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Evaluating effective sowing date for better yield production of lady finger under prevailing climatic conditions

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ABSTRACT

The growth of crops is directly influenced by growing degree days. Fluctuations in mean temperature reduce the yield of crops, particularly lady finger. Evaluating sowing dates is essential for achieving higher yield production. This study aimed to evaluate the yield aspects of lady finger under varying sowing dates. The experiment was designed using a Completely Randomized Design (CRD) approach, incorporating three

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biological replications. The sowing dates are as follows: (1) SD1: January 15, (2) SD2: February 15, (3) SD3: March 15, and (4) SD4: April 15. The results indicated that plant height, stem diameter, pods per plant, and individual pod weight increased by 12%, 21%, 33%, and 39%, respectively, in SD3 compared to SD2, attributed to higher growing degree days. This was ascribed to increased nitrogen content and chlorophyll production by 21% and 28% in SD3 compared to SD2. The elevated SD4 exhibited detrimental effects on growth and yield parameters. The SD3 indicates an optimal sowing choice for achieving higher yields of lady finger in the trending climatic conditions.

Keywords: Growth pattern, Assimilation, Yield production, Climate change, Sustainability

Introduction

Climate refers to resilient changes in weather patterns, whereas environment change is a gradually global precipitation, temperature, as well as wind shift that affects land and water regimes and agricultural output (Abbass et al., 2022). Nevertheless, Global vegetable yields and productivity are diminishing as a result of climate change, which interferes with physiological and enzymatic processes, resulting in crop failures, quality degradation, pest and disease complications, and overwintering challenges (Solankey and Kumari, 2023). Alleviating these repercussions can be accomplished by enhancing water utilization efficiency, optimizing crop management, and employing cultivars that are robust to elevated temperatures, moisture stress, salinity, and climatic variability (Ahmed et al., 2023).

Vegetables are the essential elements of the human diet, serving as the principal source of nutrients, vitamins, and minerals (Ebabhi and Adebayo, 2022). Vegetables contain fruits, root and tuber varieties, leafy greens, and bulbs. They supply vitamins, carbohydrates, salts, and proteins, assisting smallholder farmers in increasing their income and securing employment (Schreinemachers et al., 2018). Okra is essential for food and nutritional security as well as livelihoods in several locations; nonetheless, it remains little explored and unenhanced (Massrie, 2025). Enhancing vegetable production and consumption can augment nutritional diversity and quality, particularly in diets characterized by high-calorie and low-micronutrient content. Okra, sometimes referred to as Lady Finger or Bhindi, is a significant agricultural vegetable crop in India and Haryana, classified under the Malvaceae hibiscus family (PRADESH, 2023). It is extensively found in tropical areas, including Nigeria. Okra may be cultivated as either a garden or commercial crop in nations such as India, Turkey, Nigeria, Sudan, Iraq, Pakistan, and Egypt (Idowu et al., 2022). Therefore, it is vital for human nutrition, supplying critical carbohydrates, proteins, fats, minerals, and vitamins frequently deficient in the diets of underdeveloped nations.

Okra develops in an extended, warm, and humid environment, although is susceptible to frost and severely low temperatures (KAMARA, 2024). The ideal temperature range is 21-30°C, with a minimum of 18°C and a maximum of 35°C. The plant is intolerant of low temperatures and frost over extended periods, with an ideal temperature range of 18°C to 35°C (Hayamanesh, 2018).

Modulation of climatic conditions facilitates the cultivation of many crops in the

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northern Indian plains during nearly the whole year. Notably, Agriculture in a temperate environment in southern India. An optimal environment for seed production includes little precipitation, low relative humidity, and high light intensity, characterized by hot and dry circumstances during the seed ripening phase.

Moreover, environmental extremes, such as elevated temperatures and diminished soil moisture, can adversely affect crop yields due to physiological and biochemical mechanisms. Climate change may exacerbate these challenges. In addition, solar radiation supplies energy to living creatures, affecting physiological processes. Optimal input parameters, such as temperature, humidity, and radiation, are essential for effective absorption and impact crop production, impacting all phases of crop development. Different studies shown that the optimal soil temperature conditions for okra seed germination are within the range of the temperature ranges from around 21 to 35 °C, with a minimum of 15.5 °C and a maximum of 40.5 °C. The present study was planned to access the morpho-physiological and yield aspects of lady finger varying sowing dates.

Materials and methods

A pot experiment was conducted to evaluate the response of lady finger (*Abelmoschus esculents L.*) to different sowing dates under controlled environmental conditions. The experiment was carried out during the spring season at the experimental area of department of soil science, Lasbela University of Agriculture, Water and Marine Sciences Uthal using a completely Randomized Design (CRD) with four sowing dates and three replications. The variety used in the study was Sabz pari a commonly cultivated and yielding lady finger cultivar known for its adaptability and vigor. The four sowing date were selected at one month intervals as follows: SD1: January 15; SD2: February 15; SD3: March 15 and SD4 April 15. Plastic pots (30cm diameter * 35cm height) were filled with 10kg of a well-mixed soil-sand – FYM mixture in a 2:1:1 ratio. The soil used was loamy with good drainage and pH maintained at 6.5-7.0. Prior to sowing, soil was sterilized to prevent diseases infestation. Three seeds per pot were sown at a depth of 2-3cm and later thinned to retain one healthy seedling per pot after germination. Recommended agronomic practices such as timely irrigation, manual weeding, and pest control were uniformly applied to all treatments throughout the growing period.

Data collection

SPAD Chlorophyll content was measured using a portable SPAD meter on fully expanded upper leaves. The plant Nitrogen content was determined by Kjeldahl digestion method. The plant height was measured from the base to the apex of the plant. The stem diameter was measured by using Vernier caliper at the base of stem. The individual pod weight was measured after harvesting by using digital balance.

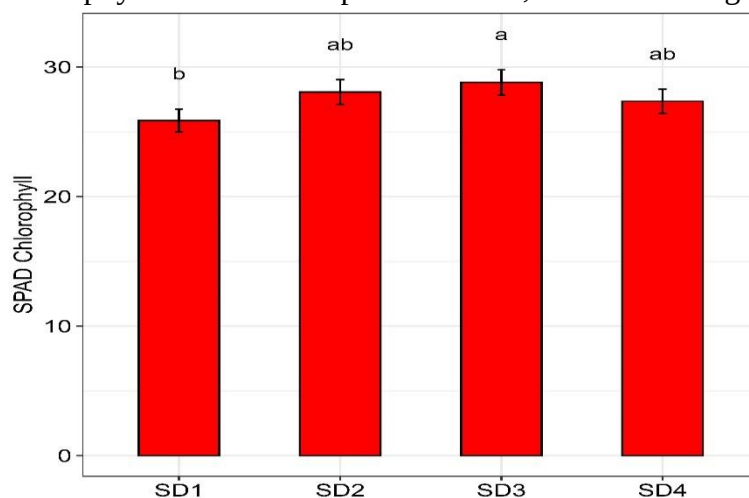
Statistical analysis

The data collected was subjected to analysis of variance (ANOVA) using statistics 8.1 software. Treatment means were compared using Tukey's Honest Significant Difference (HSD) test at a 5% level of significance to determine the significance and ranking of the sowing dates for each parameter.

Results

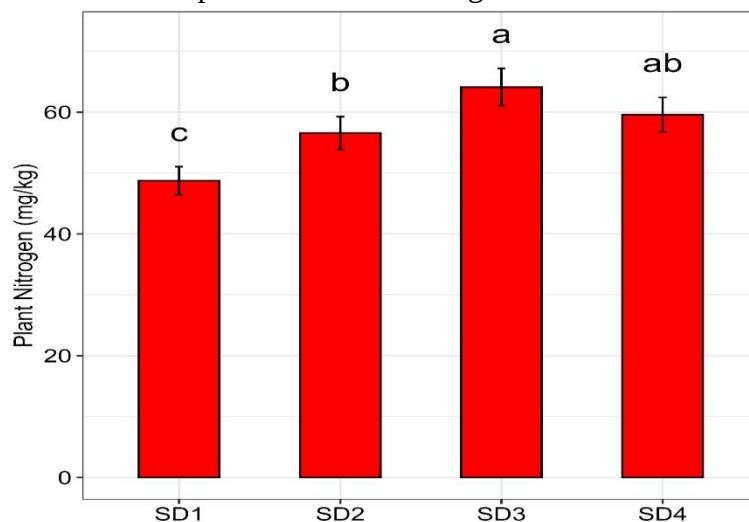
SPAD chlorophyll

The overall effect of sowing dates on SPAD chlorophyll content of lady finger was significant. The highest SPAD value was recorded in SD3 (28.81) which was statistically higher than SD1 (25.86) but statistically at par with SD2 (28.06) and SD4 (27.35). Compared to SD1, SD3 showed an 11.0% increase in SPAD values. The lowest value recorded in SD1, indicates that late sowing considerably reduced chlorophyll content under pot conditions, as shown in Fig. 1.



Plant Nitrogen content

The overall effect of sowing dates on plant nitrogen content of lady finger was significant. SD3 exhibited the highest nitrogen content (64.12%), which was significantly higher than SD2 (56.56%) and SD1 (48.74%), but statistically similar to SD4 (59.57%). Compared to SD1 nitrogen content in SD3 increased by 31.5%. The lowest nitrogen value in SD1 confirms that delayed sowing reduced nitrogen assimilation in plants as shown in Fig. 2.



Plant Height

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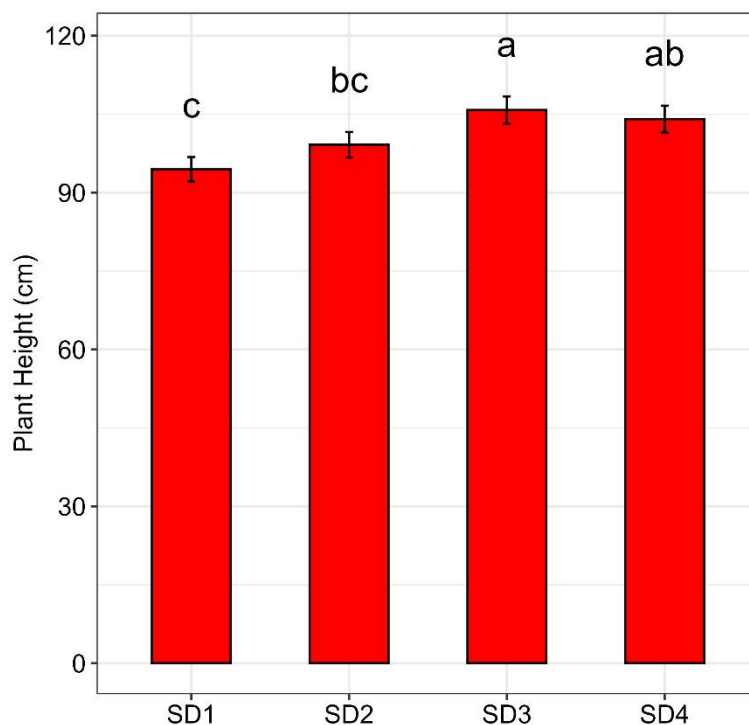
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The overall effect of sowing dates on plant height of lady finger was significant. The tallest plants were observed in SD3 (105.80cm), which was significantly taller than SD1 (94.46cm) and SD2 (99.14cm), while being statistically at par with SD4 (104.06 cm). Plant height in SD3 was 12.0% greater than in SD1. The shortest plant height recorded under SD1 indicates that late sowing adversely affected vertical growth as shown in Fig. 3.



Stem Diameter

The overall effect of sowing date on stem girth of lady finger was significant, Maximum stem diameter was observed in SD3 (2.18mm) which was statistically similar to SD4 (2.15mm) but significantly higher than SD1 (2.00mm). Compared to SD1, SD3 showed a 9.0% increases in stem girth. The reduced diameter in SD1 suggest that delayed sowing compromised stem thickness and structural robustness as shown in Fig. 4.

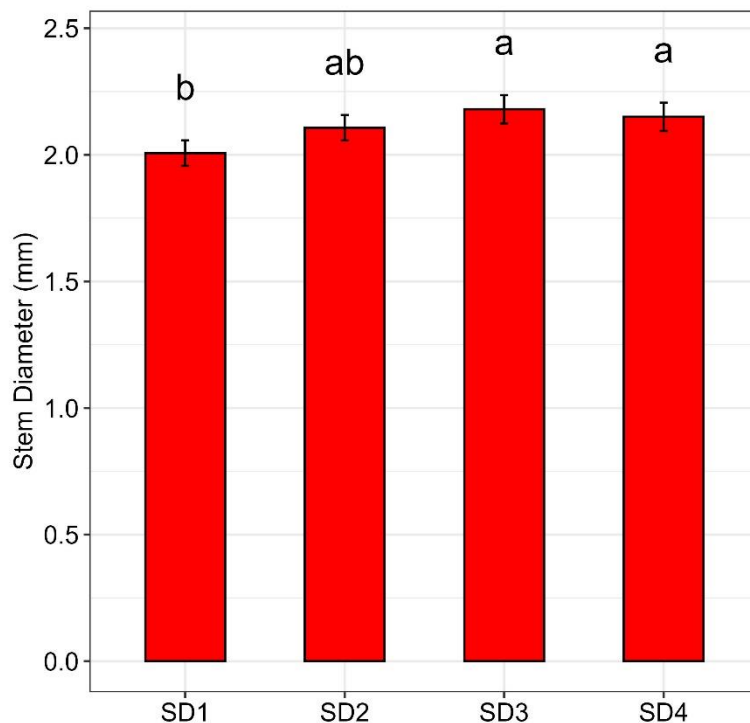
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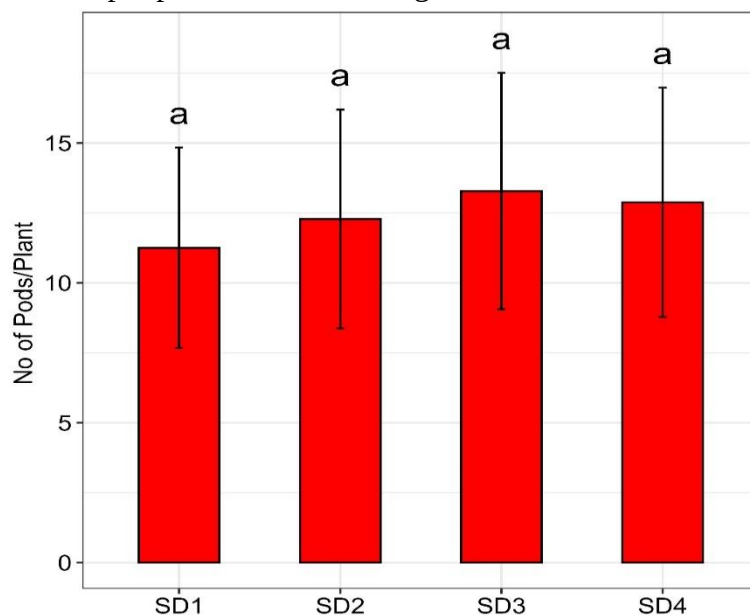
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Number of Pods per plant

The overall effect of sowing dates on the number of pods per plant of lady finger was non-significant. Although the highest number of pods was recorded in SD3 (13.28), followed by SD4 (12.88), SD2 (12.29) and SD1 (11.25), all sowing dates were statistically at par with each other. Compared to SD1, SD3 showed a 17.9% increase in the number of pods. However, late sowing in SD1 still resulted in the lowest pod number per plant as shown in Fig. 5.



Individual Pod weight

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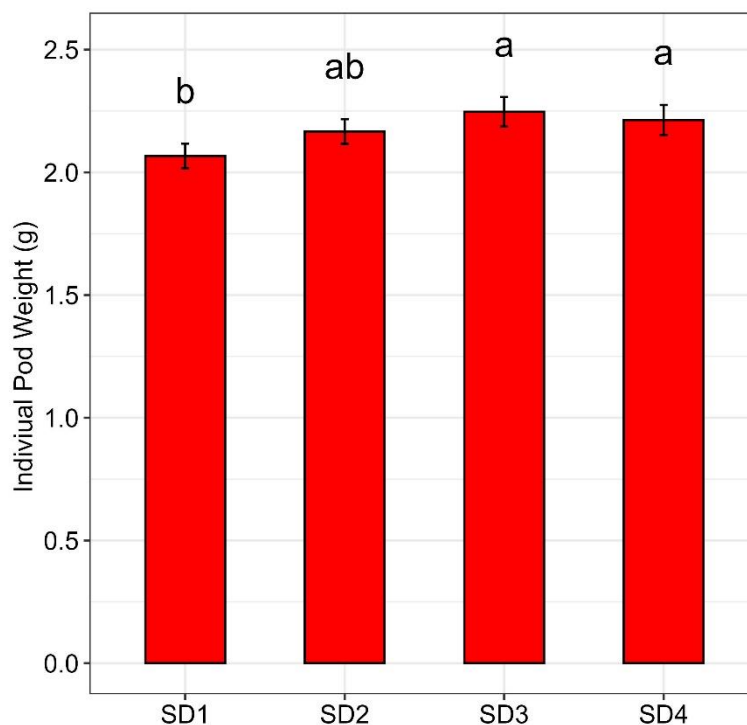
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The overall effect of sowing dates on individual Pod weight of lady finger was significant maximum pod weight was recorded in SD3 (2.25g), which was significantly higher than SD1 (2.07g), While being statistically at par with SD4 (2.21g) and SD2 (2.17g). Compared to SD1 SD3 exhibited an 8.7% increases in pod weight. The minimum value in SD1 highlights the reduction in pod development due to delayed sowing as shown in Fig. 6.



Discussion

The sowing date plays a pivotal role in determining the growth and productivity of crops, particularly temperature- sensitive vegetables like a lady finger (*Abelmoschus esculentus*) (Begum, 2025). Among all the tested sowing dates, The March 15 sowing (SD3) emerged as the most suitable window, showing clear advantage in physiological growth and yield parameters (THAPA, 2023). The improvement in plant length in SD3 can be attributed to optimal growing degree days (GDD), which provided a favorable temperature range for cell division and elongation, leading to increased intermodal length and overall vertical growth (Mohd Khairani et al., 2020). This phenomenon is physiologically linked with enhanced meristematic activity and higher auxin levels under moderate temperatures (de Wit et al., 2014). Previous studies by (Tsimba et al., 2013) also reported that sowing under moderate thermal regimes positively influences plant height by supporting uninterrupted vegetative development. In addition, temperature fluctuations during early or late sowing (SD1 or SD4) likely triggered hormonal imbalances or stress-induced growth retardation, thereby limiting height (Bhattacharya, 2022).

The stem girth was also found to be superior in SD3, and this could be physiologically explained by enhanced secondary growth due to better cambial activity under optimal temperature condition (Lopes et al., 2015). Adequate thermal accumulation facilitates better lignin synthesis, vascular tissue differentiation, and cell wall thickening which

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collectively improve stem thickness and structural strength (Wu et al., 2017). The work of (Sahoo et al., 2025; Wu et al., 2017) support these findings, where timely sowing significantly increased stem robustness in vegetables due to better assimilate partitioning toward structural development. Moreover, a healthy stem is essential for efficient translocation of water, minerals and photoassimilates, all of which contributes to higher yield output (Shakya and A. Lal, 2018).

Reproductive traits such as seed pod and pod per plant are highly sensitive to environmental conditions, especially during flowering and pollination stages (Ohnishi et al., 2010). The enhanced seed set and pod formation in SD3 can be attributed to the synchronization of critical reproduction phases with favorable environmental conditions particularly moderate daytime temperatures and cooler nights which promotes pollen viability stigma receptivity, and fertilization success (Mehmood et al., 2025). These results are in line with the finding of (Zhu et al., 2021) who observed that crops sown under optimal temperature conditions had significantly higher fruit and seed development. Physiologically, moderate temperature during anthesis ensure higher carbohydrates availability for floral organs and prevent heat-induced flower or fruit abortion, which often a major cause of yield loss in late sowing (SD4).

The Pods per plant, an important yield component, were also observed in greater numbers in SD3. This could be associated with better hormonal balance, particularly the balance between cytokinin and gibberellins, which are known to regulate floral induction and fruit set (Barbosa and Dornelas, 2021). An increased number of pods reflect better source sink relationship and is also indicative of improved nutrient assimilation and sustained photosynthesis throughout the pod development phase (Smith et al., 2018). (Agrawal et al., 2023; Thakur et al., 2012) documented similar trends in okra where sowing during the mid-season led to a higher number of pods due to synchronized flowering and optimal photosynthetic activity. Improved nitrogen content under SD3 further supports the idea that ideal sowing dates enhance physiological efficiency (Guo et al., 2022). Nitrogen is a critical element involved in chlorophyll synthesis, amino acid formation, and nucleic acid metabolism. In this study, the higher nitrogen uptake could be attributed to more active root growth and enhance microbial activity in the rhizosphere under favorable temperature (Zayed et al., 2023). Moreover, nitrogen assimilation is known to peak when root uptake coincides with vegetative expansion, which was clearly more coordinated in SD3. A study by (Wang et al., 2021) similarly reported that sowing time effect nitrogen dynamics in the soil, with mid-season sowings enhancing both uptake and assimilation efficiency. Closely linked to nitrogen metabolism is chlorophyll content, which was notably higher in SD3 plants (Muhammad et al., 2022). Chlorophyll is the principal pigment for light harvesting, and its biosynthesis is directly dependent nitrogen availability and temperature stability (Simkin et al., 2022). Moderate temperature conditions prevent photo oxidative damage and protect chlorophyll molecules from degradation, ensuring sustained photosynthesis. Enhanced chlorophyll content reflect higher carbon assimilation, improved stomatal conductance, and ultimately grater biomass accumulation (ZHANG et al., 2023). (Lv et al., 2023)also reported that mid-season sowing preserved chlorophyll content in okra and related crops by avoiding both cold and heat stress, which are known to denature chlorophyll-binding proteins.

Physiologically, the cumulative improvement in plant height, stem girth, seed

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development, and chlorophyll content indicates that the SD3 sowing date provided a balanced environment for both vegetative and reproductive growth phases, minimizing abiotic stress during sensitive's stages (Guo et al., 2022). Additionally, the positive correlation observed between physiological traits and yield attributes confirms the integrative role of these physiological processes in governing final yield outcomes (Guo et al., 2022). Efficient nitrogen uptake, preserved chlorophyll content, and optimal temperatures together created an ideal condition for achieving higher yield potential (Govindasamy et al., 2023).

Conclusion

In summary, the findings of this study underscore the critical role of sowing date optimization in aligning crop growth cycles with favorable environmental conditions. SD3 (March 15) proved to be the most suitable sowing window for maximizing yield, owing to its supportive impact on plant structure, physiological functioning, and reproductive efficiency. These results are not only consistent with previous agronomic research but also carry vital implications for developing climate-resilient cropping calendar under changing climatic scenarios. Therefore, it is recommended that farmers and agronomists consider March sowing for lady finger cultivation to exploit the synergistic effect of temperature growth, and nutrient dynamics for higher yield realization.

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