety JAUW-598 recorded significantly higher yield attributes, grain and straw yields as well as higher net returns and Benefit cost (B:C) ratio as compared to wheat variety PBW-175. Among the sowing environments, 31st October recorded significantly higher yield attributes *viz.*, number of effective tillers, length of ear (cm), number of grains/earhead, 1000-grain weight, grain and straw yields which were statistically at par with 15th November sown wheat crop except for 1000-grain weight whereas lowest values were recorded significantly with 14th January which was statistically at par in terms of length of ear and number of grains/earhead with 30th December sown wheat crop. Further, the 31st October sown wheat crop fetched higher net returns and B:C ratio and was followed by 15th November whereas lower net returns and B:C ratio were recorded with 14th January and was closely followed by 30th December sown wheat crop. In addition, the interaction effects were significant with respect to number of tillers, 1000 grain weight, grain yield and straw yield of wheat. Therefore, wheat variety JAUW-598 sown on 31st October recorded the highest yield and economic returns, making it the most effective and profitable combination.

HIGHLIGHTS

- Wheat variety JAUW-598 significantly outperformed PBW-175 in yield attributes, grain and straw yields, and economic returns across the sowing dates.
- Sowing on 31st October resulted in the highest yield parameters and economic returns, followed closely by 15th November, while sowing on 14th January led to the lowest performance.
- Interaction effects between variety and sowing date were significant with respect to number of effective tillers, 1000 grain weight, grain yield and straw yield of wheat.

Keywords: Benefit cost ratio, Net returns, Yield attributes, Yield and Wheat

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Wheat (*Triticum aestivum* L.) is one of the major food grain crops of the world including India. Major wheat producing countries of the world are China, India, United States of America, France, Russia, Canada, Germany, Turkey, Australia, Ukraine and Pakistan. Globally, wheat is grown in about 215.91 million hectares holding the position of highest acreage among all crops with annual production hovering around 765.77 million tonnes (Bahaudin *et al.* 2022). This nutrient-rich cereal is one of the most important staple food crops of many countries including India. In India, the crop is cultivated in about 30.47 million hectares to produce production output of about 106.84 million tonnes with a record average national productivity of 3507 kg/ha as per the fourth advance estimates from the MoA & FW (2022). To feed the burgeoning population, either the production of wheat needs to increase or more area need to put under wheat cultivation (Hossain *et al.* 2021; Zahan *et al.* 2021; Pramanick *et al.* 2023). Although, the area under wheat cultivation is also declining. Hence, vertical expansion is required for yield enhancement which requires appropriate varieties and agronomical practices while ensuring conservation of natural resource base. Sowing environment plays an important role in the productivity of wheat. The appropriate selection of a planting date can have a dramatic impact on both the quantity and quality of crop yield (Gul *et al.* 2008; Singh *et al.* 2021; Sagar *et al.* 2024). Late sown wheat in North Indian conditions is exposed to both the extremes of temperature i.e. low temperature during the early growth period, which restricts the vegetative phase and high temperature during the post anthesis period, which reduces the duration of grain development and consequently the grain yield. A drastic reduction in yield of wheat has been recorded with the delay of sowing beyond the optimum time (Ram *et al.* 2012). Hence, wheat and other cereal crops are sown early during the growing season to avoid heat stress and to take maximum growth and development during maturity. Early planting may avoid terminal heat stress by facilitating the grain filling during relatively cooler temperatures (Loss and Siddique, 1994). Generally, the wheat crop is sown in about 148 thousand hectares of rainfed sub-tropical areas of Jammu region during the first fortnight of November, however if no rains are received during this period and the soils have

insufficient soil moisture, the sowing of wheat may be extended to December in late sowing conditions and even up to January under very late sowing condition. It has been realized that the average yield of wheat sown during the month of November, is comparable to the state average, but the declining trend in wheat yield has been noticed with delayed sowing which can be attributed to shorter growth period available coupled with higher temperatures and hotter winds during the reproductive growth period, which leads to forced maturity and ultimately poor grain yield (Hossain *et al.* 2023). At present, there is a tremendous scope for increasing the yield of wheat with the use of multi-character high yielding varieties. Thus, keeping in view the above facts, huge reduction in yield due to the changing climatic scenario prompts to evaluate optimum time of sowing for different varieties for maximum production towards realizing the desirable productivity levels.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* season (October-January) of 2018-19 at the Advanced Center for Rainfed Agriculture of SKUAST-J University, Jammu-India. The experiment was laid out in Factorial Randomized Block Design by taking 2 factors. Factor A, two varieties PBW-175 (V1) and JAUW-598 (V2) and factor B, six sowing dates 31st October (D1), 15th November (D2), 30th November (D3), 15th December (D4), 30th December (D5) and 14th January (D6) which were replicated thrice. The soil of the experimental site is sandy loam in texture with having pH 6.78. All agronomic practices were kept normal and uniform for all the treatments. For recording data related to yield attributes like number of effective tillers/m² was recorded from the five rows on each plot at the time of harvest. Ten spikes were randomly selected from the sampling area and length was recorded by measuring scale from the point of attachment of the lower most primary rachis to the tip of the panicle. Length of the ear from each plot was measured and the average length of ear was calculated (cm). Total number of grains from the ten randomly selected spikes from the tagged plants of sampling rows were separately threshed, drawn, cleaned and were counted. The average of all the ten spikes were calculated and were expressed as grains/ear head.



One thousand grains were randomly taken from the bulk produce of each net plot and were counted and weighed manually and their weight was recorded in grams (g). With respect to grain yields, from the individual plot, net plot area was harvested; sun dried for 3-4 days and was subsequently threshed (through thresher) and cleaned. The grain thus obtained, were weighed and expressed in kilograms per hectare (kg/ha). The total biological yield (grain + straw) from the net plot was recorded and straw yield was worked out by subtracting the grain yield from the biological yield and expressed in kilograms per hectare (kg/ha). Cost of different operations was calculated for different treatments on the basis of existing market prices of inputs and operations and the total cost was calculated by adding the expenditure involved in all kinds of operations as per treatment on per hectare basis in ₹/ha. Gross returns were calculated by multiplying the total grain and straw yield with prevalent market prices of the items and then presented on per hectare basis as per treatments. Market sale price of wheat grain and straw was ₹ 2051/q and ₹ 500/q, respectively. Net returns were computed by deducting the total cost of cultivation from the gross returns as per treatments.

$$\text{Net Returns} = \frac{\text{Gross Returns (₹ /ha)}}{\text{Cost of cultivation (₹ /ha)}}$$

Benefit: Cost ratio was calculated by dividing net returns with the cost of cultivation for each treatment.

$$\text{BC: Ratio} = \frac{\text{Net Returns (₹ /ha)}}{\text{Cost of cultivation (₹ /ha)}}$$

RESULTS AND DISCUSSION

Yield and Yield attributes of wheat

The data related to yield attributes viz. number of effective tillers/m², length of ear (cm), number of grains/earhead and 1000-grain weight (g) is reported in Table 1 revealed that significantly higher yield attributes with wheat variety JAUW-598 as compared to wheat variety PBW-175. This might have happened probably due the relatively superior genetic configuration of wheat variety JAUW-598 leading to enhancement in most of the

growth parameters under suitable environmental adaptability which provided substantial reduction in inter-generic competition due to weed suppression thereby resulting in better plant growth. Also, differences in number of effective tillers/m² among varieties might be attributed to their genetic diversity bifurcation that wheat variety JAUW-598 was found to be more competitive to weed infestation than PBW-175 variety while wheat variety PBW-175 was found to be more susceptible to weed infestation than JAUW-598 variety. Similar findings were also reported by Habibi and Fazily (2020); Bachhao *et al.* (2018); Wahid *et al.* (2017) and Mukhtarullah *et al.* (2016).

The interaction effects of varieties and sowing environments with reference to number of effective tillers/m² were found to be significant at crop harvest (Table 2). At harvest, the number of effective tillers/m² with almost all the sowing environments significantly increased with variety JAUW-598 as compared to variety PBW-175 except for that at 31st October and 14th January sowing environments.

Moreover, in connection to the interaction effects of varieties and sowing environments on 1000-grain weight, the interactive effects were found to be significant. 1000-grain weight was remained statistically at par in 31st October, 15th November and 14th January sowing times with both the varieties but was recorded significantly higher at 30th November, 15th December and 30th December sowing environments with variety JAUW-598 as compared to variety PBW-175.

Among the sowing environments, 31st October sown wheat crop recorded significantly higher yield attributes viz., number of effective tillers/m², length of ear (cm), number of grains/earhead and 1000-grain weight which were statistically at par with 15th November sown wheat crop except for 1000-grain weight whereas, lowest values were recorded significantly with 14th January sown wheat crop which was statistically at par in terms of length of ear (cm) and number of grains/earhead with 30th December sown wheat crop. This could be due to favorable crop growing conditions with lower total weed density and total weed dry matter that provided higher number of tillers, higher plant height, higher dry matter for better interception of solar radiation as well as availability of other essential natural inputs that results in more

Table 1: Effects of varieties and sowing environments on yield and yield attributes of wheat

Treatment combinations	Number of effective tillers/ m ²	Length of the Ear (cm)	Number of grains per ear head	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Factor (A) Varieties						
PBW-175	364.94	10.06	36.67	35.82	1920.07	3447.45
JAUW-598	429.06	10.95	38.93	41.25	2291.79	4039.29
SEm±	6.78	0.21	0.77	0.67	41.70	81.74
CD (5%)	19.88	0.63	2.26	1.96	122.30	239.73
Factor (B) Sowing Environment						
31 st October	496.67	11.50	43.45	45.49	2695.30	4642.51
15 th November	470.33	11.06	41.24	42.07	2586.46	4576.74
30 th November	428.83	10.34	38.99	38.67	2363.42	4126.99
15 th December	390.00	10.30	36.42	37.13	2033.44	3539.60
30 th December	334.17	10.15	34.67	36.02	1599.46	3019.85
14 th January	262.00	9.68	32.03	31.84	1357.50	2554.52
SEm±	11.74	0.37	1.33	1.16	72.23	141.57
CD (5%)	34.43	1.08	3.91	3.40	211.83	415.22
Interaction (A*B)	S	NS	NS	S	S	S

Table 2: Interaction effects of varieties and sowing environments on yield attributes and yield of wheat

Variety*Sowing Environment	Number of effective tillers/ m ²		1000-Grain Weight (g)		Grain Yield (kg/ha)		Straw Yield (kg/ha)	
	PBW-175	JAUW-598	PBW-175	JAUW-598	PBW-175	JAUW-598	PBW-175	JAUW-598
A*B								
31 st October	474.67	518.67	45.00	45.98	2643.90	2746.70	4577.97	4707.06
15 th November	444.33	496.33	41.14	43.00	2536.04	2636.88	4571.27	4582.22
30 th November	391.00	466.67	35.17	42.17	2210.14	2516.70	3941.58	4312.40
15 th December	366.67	413.33	32.69	41.57	1776.72	2290.16	3122.01	3957.19
30 th December	266.00	402.33	30.93	41.10	1286.67	1912.26	2444.67	3595.04
14 th January	247.00	277.00	29.98	33.700	1066.96	1648.03	2027.22	3081.82
SEm±	16.60		1.64		102.14		200.21	
CD (5%)	48.69		4.81		299.58		587.21	

photosynthesis thus leading to greater chances of producing longer ears containing larger number of grains. The decreased in number of tillers in late sowing (14th January) might be due to higher air and soil temperature as compared to early sowing times (31st October and 15th November). High temperature, even for short periods, affects crop growth especially in temperature crops like wheat. The high air temperature reduces the shoot and root growth. However, high soil temperature may cause severe damage to roots resulting in substantial reduction in shoot growth. More assimilation of photosynthates due to prolonged growth period contributed to longer spikes in the early sown wheat crop. Grains/earhead is sensitive to increase in temperature during productive period in late

sowing time. Wheat experiences heat stress to varying degrees at different phenological stages, but heat stress during the reproductive phase is more harmful than during the vegetative phase due to direct effect on grain number. Higher 1000-grain weight in 31st October sown wheat crop might have been due to cooler climate prevailed during both vegetative and reproductive period and prolonged maturation resulted in higher 1000-grain weight. Moreover, lower weed biomass in early sown wheat crop provided chance to crop for better utilization of resources available and efficient source sink relationship. However, late sown crop is exposed to higher temperature during the reproductive growth. Temperature had complex relationship with spikelet formation, ripening and grain yield



than other weather parameters. Grain number is much sensitive to temperature after anthesis. The improvement in yield attributes might be owing to more time available for better use of growth resources and expression of its potential. These results are in close conformity with those reported by Mumtaz *et al.* (2015); Singh *et al.* (2017); Dar *et al.* (2020) and Baloch *et al.* (2010).

With respect to performance of individual varieties at different dates, an apparent decline in number of effective tillers/m² was recorded with each 15 days of delay in sowing time. The decrease however, remained significantly different at 15th December and 14th January with wheat variety JAUW-598 and at 15th November and 30th December, with wheat variety PBW-175. Further, with respect to enactment of individual varieties at different dates, a conspicuous reduction in 1000-grain weight was recorded with each 15 days of postponement in sowing time. The turn down however, remained statistically at par up to 30th December sowing environments with wheat variety JAUW-598 and almost at all sowing environments except for 30th November with wheat variety PBW-175. The interaction effects of varieties and sowing environments on length of ear and number of grains/earhead of wheat crop found to be non-significant.

Grain and straw yields of wheat crop as shown in Table 1 recorded significant variations with respect to varieties and sowing environments. However, wheat variety JAUW-598 was found to be significantly higher as compared to wheat variety PBW-175 in terms of grain and straw yields. This might be due to the fact that the greater number of tillers/m² at harvest was obtained with wheat variety JAUW-598 as compared to wheat variety PBW-175. Similar findings were also reported by Mukhtarullah *et al.* (2016) and Mahajan *et al.* (2018).

Among the sowing environments, grain and straw yields of wheat crop were significantly higher in 31st October sowing date which were statistically at par with 15th November sowing date whereas significantly lowest value was recorded with 14th January sown wheat crop. This could have happened owing to fact that favorable environmental conditions were available for longer duration to earlier sown crop like that of more time at hand for accumulation of ideal amount of dry

matter followed by relatively longer grain filling period of the crop which registered better growth and yield attributes of the crop and ultimately led to increase in the grain yield of wheat crop. In addition, the possible reason for higher grain yield of wheat due to early sown wheat might possibly be attributed to lower total density and total biomass of weeds which might have reduced crop-weed competition for various growth factors and enhanced the most of the crop-growth parameters under the favorable environmental situation thus resulting in better plant growth and finally grain and straw yields. In late planting, due to severe infestation of weeds and the loss of suitable time for the growth, the plant has not achieved its potential ability because light interception and crop simulates partitioning were severely affected and consequently led to yield decline. In case of early planting there was more time for plant growth and development, so seed yield increased was rational. The above results could be corroborated with the findings of Dar *et al.* (2020); Chauhan *et al.* (2020) and Singh *et al.* (2017).

The interaction effects of varieties and sowing environments on the grain yield, the interactive effects were found to be significant. After harvest, the grain yield of wheat with almost all the sowing environments significantly raised with variety JAUW-598 as compared to variety PBW-175 except for that at 31st October and 15th November sowing environments (Table 2). Moreover, with respect to performance of individual varieties at different dates, a conspicuous decline in grain yield production was recorded with each 15 days of delay in sowing time. The reduction however, remained statistically at par up to 15th December and beyond 30th December sowing environments successively with wheat variety JAUW-598 and up to 15th November and beyond 30th December sowing times continually with wheat variety PBW-175.

With reference to the interaction effects of varieties and sowing environments on the straw yield, the interactive effects were found to be significant. After harvest, the straw yield of wheat crop in beyond-December sowing environments significantly increased with variety JAUW-598 as compared to variety PBW-175 but remained statistically at par with prior-December sowing environments. Similarly, with respect to enactment of individual

Table 3: Effects of varieties and sowing environments on relative economics of wheat

Treatment combinations	Cost of Cultivation (₹/ha)	Gross Returns (₹/ha)	Net Returns (₹/ha)	B: C ratio
Factor(A) Varieties				
PBW-175	23168	56618	33450	1.44
JAUW-598	23168	67201	44033	1.90
Factor(B) Sowing Environment				
31 st October	23168	74493	55325	2.39
15 th November	23168	75932	52764	2.28
30 th November	23168	69109	45940	1.98
15 th December	23168	59404	36236	1.56
30 th December	23168	47904	24736	1.07
14 th January	23168	40615	17447	0.75

varieties at various dates, an apparent turn down in straw yield production was recorded with each 15 days of postponement in sowing time. The reduction however, remained statistically at par at all the sowing environments successively with wheat variety JAUW-598 and up to 15th November and beyond 30th December successively with wheat variety PBW-175 but a significant decrease was observed after 15th November till 30th December with PBW-175 wheat variety.

Economics of wheat

Relative economics of wheat crop was calculated on grain yield and straw yield basis and depicted in Table 3 that amongst wheat varieties, JAUW-598 fetched higher net returns and B:C ratio as compared to wheat variety PBW-175 which might have happened due to lower total weed density, total weed biomass and genetically inherent character of wheat variety JAUW-598 resulting in higher yield responsible for the corresponding higher net returns and B:C ratio. Further, these findings are also in close conformity with those of Bachhao *et al.* (2018) and Mukherjee (2012).

With respect to sowing environments, 31st October sown wheat crop fetched higher net returns and B:C ratio and was followed by 15th November sown wheat crop whereas lower net returns and B:C ratio were recorded with 14th January sown wheat crop and was followed by 30th December sown wheat crop which might have happened due to prevailing favorable temperature required for wheat crop for higher photosynthate accumulation and lower total weed density and total weed biomass consequently resulting in higher yield responsible for the

corresponding higher net returns and B:C ratio. Further, these findings are also in close conformity with those of Baloch *et al.* (2012).

CONCLUSION

In the light of above experiment, it was evident that wheat variety JAUW-598 recorded significantly higher yield contributing characters like number of effective tillers/m², length of ear (cm), number of grains/earhead and 1000-grain weight (g) thus, leading to higher grain and straw yield. With regard to sowing environments, it was evident from the study that 31st October sown wheat crop recorded significantly higher yield contributing characters *viz.*, number of effective tillers/m², length of ear (cm), number of grains/earhead and 1000-grain weight (g) which contributed to higher grain and straw yield. Wheat variety JAUW-598 and sowing of wheat crop on 31st October proved to be superior economically over rest sown wheat dates with superior net returns and B:C ratio. Therefore, wheat variety JAUW-598 sown on 31st October recorded the highest yield and economic returns, making it the most effective and profitable combination.

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