



**GROWTH AND YIELD COMPONENTS OF WHEAT (*TRITICUM AESTIVUM* L.)
VARIETIES AS INFLUENCED BY SOWING INTERVALS IN SOUTH-EASTERN NIGERIA**

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ABSTRACT

The research was conducted to determine the effects of different sowing intervals (*SIs*) on growth and yield of some wheat varieties under Southern-Nigeria's climatic conditions. The treatments consisted of four (4) varieties of wheat (*Imam*, *Sc. Sahai*, *Norman* and *WZ 273 2015*) and three (3) sowing intervals (*5th December, 2024*; *5th January* and *5th February, 2025*). These were factorially combined and laid out in a completely randomized design and replicated three times. Growth, physiological and yield variables were measured. The result revealed that, sowing wheat on *5th December* recorded the highest growth compared with other *SIs* (*5th January* and *February*). Variety on the other hand, *imam* was better in growth traits and optimized more ($p \leq 0.05$) photosynthesis at 8 WAS whereas *WZ 273 2015* was higher in photosynthetically active radiation at 4 and 6 WAS. *Sc.Sahai* significantly took fewer (55.71) number of days to heading relative to other varieties. *WZ 273 2015* had longer ($p \leq 0.05$) spike length when sown on *5th December*, as well as number of spikelets/main spike and spike weight. Sowing wheat on *5th December* resulted in significantly higher dry matter and yield viz., plant's dry weight, number of grains/plant and grain weight/plant, especially in *Norman* and *WZ 273 2015*, relative to other *SIs*. *Imam* consistently performed better in growth traits, whereas *WZ 273 2015* and *Norman* were stable in yield components and grain yield. Overall, *5th December* was a more suitable timing than other *SIs*, as it recorded better performance among the varieties. Based on the result of this study, cultivating wheat in Calabar could be sustainable in the early part of *December*, which is subject to further investigation.

Keywords: *Triticum aestivum*, Sowing, Dates, Varieties, Yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major food crops in the world (Naja *et al.*, 2018). It is a cool season, annual, monocot and C3 plant that belongs to the family *Graminae*, common to temperate and savanna zones. The crop is grown from temperate, irrigated, to dry and high rain fall areas and from warm, humid to dry, cold environments (Singh *et al.*, 2008). Wheat yield in South-Eastern Nigeria is low chiefly due to delayed planting time, planting unsuitable varieties, inappropriate seeding rates, soil type and other factors. Sowing time and selection of variety are the most important factors that influence wheat yield (Bangar *et al.*, 2020). Increase in wheat grain yield can be achieved by sowing wheat crops at the appropriate time, although this depends on the wheat variety, climatic conditions and nutrient availability. Suitability of wheat varieties to a particular agro-climate is a crucial factor in optimizing wheat yield potential. This is because plants production efficiency is influenced by variety and environmental interaction. Further, although the prevailing environmental conditions in an agro-climatic zone cannot be altered, the crop sowing time can be adjusted to maximize the environmental factors that best favour the crop's growth stages (Eyshi *et al.*, 2017). Selecting suitable



wheat varieties for an agro-climatic condition optimizes wheat yield since the varieties do not perform equally in early and late sown conditions (Alam *et al.*, 2022). It therefore implies sowing time and selection of wheat variety play a critical role in wheat productivity. Wheat is a staple food for the world's population (FAO, 2017) that is rich in gluten protein, an important ingredient for bread industry. The grain consists of 63-71% starch, 8-17% protein, 8-17% water, 2-2.5% cellulose, 1.5-2% fat, 23% sugar, and 1.5-2 % mineral elements (Singh *et al.*, 2021). The global cultivated wheat area is about 736,000 hectares and its productivity is expected to be about 739.9 million tons (Kumar *et al.*, 2024).

Soil acidification constitutes serious environmental stress to wheat production especially soils developed on coastal plain sands in South-Eastern Nigeria. Coastal plain sands cover over 25 % of the tropical rainforest belt. The area is characterized by high annual rainfall (3000 mm per annum) and frequently wet soil with insufficient oxygen for roots respiration (Araki *et al.*, 2012) and uptake of nutrients and water (Madueke *et al.*, 2020). Improper use of inorganic fertilizer is often associated with reduced crop yield, soil acidity, nutrient imbalance and environmental pollution such as eutrophication and excess nitrous oxide in the air. The inherent low fertility and poor structural stability associated with coastal plain sands call for effective management and sustainable use of such soils (Abam and Orji, 2019).

The phenomenon of climate change is one of the most important challenges facing humanity at the present time, and one of the most important scenarios witnessed by several regions of the world (Alam *et al.*, 2022). Increasing delays in the onset of the rainy season and extended dry spells in the Nigerian agro-ecology complicate the optimal planting dates for rain-fed crops (Figures 1 and 2) and could result in reduction of yield and yield attributes. Studies have shown that inappropriate planting dates affect wheat yield and its yield components (Mahmood *et al.*, 2021; Kumar *et al.*, 2024), as earlier or later plantings significantly reduced crop yield (Rehan, 2012). Omoloye *et al.* (2015) examined the impact of planting dates on *Hemipteran* sucking bugs in soybeans in Nigeria and found that early-planted soybeans had fewer infestations and less seed damage than late-planted soybeans. Similarly, Kumar *et al.* (2013) reported that growth and grain yield per hectare of wheat decreased with delayed planting, regardless of the season or variety used. Timely sowing and harvesting play important roles in wheat production, as appropriate management decisions are necessary to cope with climate change and ensure high and stable crop yields. Deciding the appropriate planting date is vital to prevent poor crop establishment and avoid the additional expenses of seed and labor needed for replanting (Lak *et al.*, 2013). Crop management techniques, such as adjusting planting dates and selecting suitable wheat varieties can significantly improve wheat yield and resilience under recent changing climatic conditions (Khalil *et al.*, 2011). However, currently, there are limited information on the appropriate planting date for wheat varieties in South-Eastern Nigeria. The present study evaluated the effects of different sowing intervals on growth and yield of some wheat (*Triticum aestivum* L.) varieties in South-Eastern Nigeria.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the University of Calabar Screen House (04° 57' -13° N, 08° 20' E, 39 m above sea level). Calabar is characterized by high rainfall with distinct wet and dry seasons. The rainy season starts from March to late October while the dry season begins from November to late February. The soil is sandy loam in the *Ustisols* order using the USDA soil taxonomy with a pH of 4.0-5.5 with high buffering capacity of about 2.0-10.0 cmol/kg, low base saturation, high exchangeable aluminium, low organic matter and severe leaching (Akpan *et al.*, 2017).

Collection and Preparation of Research Materials

i. Wheat varieties

The wheat varieties were sourced from Lake Chad Research Institute (LCRI), Maiduguri, Zamfara State, Nigeria.

ii. Soil sample collection and preparation

Soil samples were collected from 8 points in previously cultivated plot at the Faculty of Agriculture Practical Year Research Farm, University of Calabar, Nigeria. The soil was collected using an auger to the plough layer of 0-30cm and composited. A portion (130 g) was



weighed and bagged for pre-physicochemical analysis using standard laboratory procedures as outlined in Otie *et al.* (2025). The remaining soil was air-dried and screened using 4mm sieve. Fourteen kilogram (14.0 kg) of the soil was filled in each of the 32 base-perforated plastic buckets with 40cm height and 28 cm diameter for seeding the wheat varieties.

Experimental Design, Treatments and Treatment Allocation

The experiment comprised of four wheat varieties (*Imam, Sc. Sahai, Norman and WZ 272 2015*) and three sowing intervals of 5th December, 2024; 5th January and 5th February, 2025, respectively. The treatments were 4 x 3 factorial, arranged in a completely randomized design, and replicated three times to give a total of thirty-six (36) experimental units.

Planting and Maintenance of Experimental Units

Pre-sowing irrigation was done prior to sowing wheat seeds because it is necessary to maintain optimum moisture level to ensure good germination/emergence (Yang *et al.*, 2025). Poultry manure (PM) was sourced from University of Calabar poultry farm, shade-dried, crushed and analyzed for nutrient contents (Udo *et al.*, 2009). Sixty kilogram (60 kg) of the manure was basally incorporated into the soil five days before sowing following the recommended rate of 10 tons/ha (Agbede, 2025). Fifteen wheat seeds were drilled in 3 rows into the soil at 2 cm depth and at 10 cm apart and later thinned to nine vigorous seedling per row at 14 days after sowing (DAS). Irrigation was carried out twice daily at 800 mL per pot. Weed species were handpicked. Harvesting was done at physiological maturity.

Plant Data Collection

The vegetative variables measured were plant height at 8 weeks after sowing (WAS), number of tillers at 4 WAS, number of functional tillers at 8 WAS. The functional tillers are the fully developed tillers with grain-bearing head at maturity. Flag leaf area was measured at 6 WAS, and number of days to heading was measured at 6 WAS. The photosynthetically active radiation ($\mu\text{mol m}^{-2}\text{s}^{-1}$) was determined periodically as spot measurement on the flag leaves at 4, 6, and 8 WAS on cloudless days, using the MQ-100: Quantum Integral Sensor with Handheld Meter (Apogee Instruments INC. USA). Length of spike, number of spikes per plant, number of spikelets per main spike and number of spikelets per plant were measured at 10 WAS. Spike weight and plant dry weight were measured after harvest after oven drying at 75°C for 72 hours. Harvest index (%) was estimated as:
$$\text{HI} = \frac{\text{Seed dry matter}}{\text{Plant dry matter}} \times 100.$$

The grain yield (g) per plant was measured at harvest.

Data Analysis

The data obtained were subjected to analysis of variance using GenStat software 15.1, 8th edition (VSN International, 2008) to partition the effects of the 2-factor experiment and their interactions. Treatment means were compared using Duncan's new multiple-range test at a 5 % level of probability.

RESULTS AND DISCUSSION

Background Experimental Soil Chemical Properties

The results of soil analysis showed that soil reaction (pH) was strongly acid The soil reaction (pH) was strongly acid (5.3). The soil organic matter content was within a moderate value of 1.04 %, and contained 0.09 % total nitrogen, and 4.55 mg/kg available phosphorus (P); The exchangeable cation values (cmol/kg) were 3.33 for Ca, 1.67 for Mg, 0.11 for Na and 0.09 for K. The values (cmol/kg) of exchangeable acidity were 2.52 for Al^{3+} and 0.76 for H^{+} . The soil effective cation exchange capacity (ECEC) was also low with the value of 8.42 cmol/kg. However, the base saturation (61.0 %) was within the sufficiency limit of 60.0 – 80.0 %).

Growth Attributes

The results of effect of sowing intervals (*SIs*) on plant height, number of tillers, flag leaf area and number of days to heading of four spring wheat varieties are shown in Table 1. The results showed that *SIs* had significant ($p \leq 0.05$) impact on the growth of wheat varieties. Among the varieties, *Imam* was significantly the tallest ($p \leq 0.05$) at 8 WAS. This is evident that *Imam*'s tendency in optimizing the favorable weather at sowing time and the optimal usage of the soil's nutrient and moisture contents



(Netam *et al.*, 2020) was more effective than other varieties. Across the sowing intervals, 5th December better ($p \leq 0.05$) supported wheat growth relative to 5th January and February. Similar outcomes were also reported by Yusuf *et al.* (2019). The interaction effect confirmed that *Imam* had superior growth characteristics, especially when cultivated earlier (on 5th December). There was significant ($p \leq 0.05$) varietal and sowing interval effect on the number of tillers and functional tillers. *Imam* recorded more tillers and functional tillers relative to other varieties. Variability among the varieties with respect to the number of tillers and functional tillers might be due to their genetic makeup and environmental conditions (Al-Jiashi and Abdel-Sada, 2020). The interaction results shows that *Imam* maintained the highest ($p \leq 0.05$) number of tillers under the 5th December sowing. WZ 273 2015 significantly ($p \leq 0.05$) had the highest (23.17 cm²) flag leaf area, relative to other varieties (Table 1). The lowest (11.89 cm²) flag leaf area was recorded for *Norman* variety. The significant differences among the wheat varieties with respect to the flag leaf area could also be due to their genetic variations. The earlier sowing interval had a significant ($p \leq 0.05$) effect on the flag leaf area, as plants sown on 5th December significantly produced the highest area (18.13 cm²) at 6 WAS relative to other SIs. These findings are similar to those of Al-Kafaei and Hamed (2017) and Singh *et al.* (2017) who reported that appropriate climatic conditions at earlier planting date could positively influence photosynthetic products and enhance flag leaf development. A similar trend occurred in their interactions (Table 1). *Sc. Sahai* had shorter duration (55.71 days) to heading while *Norman* had longer (63.81 days) duration to heading. The consistent trend in the improved growth traits for 5th December SI could be attributed to stability in photoperiod requirements during this period (Al-Jiashi and Abdel-Sada, 2020).

Table 1: Effect of Sowing Interval on Growth Attributes of Four Spring Wheat Varieties

Treatment	Plant height (cm) at 8WAS	No. of tillers at 4WAS	Number of functional tillers at 8WAS	Flag leaf area (cm ²) at 6WAS	Number of days to heading at 6WAS
Wheat variety (V)					
Imam (V ₁)	44.64 ^a	6.68 ^a	4.26 ^a	14.23 ^{bc}	58.28 ^b
Sc. Sahai (V ₂)	31.50 ^{bc}	3.75 ^d	2.20 ^c	15.72 ^b	55.71 ^c
Norman (V ₃)	34.51 ^b	4.73 ^c	3.53 ^b	11.89 ^c	63.81 ^a
WZ 273 2015 (V ₄)	32.08 ^{bc}	5.94 ^b	2.12 ^c	23.17 ^a	58.50 ^b
Sowing intervals (SIs)					
5 th December (5 th D)	56.02 ^a	5.76 ^a	5.66 ^a	18.13 ^a	48.94 ^c
5 th January (5 th J)	42.58 ^b	3.49 ^a	4.88 ^b	12.56 ^b	58.32 ^b
5 th February (5 th F)	40.80 ^b	3.92 ^a	2.40 ^c	12.54 ^b	61.95 ^a
SIs × V					
5 th DV ₁	48.88 ^a	5.50 ^a	4.71 ^a	23.85 ^b	53.00 ^{fg}
5 th DV ₂	34.89 ^b	4.11 ^{b-d}	4.33 ^{ab}	9.20 ^d	51.66 ^g
5 th DV ₃	34.11 ^b	4.24 ^{bc}	4.40 ^{ab}	12.39 ^c	64.88 ^a
5 th DV ₄	34.94 ^b	3.83 ^{b-e}	3.60 ^b	31.09 ^a	53.88 ^{fg}
5 th JV ₁	33.11 ^{cd}	2.54 ^{c-e}	3.03 ^c	6.27 ^e	57.44 ^{d-f}
5 th JV ₂	34.50 ^b	2.60 ^{c-e}	2.42 ^{cd}	6.27 ^e	56.00 ^{e-g}
5 th JV ₃	34.55 ^b	2.57 ^{c-e}	2.64 ^{cd}	6.63 ^{de}	63.29 ^a
5 th JV ₄	33.44 ^{bc}	2.28 ^e	1.83 ^d	8.13 ^{de}	60.90 ^{c-e}
5 th FV ₁	25.33 ^f	2.67 ^{c-e}	1.10 ^{de}	2.63 ^f	62.05 ^{bc}
5 th FV ₂	28.33 ^{d-f}	2.53 ^{c-e}	1.17 ^{de}	1.32 ^f	60.05 ^{c-e}
5 th FV ₃	31.66 ^{c-e}	2.40 ^{de}	1.13 ^{de}	1.13 ^f	63.25 ^a
5 th FV ₄	26.87 ^{ef}	2.44 ^{c-e}	1.13 ^{de}	2.96 ^f	62.46 ^{bc}

Mean pairs with different letters are significantly different at the 5% probability level according to Duncan's new multiple range test; WAS = Weeks after sowing

Photosynthetically Active Radiation (PAR)

Table 2 presented results of the effect of sowing intervals on the photosynthetically active radiation (PAR) of four wheat varieties at 4, 6 and 8 WAS. At 4 and 6 WAS, the PAR for WZ 273 2015 increased ($p \leq 0.05$) tremendously relative to other varieties. However, at 8 WAS, *Imam* recorded the highest ($p \leq 0.05$) value ($73.17 \mu\text{mol m}^{-2}\text{s}^{-1}$) though at a later stage. Despite the variations, *Imam* had higher overall PAR, indicating stronger photosynthetic performance and greater accumulation of photosynthetic products (Zhang *et al.*, 2025) than all other varieties. Sowing intervals had significant ($p \leq 0.05$) impact on the photosynthetic activities of wheat. While early sowing allows for a larger, well-developed canopy, delay in sowing can minimize photosynthesis and increase leaf senescence, thereby decreasing post-anthesis biomass accumulation (Zhan *et al.*, 2021). The highest PAR was consistently recorded for the 5th December sowing interval relative to other SIs. A similar trend was observed for the wheat varieties and SIs interactions.

Table 2: Effect of Sowing Interval on the Photosynthetically Active Radiation (PAR) of Four Spring Wheat Varieties

Treatments	PAR 4 WAS $\mu\text{mol m}^{-2}\text{s}^{-1}$	PAR 6 WAS $\mu\text{mol m}^{-2}\text{s}^{-1}$	PAR 8 WAS $\mu\text{mol m}^{-2}\text{s}^{-1}$
Wheat variety (V)			
Imam (V ₁)	34.86 ^b	39.58 ^c	73.17 ^a
Sc. Sahai (V ₂)	28.35 ^d	49.55 ^b	51.68 ^b
Norman (V ₃)	31.60 ^c	39.50 ^c	58.77 ^c
WZ 273 2015 (V ₄)	42.47 ^a	58.82 ^a	67.29 ^b
Sowing intervals (SIs)			
5 th December (5 th D)	41.96 ^a	54.72 ^a	74.10 ^a
5 th January (5 th J)	36.75 ^b	46.69 ^b	69.25 ^b
5 th February (5 th F)	33.55 ^c	43.29 ^c	63.14 ^c
SIs × V			
5 th DV ₁	40.00 ^b	54.30 ^{bc}	85.13 ^a
5 th DV ₂	37.08 ^c	47.91 ^d	79.16 ^b
5 th DV ₃	32.14 ^d	55.06 ^b	64.40 ^c
5 th DV ₄	45.03 ^a	61.11 ^a	83.40 ^{ab}
5 th JV ₁	30.00 ^e	39.80 ^e	60.53 ^d
5 th JV ₂	25.16 ^f	35.08 ^e	42.34 ^f
5 th JV ₃	20.62 ^h	24.17 ^f	45.19 ^e
5 th JV ₄	23.11 ^g	26.75 ^{ef}	39.82 ^g
5 th FV ₁	17.00 ⁱ	21.84 ^g	31.03 ^h
5 th FV ₂	16.50 ^{ij}	21.04 ^g	30.03 ^h
5 th FV ₃	14.14 ^j	19.89 ^h	26.16 ⁱ
5 th FV ₄	12.14 ^k	17.80 ^{hi}	21.58 ^j

Mean pairs with different letters are significantly different at the 5% probability level according to Duncan's new multiple range test; PAR= Photosynthetically active radiation; WAS = Weeks after sowing

Yield Components

The results of effect of sowing intervals on yield components of four spring wheat varieties are presented in Table 3. There was a significant ($p \leq 0.05$) varietal differences in spike length at 10 WAS. WZ 273 2015 recorded a higher spike length (7.52 cm) relative to other varieties, which however, were statistically at par. Among the SIs, 5th December had the highest ($p \leq 0.05$) spike length and weight while 5th January had the greatest ($p \leq 0.05$) number of spikelets/main spike. The significant ($p \leq 0.05$) differences in spike length across the varieties and sowing time may be attributed to their genetic diversity and favorable season that supported sufficient assimilate absorption and translocation of photosynthates (Al-Salem, 2018). Significant interaction effect of 5th December × WZ 273 2015 recorded highest ($p \leq 0.05$) spike length (8.33 cm) for WZ 273 2015 when sown on 5th December, while



the interaction of 5th February \times Imam gave the lowest spike length of 4.74 cm for Imam when sown on 5th February. There were no significant varietal or SI differences either singly or interactively in the number of spike/plant. The discrepancy in this trait may be due to the effect of different environmental conditions on the crop's performance. WZ 273 2015 variety had higher ($p \leq 0.05$) number of spikelets/main spike relative to other varieties except Norman. Similarly, WZ 273 2015 had the highest ($p \leq 0.05$) spike weight as compared with other varieties. Sowing intervals significantly ($p \leq 0.05$) enhanced spikelet counts, as plants sown on 5th January gave the highest ($p \leq 0.05$) number of spikelets/main spike (22.82) compared with other SIs. However, the spike weight across the SIs was highest ($p \leq 0.05$) for 5th December (16.09 g) compared with other SIs. This variation in spike development may be due to the late sowing effect which may have affected the overall vegetative performance of the plants, especially the straw count that is directly attributed to spikelet production (Mahmood *et al.*, 2021).

Plant Dry Weight, Number of Grains and Grain Weight

The effect of sowing intervals on plant dry weight, number of grains/plant and grain weight/plant of four spring wheat varieties are presented in Table 4. The result indicated that among the wheat varieties, WZ 273 2015 (22.47 g) and Norman (21.49 g) had significantly ($p \leq 0.05$) higher dry weight than Imam (16.98 g), with Sc. Sahai having the least dry weight of 14.39 g. 5th December sowing interval produced the highest ($p \leq 0.05$) wheat dry matter yield compared with other SIs. The interaction results indicate that both Norman and WZ 273 2015 significantly ($p \leq 0.05$) produced higher dry weight on 5th December SI relative to other varieties. Timely sown crops may take longer than expected to achieve the required development which could account for higher dry matter accumulations. On the other hand, a crop that was sown later may have a shorter growth season, which could lead to shorter plant heights and fewer tillers, both of which can decrease the amount of dry matter accumulated in plants (Jin *et al.*, 2018). WZ 273 2015's higher dry matter accumulation may be due to faster initial growth, more tillering and larger leaf area, all of which increased photosynthetic efficiency and dry matter yield. This result is similar to that in Bachhao *et al.* (2018) and Jin *et al.* (2018).

Sowing intervals affected the number of grains and grain weight per plant, with the highest ($p \leq 0.05$) values (19.61 g; 10.15 g) recorded in WZ 273 2015 when planted on 5th December. This confirmed the crop's ability to perform best under the optimum weather timing due to greater efficiency in photosynthates accumulation from source to sink (Kaur *et al.*, 2020). Differences in grain yield among the varieties might be due to the inherent quality of the varieties. Delayed seeding can lead to reduced grain yield due to a decrease in the number of grains per spike and other yield-contributing factors (Li *et al.*, 2023). The increased biomass accumulation observed in WZ 273 2015 could be attributed to timely efficient utilization of radiation and nutrients. Consequently, WZ 273 2015 exhibited heightened photosynthetic activity at its critical growth stages which ultimately led to a greater grain yield (Kaur *et al.*, 2020).

Table 3: Effect of Sowing Interval on Yield Attributes of Four Spring Wheat Varieties

Treatment	Spike length (cm)	Number of spike/plant	Number of spikelets/main spike	Spike weight/plant (g)
Wheat variety (V)				
Imam (V ₁)	5.59 ^b	4.50 ^a	11.65 ^d	14.95 ^b
Sc. Sahai (V ₂)	5.75 ^b	4.51 ^a	15.96 ^c	12.27 ^c
Norman (V ₃)	5.93 ^b	4.31 ^a	21.16 ^{ab}	14.88 ^b
WZ 273 2015 (V ₄)	7.52 ^a	4.59 ^a	22.57 ^a	22.60 ^a
Sowing intervals (SIs)				
5 th December (5 th D)	6.89 ^a	5.44 ^a	20.70 ^b	16.09 ^a
5 th January (5 th J)	4.81 ^b	5.44 ^a	22.82 ^a	14.03 ^b
5 th February (5 th F)	3.86 ^c	5.55 ^a	20.46 ^b	14.12 ^b
SIs × V				
5 th DV ₁	6.00 ^c	4.50 ^a	22.55 ^{ab}	14.35 ^{bc}
5 th DV ₂	7.67 ^b	4.32 ^a	22.94 ^{ab}	15.06 ^{ab}
5 th DV ₃	7.00 ^{bc}	4.29 ^a	21.78 ^{ab}	14.43 ^b
5 th DV ₄	8.33 ^a	4.66 ^a	21.55 ^{ab}	15.56 ^a
5 th JV ₁	5.32 ^c	4.55 ^a	21.61 ^{ab}	13.27 ^c
5 th JV ₂	5.33 ^c	4.50 ^a	23.89 ^{ab}	13.23 ^c
5 th JV ₃	6.55 ^{bc}	4.33 ^a	22.22 ^{ab}	10.27 ^{cd}
5 th JV ₄	6.55 ^{bc}	4.38 ^a	26.05 ^a	9.16 ^d
5 th FV ₁	4.74 ^d	4.44 ^a	19.11 ^{ab}	7.63 ^e
5 th FV ₂	5.84 ^c	4.70 ^a	18.00 ^b	4.33 ^f
5 th FV ₃	5.77 ^c	4.32 ^a	18.00 ^b	4.20 ^f
5 th FV ₄	5.85 ^c	4.73 ^a	18.33 ^b	3.40 ^{fg}

Mean pairs with different letters are significantly different at the 5% probability level according to Duncan's new multiple range test.

Table 4: Effect of Sowing Interval on Plant Dry Weight, Number of Grains and Grain Weight of Four Spring Wheat Varieties

Treatment	Plant dry weight (g)	Number of grains/plant	Grain weight/plant (g)
Wheat variety (V)			
Imam (V ₁)	16.98 ^b	16.63 ^{bc}	8.32 ^b
Sc. Sahai (V ₂)	14.39 ^c	12.71 ^c	6.15 ^c
Norman (V ₃)	21.49 ^a	17.29 ^b	9.26 ^{ab}
WZ 273 2015 (V ₄)	22.47 ^a	19.61 ^a	10.15 ^a
Sowing intervals (SIs)			
5 th December (5 th D)	18.47 ^a	17.61 ^a	8.22 ^a
5 th January (5 th J)	13.38 ^b	11.17 ^b	5.20 ^b
5 th February (5 th F)	11.15 ^c	10.61 ^c	5.19 ^b
SIs × V			
5 th DV ₁	11.26 ^d	11.00 ^{cd}	7.35 ^c
5 th DV ₂	13.56 ^c	11.34 ^{cd}	10.11 ^b
5 th DV ₃	18.16 ^b	13.44 ^b	10.30 ^b
5 th DV ₄	21.13 ^a	15.67 ^a	12.16 ^a
5 th JV ₁	6.66 ^{ef}	9.36 ^f	5.12 ^{de}
5 th JV ₂	7.46 ^e	10.55 ^e	5.54 ^d
5 th JV ₃	7.08 ^e	12.88 ^c	5.66 ^d
5 th JV ₄	10.38 ^{de}	13.88 ^b	5.84 ^d
5 th FV ₁	5.35 ^f	6.54 ^g	2.23 ^{ef}
5 th FV ₂	3.94 ^g	6.00 ^{gh}	2.14 ^{ef}
5 th FV ₃	5.45 ^f	9.65 ^f	2.23 ^{ef}
5 th FV ₄	5.63 ^f	10.65 ^e	3.15 ^e

Mean pairs with different letters are significantly different at the 5% probability level according to Duncan's new multiple range test.



CONCLUSION AND RECOMMENDATION

The present results confirm that sowing intervals significantly ($p \leq 0.05$) affected growth, physiology, yield and yield components of wheat. *Imam* variety had the highest wheat growth when sown on 5th December. A similar trend was observed in the number of tillers and functional tillers. Flag leaf area was highest in WZ 273 2015 (23.17 cm²), while Norman had the least area (11.89 cm²). *Sc. Sahai* headed earlier than other varieties, whereas WZ 273 2015 was more efficient in intercepting light at 4 and 6 WAS for optimal canopy structure and elevated yields. Sowing time is a very important management strategy to improve the productivity of wheat crops. Early sowing (5th December) produced the maximum yield components across the wheat varieties. Earlier sowing (5th December) rather than later sowing (5th January and February) enhanced dry matter accumulation and grain yield in WZ 273 2015. In all, the results show that early sowing time optimizes wheat productivity. Prior to disseminating the present results to farmers, more field studies are recommended to validate the findings in this research.

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