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Assessment of suitable sowing time of wheat to avoid the terminal heat under the late sown condition

¹Praveen Kumar, ¹Dr. Paritosh Kumar, ¹Dr. Lalbabu Kumar, ¹Dr. Prabhat Kumar, ²Diwakar Paswan and ³Dr. DK Mahto

¹Assistant Professor-cum-Junior Scientist, Jute Research Station, Katihar, BAU, Sabour, Bhagalpur, Bihar, India

²Officer In-charge Jute Research Station, Katihar, BAU, Sabour, Bhagalpur, Bihar, India

³Associate Dean-cum-Principal, B.P.S.A.C., Purnea and Controlling Officer, JRS, Katihar, Bihar, India

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Corresponding Author: Praveen Kumar

Abstract

The present study entitled “Assessment of suitable sowing time of wheat to avoid the terminal heat under late sown conditions” was conducted during *Rabi* season 2022-23 at nine (09) farmers’ fields and the Krishi Vigyan Kendra (KVK) farm, Amas, Gaya, Bihar. The main objective of the investigation was to evaluate the effect of different sowing dates and wheat varieties on growth, yield attributes, and yield, and to identify the most profitable treatment combination under late sown conditions. The experiment was laid out in a Randomized Block Design (RBD) with ten replications and four sowing date treatments (25th November, 5th December, 15th December, and 25th December). Among the treatments, the wheat variety *Sabour Nirjal* sown on 25th November recorded superior performance in all major growth and yield parameters. It exhibited the maximum plant height (86.50 cm), ear length (13.14 cm), number of grains per ear (41.90), and 1000 grain weight (45.50 g), leading to the highest grain yield (26.50 q/ha). Economic analysis also revealed that *Sabour Nirjal* sown on 25th November gave the highest net return of ₹31,428 per hectare with a benefit cost (B:C) ratio of 2.13, which was considerably higher than the returns obtained from sowings on 5th, 15th, and 25th December. The delayed sowing dates suffered from reduced yield and profitability due to the adverse effect of terminal heat during the grain filling stage. Therefore, the results clearly indicate that sowing of wheat variety *Sabour Nirjal* on 25th November is the most suitable and economically viable option for farmers in the Gaya region under late sown conditions to mitigate the negative impacts of terminal heat stress and achieve higher productivity and profitability.

Keywords: Wheat, date of sowing, terminal heat, variety, yield, economics

Introduction

Wheat (*Triticum aestivum* L.), a member of the family Poaceae, is one of the most important cereal crops worldwide and serves as a staple food for a large portion of the global population. It is highly adaptable to a wide range of agro-climatic conditions and plays a vital role in ensuring food and nutritional security both in India and across the world. In India, wheat ranks second after rice in terms of area and production. During 2022-23, the total wheat production in the country was estimated at 110.55 million tonnes, cultivated over an area of 32.05 million hectares, with an average productivity of 3507 kg/ha (Anonymous, 2022-23) ^[2]. In Bihar, wheat occupies about 2.24 million hectares, producing approximately 6.22 million tonnes, with an average yield of 2780 kg/ha, which is below the national average. Among the various factors influencing wheat productivity, sowing time and varietal selection are the most crucial in the state of Bihar. Wheat sowing generally begins from the last week of November and continues up to the last week of December, depending on the prevailing weather conditions and the harvesting time of the preceding rice crop. In the predominant rice wheat cropping system of Bihar, late sowing of wheat is a common practice, as most

fields are vacated only after paddy harvest. Consequently, about 75-80% of the wheat area in Bihar is sown under late sown conditions. Under such conditions, wheat experiences low temperatures during the early vegetative phase and high temperatures during the reproductive and grain filling stages. This terminal heat stress adversely affects grain setting and filling, resulting in a substantial reduction in yield. Adequate soil moisture during the reproductive phase becomes crucial for mitigating these effects, but late sown crops often face moisture stress as well. Several studies have highlighted the negative impact of delayed sowing on wheat productivity. For instance, Tanveer *et al.* (2003) ^[12] reported that early sown wheat produces significantly higher yields due to an extended growing period and favorable temperature regimes during critical growth stages. Similarly, Singh and Uttam (1994) ^[10] observed that delaying sowing beyond 25th November results in a yield reduction of approximately 39 kg/ha per day. Despite the lower yield potential under late sown conditions, wheat cultivation remains indispensable in Bihar due to its role as a key component of the prevailing cropping system and as a source of livelihood for small and marginal farmers. Therefore, efforts must be directed toward optimizing the

sowing time and selecting suitable varieties that can withstand terminal heat stress and perform better under late sown situations. The present study was thus undertaken with the objective to assess the suitable sowing time of wheat to avoid terminal heat under late sown conditions and to identify the most productive and economically viable sowing window for enhancing wheat yield performance in Bihar.

Materials and Methods

The present On Farm Trial (OFT) was conducted during the *Rabi* season of 2022-23 to assess the suitable sowing time of wheat to avoid terminal heat under late sown conditions. The experiment was implemented at nine (09) farmers' fields and the Krishi Vigyan Kendra (KVK) Farm, Amas, located in Gaya district, Bihar (Latitude: 24.615438° N; Longitude: 84.662168° E; Altitude: 149.05 m above mean sea level). The region falls under the south Bihar alluvial agro-climatic zone, characterized by subtropical climate with cool winters and hot summers.

The trial comprised four different sowing dates as treatments using the wheat variety *Sabour Nirjal*. The treatments were:

- T₁: Sowing on 25th November
- T₂: Sowing on 5th December
- T₃: Sowing on 15th December
- T₄: Sowing on 25th December

The experiment was laid out in a Randomized Block Design (RBD) with ten replications (one at KVK farm and nine at different farmers' fields). Each plot represented one treatment under similar management conditions. Sowing was carried out using a seed drill at the recommended seed rate and row spacing for the variety. A uniform dose of fertilizers was applied at the rate of 120:60:40 kg N:P₂O₅:K₂O per hectare, following the recommended agronomic practices for wheat cultivation in the region. Half of the nitrogen and full doses of phosphorus and potassium were applied as basal, while the remaining nitrogen was top dressed in two equal splits at the crown root initiation (CRI) and booting stages. Irrigation was applied at critical growth stages, CRI, tillering, booting and grain filling, depending on soil moisture status. Standard weed control, insect pest, and disease management practices were followed uniformly across all treatments to ensure optimum crop growth. Observations were recorded on various growth and yield parameters by tagging and monitoring five randomly selected plants from each replication for each treatment. The parameters recorded included:

- Plant height (cm)
- Ear length (cm)
- Number of grains per ear

- 1000 grain weight (g)
- Average grain yield (q/ha)

Economic evaluation was conducted to determine the most profitable sowing time. The parameters recorded included:

- Cost of cultivation (₹/ha)
- Gross return (₹/ha)
- Net return (₹/ha)
- Benefit:Cost (B:C) ratio

The cost of inputs (seeds, fertilizers, labor, irrigation, etc.) and market price of wheat grain were calculated based on the prevailing local market rates during the cropping season. The crop was harvested between 12th and 15th April 2023 when physiological maturity was attained. The final yield was recorded after threshing, cleaning, and drying of grains to standard moisture content.

Results and Discussion

The results of the study revealed that the sowing date had a significant influence on the growth and yield attributes of wheat, particularly plant height, ear length, and number of grains per ear. The data presented in *Table 1* indicate that the earliest sowing date (25th November; T₁) produced superior performance in all measured parameters compared to the later sowing dates (5th December, 15th December, and 25th December).

Effect on Plant Height

Plant height was found to be highest (86.50 cm) when wheat was sown on 25th November (T₁), followed by 5th December, 15th December, and 25th December sowings. The increase in plant height under early sowing may be attributed to the favorable thermal regime and longer vegetative period, which facilitated better tiller development and accumulation of photosynthates. These findings are in close agreement with the results of Tahir *et al.* (2009) ^[11], who reported that early sowing of wheat promotes higher dry matter accumulation and overall plant growth due to prolonged exposure to optimum temperature and solar radiation. Similarly, Shahzad *et al.* (2002) ^[8] observed that timely sown wheat exhibited significantly greater plant height and biomass production compared to late sown crops. The reduced plant height in late sown conditions might be due to shortened growing duration and exposure to high temperatures during the vegetative and reproductive stages, which restricted internodal elongation and overall growth. Thus, it can be concluded that early sowing (around 25th November) allows wheat plants to utilize favorable weather conditions for extended growth, resulting in taller and more vigorous plants.

Table 1: Effect of different sowing date of wheat (Sabour Nirjal) on yield and Economics

Treatments	Plant height (cm)	Ear length (cm)	No. of grains/ear	1000 grains wt. (gm)	Av. Yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
T ₁	86.50	13.14	41.90	45.50	26.50	27,800	59,228	31,328	2.13
T ₂	78.40	11.40	35.90	44.00	24.30	27,800	54,311	26,511	1.95
T ₃	76.50	10.20	37.00	43.30	20.70	27,800	46,265	18,465	1.66
T ₄	73.20	09.90	30.40	40.10	17.90	27,800	40,007	12,207	1.43

Effect on Ear Length

The data presented in *Table 1* clearly indicated that the ear length of wheat was significantly affected by the date of sowing. The crop sown on 25th November (T₁) produced the longest ears (13.14 cm), which was superior to those sown on 5th December (11.00 cm), 15th December (10.20 cm), and 25th December (09.90 cm). The superiority of the early sown crop may be attributed to the longer vegetative and reproductive growth period, which allowed for better spike development and grain setting. These findings are in conformity with those of Upadhyay *et al.* (2015) [13], who reported that early sowing of wheat provides favorable thermal conditions during the spike development stage, resulting in enhanced ear length and better yield components.

Effect on Number of Grains per Ear

A significant variation was also observed in the number of grains per ear across different sowing dates. The maximum number of grains per ear (41.90) was recorded in wheat sown on 25th November (T₁), followed by 5th December (39.90), 15th December (37.00), and 25th December (30.40). The reduction in grain number under delayed sowing can be attributed to shortened grain filling duration and the adverse impact of terminal heat stress during the reproductive phase. Similar results were reported by Shehzad *et al.* (2002), who found that timely sown wheat produced more grains per spike compared to late sown wheat, owing to better synchronization between vegetative and reproductive growth under optimal temperature conditions.

Effect on 1000 Grain Weight (Test Weight)

The 1000 grain weight (test weight), a key indicator of grain quality and yield, was also significantly influenced by the date of sowing. The highest test weight (45.50 gm) was recorded in the crop sown on 25th November, followed by 44.00 gm in the 5th December sowing, 43.30 gm in the 15th December sowing, and the lowest (40.10 gm) in the 25th December sowing. The decline in test weight with delayed sowing was primarily due to shortened grain filling duration and high temperature stress during the milking and grain development stages, which caused shriveling and incomplete grain filling. Mahajan and Nayeem (1990) [4] similarly reported that the earliest sowing (25th November) resulted in the highest test weight compared to the late sown crop (25th December). Singh and Uttam (1993) [9] and Nainwal and Singh (2000) [5] also observed that delaying sowing by one month beyond 27th November led to a significant reduction in 1000 grain weight. Furthermore, Shahzad *et al.* (2007) [8] confirmed that early sown wheat benefited from favorable temperature regimes during grain development, resulting in heavier and well filled grains.

Effect on Grain Yield

The data revealed that the average grain yield was significantly influenced by sowing dates. The highest yield (26.50 q/ha) was obtained when wheat was sown on 25th November (T₁), followed by 24.30 q/ha in 5th December (T₂), 22.10 q/ha in 15th December (T₃), and the lowest yield (17.90 q/ha) in 25th December (T₄). The superior performance of the 25th November sowing can be ascribed to the longer growing duration, optimum temperature

conditions during critical growth stages and higher values of yield attributing traits such as ear length, grain number and test weight. The results are in close agreement with the findings of Ram *et al.* (2012) [7], who reported that timely sowing enhances yield potential due to increased growing degree days and photo thermal units, leading to improved physiological efficiency. Similar trends were also observed by Patel *et al.* (1999) [6], Akhtar *et al.* (2002) [1] and Kumar *et al.* (2005) [3].

Economic Analysis

Economic evaluation of the treatments revealed that while the cost of cultivation remained almost uniform across all treatments, there was considerable variation in gross and net returns. The highest gross return (₹59,229/ha) was obtained from wheat sown on 25th November (T₁), followed by ₹54,311/ha in 5th December sowing (T₂). The corresponding net return and benefit-cost (B:C) ratio were also maximum in T₁ (₹31,428/ha and 2.13), followed by T₂ (₹26,511/ha and 1.95). The profitability decreased sharply with further delay in sowing, mainly due to the reduction in yield under the influence of terminal heat during the reproductive phase. These results emphasize that timely sowing around 25th November not only enhances yield attributes but also maximizes economic returns, making it the most suitable sowing window for wheat under the late sown conditions prevalent in Bihar.

Conclusion

Based on the results of the present on farm trial, it can be concluded that the date of sowing has a profound influence on the growth, yield attributes, yield performance and economic returns of wheat under the agro-climatic conditions of Gaya, Bihar. Among the different sowing dates tested, the 25th November sowing with the variety *Sabour Nirjal* recorded the highest plant height, ear length, number of grains per ear, 1000 grain weight and grain yield. The superior performance of this treatment was mainly due to the availability of favorable temperature and longer growing period, which supported better crop growth and physiological development. In contrast, delayed sowing beyond 5th December resulted in yield reduction due to the adverse effect of terminal heat stress during the reproductive and grain filling stages. The economic analysis also revealed that the 25th November sowing achieved the maximum gross return (₹59,229/ha), net return (₹31,428/ha) and the highest benefit cost ratio (2.13), indicating its economic superiority over later sowing dates.

Therefore, it is recommended that farmers in the south Bihar alluvial zone should sow wheat on or before 25th November, particularly using the variety *Sabour Nirjal*, to achieve higher productivity and profitability under late sown conditions and to minimize yield losses caused by terminal heat stress.

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