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Assessing the Effect of Sowing Methods and Nutrient Management on Growth and Development of Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Integrated nutrient management (INM) combines multiple organic sources to ensure a balanced supply of essential nutrients, improving plant growth and resilience. Understanding the interaction between sowing methods and nutrient management in organic wheat farming is essential for optimizing crop productivity and environmental sustainability. The present study aims to evaluate the effects of different sowing methods and nutrient management strategies on the growth and

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development of wheat under organic farming conditions. A field experiment was conducted during the *rabi* seasons of 2022–23 and 2023–24. The experiment was laid out in a strip plot design with three replications and horizontal strip four sowing methods treatments *viz.* S_1: Line sowing, S_2: Criss cross sowing, S_3: Line sowing with 150 % seed rate and S_4: Criss cross sowing with 150% seed rate and vertical strip six organic nutrient management *viz.* N_1: 100% RDN, N_2: 75% RDN + Azotobacter + PSB, N_3: 100% RDN + Azotobacter + PSB, N_4: 75% RDN + Azotobacter + 4 foliar spray of 10 % Cow urine at 20 days interval, N_5: 100% RDN + Azotobacter + PSB + 4 foliar spray of 10 % Cow urine at 20 days interval and N_6: 125% RDN. Results indicated that CGR, RGR, and LAI increased from the early vegetative phase to the reproductive stage, then declined towards maturity due to leaf senescence and remobilization of assimilates. Among sowing methods, criss-cross sowing with 150% seed rate (S4) consistently produced the highest CGR, RGR, and LAI, highlighting the benefits of better plant distribution and canopy structure. Nutrient management significantly influenced LAI and LPR, with the highest values recorded under 125% RDN (N6) and 100% RDN integrated with biofertilizers and cow urine foliar sprays (N5). The lowest growth values were found under the lowest nitrogen level with biofertilizers (N2). The interaction effect between sowing methods and nutrient management was non-significant for all parameters, indicating independent effects. Among nutrient management treatments, applying 125% of the recommended dose of nitrogen produced superior results across most growth parameters, highlighting the importance of adequate nitrogen availability for optimum growth and canopy development. The integrated use of biofertilizers and organic foliar sprays also showed promise, often yielding values comparable to the higher nitrogen level.

Keywords: Wheat, sowing methods; nutrient management; crop growth rate; leaf area index; strip plot design.

1. INTRODUCTION

To achieve the best possible coordination between soil moisture and temperature, sowing techniques should be improved. The sowing technique important because it affects how a crop stand should be established and producing individual plants requires balancing plant to plant combinations. Broadcasting, seed drilling, criss-cross, wide belt and furrow sowing are the main sowing techniques used to plant the barley crop, although other sowing techniques may have an impact on yield by changing how much water is used. While the line sowing method is recommended due to its uniform seed distribution and planting at desired depth, which typically leads in higher germination and uniform stand, broadcasting not only demands a larger seed rate but also results in lower or higher plant population (Bakhsh et al., 2020; Saini et al., 2024). Wheat (*Triticum aestivum* L.) is one of the most important staple crops globally, playing a significant role in food security and agricultural sustainability. Under organic farming systems, optimising sowing methods and nutrient management is crucial to achieving high productivity while maintaining soil health. Organic farming emphasises the use of natural inputs, soil biodiversity, and sustainable practices to enhance crop growth and development. Sowing methods influence seed germination, crop establishment, and overall yield performance. Traditional sowing techniques such as broadcasting and line sowing have been widely used, but recent advancements in precision seeding have improved resource efficiency. Proper sowing ensures better root development, nutrient uptake, and resistance to environmental stressors. Among the various management practices, management of nutrient is very important in crop nutrition in order to produce larger yield. Expectation for nutrient application in agricultural system in future is to be increasing to produce more food, feed and fiber from lesser land area. Efficient utilization of applied nutrients will be the key to sustainability in such high input-high output systems (Kumar et al., 2023; Marufi et al., 2024). Nutrient management in organic farming relies on organic amendments such as compost, manure, and biofertilizers, which enhance soil fertility without the negative impacts associated with chemical fertilizers. Integrated nutrient management (INM) combines multiple organic sources to ensure a balanced supply of essential nutrients, improving plant growth and resilience. Understanding the interaction between sowing methods and nutrient management in organic wheat farming is essential for optimizing crop productivity and environmental sustainability. This study aims to evaluate the effects of different sowing methods and nutrient management strategies on the growth and development of wheat under organic farming conditions. The findings will contribute to developing sustainable agricultural practices that enhance wheat yield while preserving soil health and ecosystem integrity.

2. MATERIALS AND METHODS

2.1 Experimental Details

The study was conducted at the Instructional-cum-Research Farm, IGKV, Raipur (C.G) during the *Rabi* seasons of 2022-23 and 2023-24. The experiment was laid out in a strip-plot design with three replications, comprising 24 treatment combinations. Four sowing methods were assigned to horizontal strips, while six organic nutrient management treatments were assigned to vertical strips. The test wheat variety "Amber" was sown on 10 December and 14 December during *rabi* 2022-23 and 2023-24 respectively.

2.2 Growth Parameters

2.2.1 Crop growth rate (CGR, g plant^{-1} day^{-1})

Crop growth rate was calculated by using the formula suggested by Watson (1952) and expressed in g plant^{-1} day^{-1}

$$\text{CGR} = \frac{w_2 - w_1}{t_2 - t_1} S$$

Were,
CGR = Crop growth rate (g plant^{-1} day^{-1})
W_1 and W_2 = are plant dry weight (g) at time t_1 and t_2, respectively

S is land area (m^2) over which dry matter was recorded.

2.2.2 Relative growth rate (RGR, g g^{-1} day^{-1})

The relative growth rate of crops at time instant (t) is defined as the increase of plant material per unit weight per unit time. It is expressed in g g^{-1} day^{-1}

$$\text{RGR} = \frac{In\, w_2 - In\, w_1}{t_2 - t_1}$$

Where,
ln = Natural logarithm
W_1 and W_2 are plant dry weight at time t_1 and t_2, respectively.

2.3 Leaf Area Index (LAI)

The leaves from five plants were taken at 30, 60 and 90 DAS for measuring the leaf area. During these stages, the leave was divided into three groups *i.e.,* small, medium and large size. The leave of each group was arranged in above group and separately to measure the length and width. The length and width of each group were multiplied in their respective number of leaves.

A = L X W X 0.75 (Chanda & Singh, 2002)

Where,
A= Laef area, L = Length of leaf, W = Width of leaf

The leaf area index of each stage was calculated by following formula:

$$\text{LAI} = \frac{Leaf\ area}{Ground\ area}$$

Table 1. Details of treatment

Symbol	Treatments
	A. Horizontal strip- Sowing Methods
S_1	Line sowing
S_2	Criss cross sowing
S_3	Line sowing with 150 % seed rate
S_4	Criss cross sowing with 150% seed rate
	B. Vertical strip – Organic Nutrient Management
N_1	100% RDN
N_2	75% RDN + Azotobacter* + PSB*
N_3	100% RDN + Azotobacter + PSB
N_4	75% RDN + Azotobacter + PSB + 4 foliar spray of 10 % cow urine at 20 days interval
N_5	100% RDN + Azotobacter + PSB + 4 foliar spray of 10 % cow urine at 20 days interval
N_6	125% RDN

*Note- All nutrient applied through organic sources. (75% nitrogen through FYM and 25% nitrogen vermicompost) *Seed treatment of PSB @ 5 g kg^{-1} seed *Seed treatment of Azotobacter @ 10 g kg^{-1} seed *RDN (Recommended Dose of Nitrogen)*

2.4 Leaf Production Rate (LPR)

Leaf Production Rate can be estimated by counting the number of invers on randomly selected plants at periodical intervals. It is expressed as number of leaves day^{1}.

$$\text{LPR} = \frac{L_{n2} - L_{n1}}{t_2 - t_1}$$

Were, **L_{n2} =** Number of leaves at times ***t_2***. **L_{n1} =** Number of leaves at times ***t_1***

3. RESULTS AND DISCUSSION

3.1 Crop Growth Rate (g day^{-1} m^{-2})

The crop growth rate (CGR) is a critical parameter that reflects the accumulation of dry matter per unit area over time. It serves as an important indicator of plant growth performance and productivity. The CGR values recorded at different growth stages demonstrate a gradual increase from early vegetative stages to peak growth, followed by a decline towards maturity. This trend is primarily attributed to increased leaf area, enhanced photosynthetic efficiency, and improved nutrient uptake during vegetative and reproductive phases. The subsequent decline at harvest is likely due to the translocation of assimilates to reproductive structures and leaf senescence. The data on crop growth rate are depicted in Fig. 1.

The impact of sowing methods on CGR was not pronounced during the early growth phase but became significant at later stages. Among the sowing methods, criss-cross with 150% seed rate (S_4) recorded the highest CGR at all growth stages, indicating that better plant distribution and increased seed rate contributed to improved canopy structure, enhanced light interception, and efficient resource utilization, resulting in higher biomass accumulation. The lowest CGR was observed under line sowing (S_1), at all growth stages during both years and on a mean basis.

The dense planting in criss-cross sowing often leads to higher dry matter accumulation due to better light interception, while line sowing may have moderate accumulation due to wider spacing (Kumawat *et al.,* 1997, Silva and Gomez 1990, Dhingra *et al.,* 1987 and Bhatnagar *et al.,* 1990).

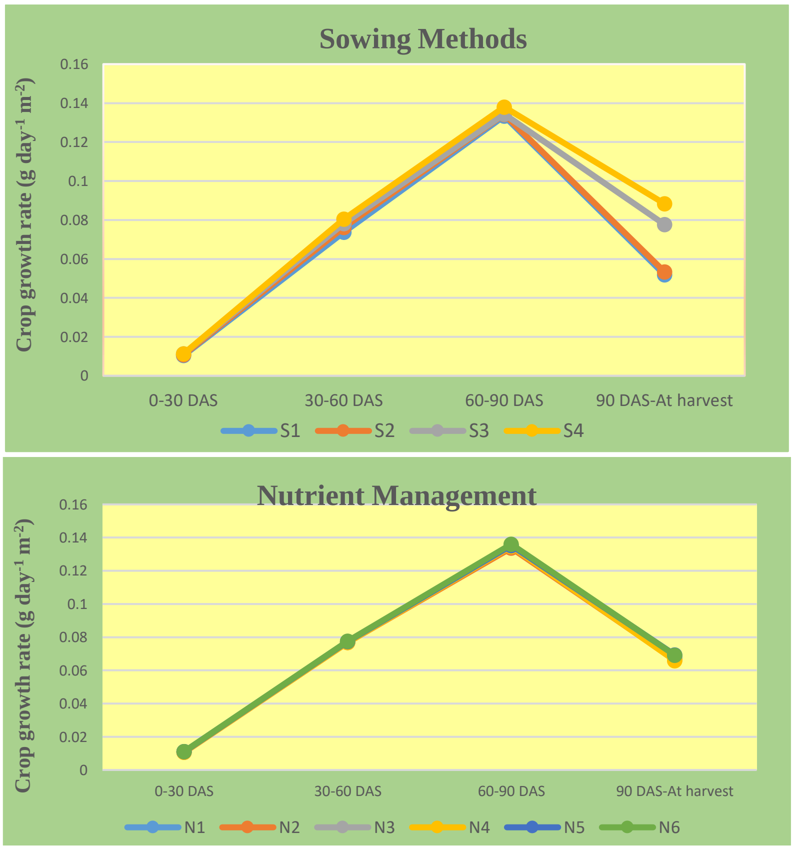


Fig. 1a. Crop growth rate (g day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (2022-23) at different time intervals

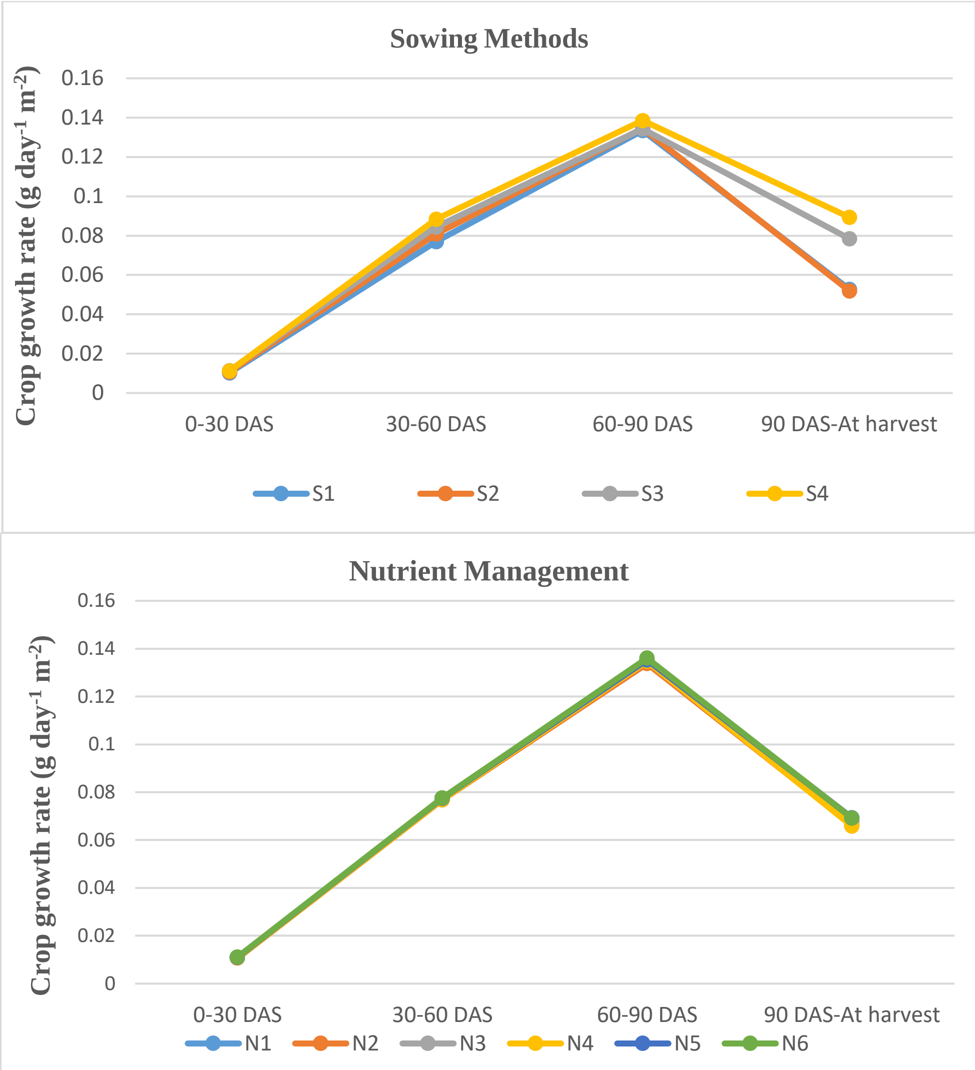
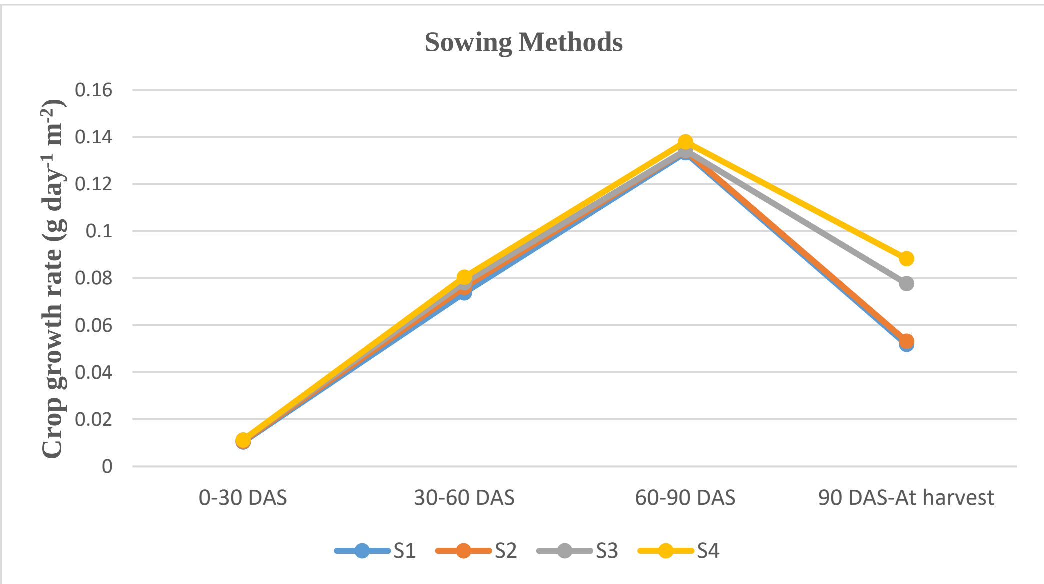


Fig. 1b. Crop growth rate (g day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (2023-24) at different time intervals



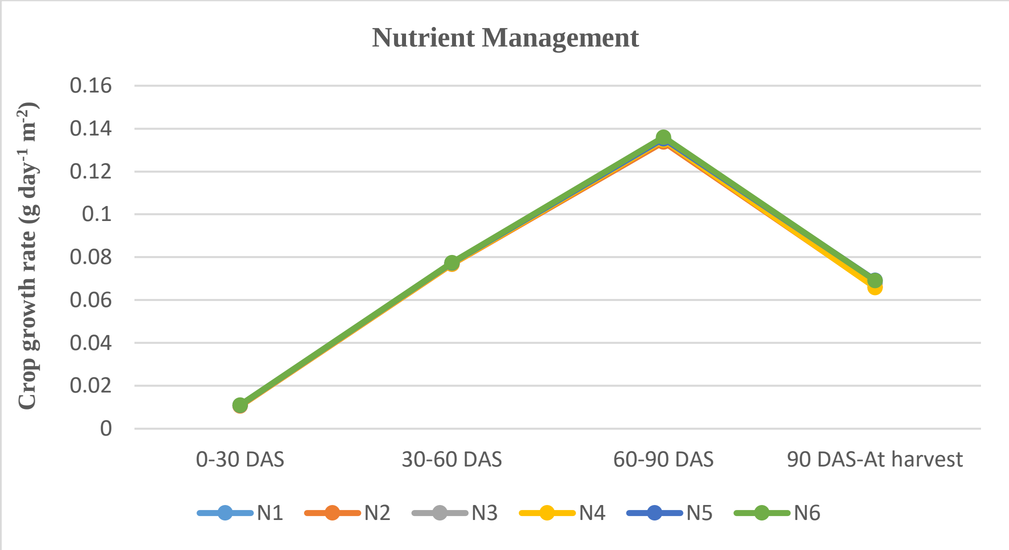


Fig. 1c. Crop growth rate (g day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (on mean basis) at different time intervals

The different nutrient management treatments were found non- non-significant at all growth stages. Higher CGR observed under 125% RDN (N_6) followed by 100% RDN + Azotobactor + PSB + 4 foliar sprays of 10% cow urine at 20 days intervals (N_5) during all growth stages except 60 DAS and at harvest during 2022-23. The lowest value was found under 75% RDN + Azotobactor +PSB (N_2) during both years and on the mean basis.

The interaction between sowing methods and nutrient management was found to be non-significant across all growth stages. This indicates that the effects of these factors operated independently and no combined interaction influenced CGR significantly. While both sowing methods and nutrient availability impacted crop growth, their combined effect did not exhibit any notable synergistic or antagonistic variations during both years and on a mean basis.

3.2 Relative Growth Rate (g g^{-1} day^{-1})

Relative growth rate (RGR) represents the increase in plant biomass relative to its existing size over time. It is a crucial physiological parameter that indicates the efficiency of resource utilization for plant growth. The RGR values recorded at 30-60 DAS, 60-90 DAS, and 90 DAS- at harvest of wheat during both the years and on mean basis are presented in Fig. 2 The results demonstrate a gradual decline in RGR with advancing crop growth stages. This decreasing trend can be attributed to the reduction in the number of actively growing leaves, increased respiration demand and redistribution of assimilates toward reproductive structures.

The influence of sowing methods on RGR was statistically non-significant at 30-60 DAS but became significant at 60-90 DAS and 90 DAS- at harvest, indicating that the effect of different sowing patterns becomes more pronounced in later stages of crop growth. Among the sowing methods, criss-cross with 150% seed rate (S_4) recorded the highest RGR at all growth stages, suggesting that an optimal plant distribution and higher seed rate contributed to better light interception and efficient utilization of nutrients. The increased canopy coverage in this method might have enhanced photosynthetic efficiency and biomass accumulation, leading to sustained growth over time.

Nutrient management treatments did not show statistically significant differences at any growth stage, the highest RGR was recorded in 100% RDN + Azotobactor + PSB + 4 foliar sprays of 10% cow urine at 20 days interval (N_5**)** during 2022-23 and 125% RDN (N_6) during 2022-23 at 90 DAS- at harvest. The lowest RGR was recorded in 75% RDN + Azotobactor + PSB + 4 foliar sprays of 10% cow urine at 20 days interval (N_4)**.**

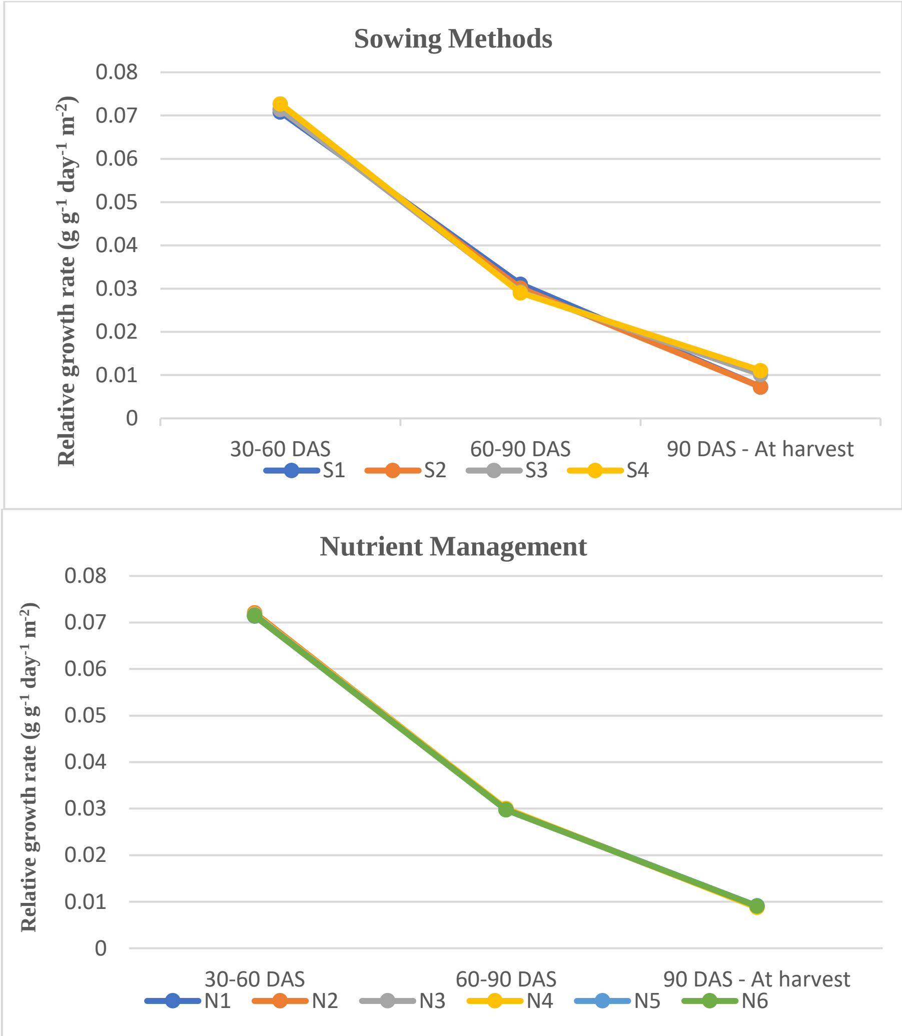
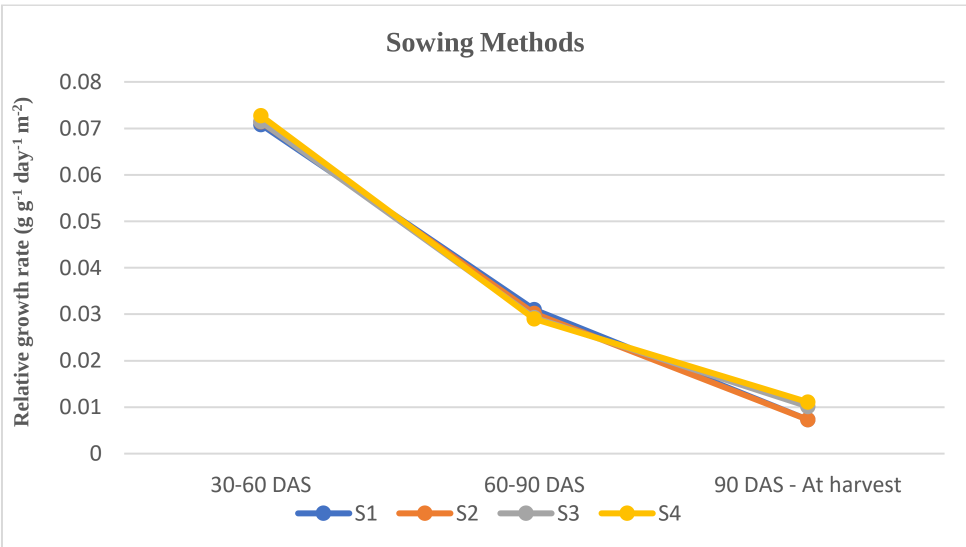


Fig. 2a. Relative growth rate (g g^{-1} day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (2022-23) at different time intervals



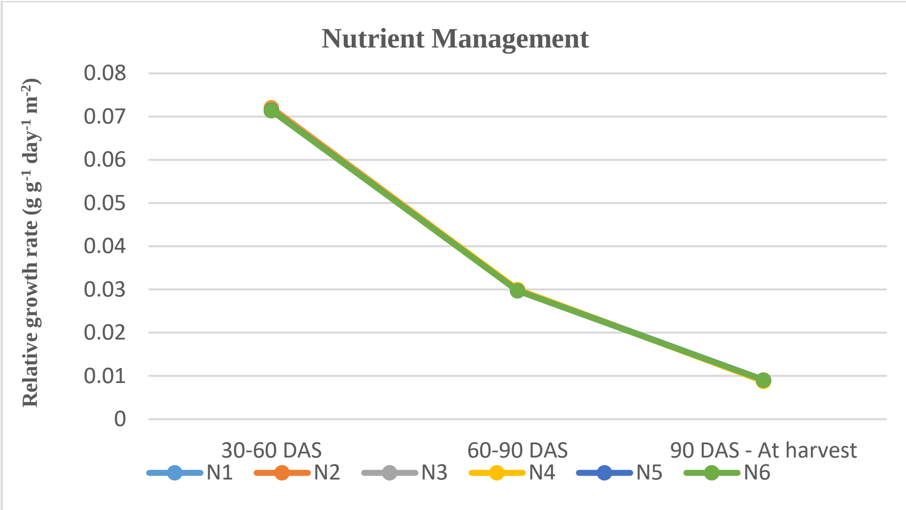


Fig. 2b. Relative growth rate (g g^{-1} day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (2023-24) at different time intervals

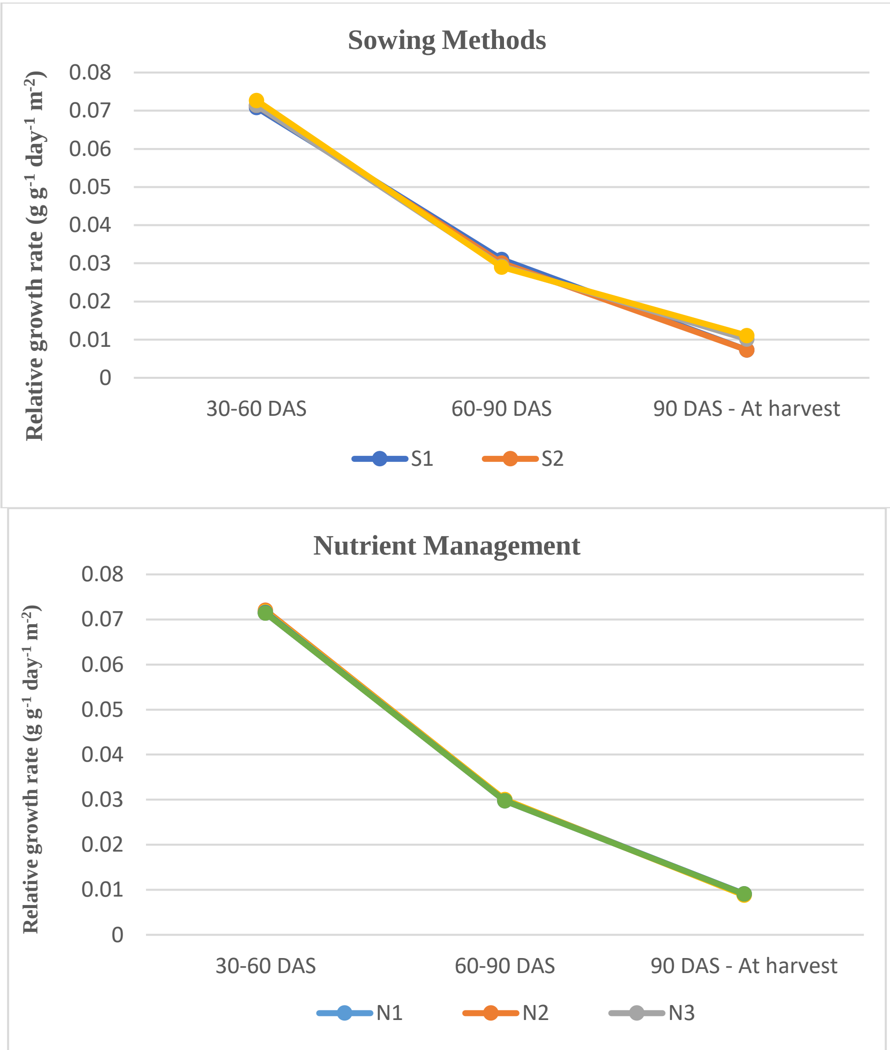


Fig. 2c. Relative growth rate (g g^{-1} day^{-1} m^{-2}) of wheat as influenced by sowing methods and nutrient management (mean basis) at different time intervals

The interaction among sowing methods and nutrient management did not cause significant variation in the relative growth of wheat during both the years and on mean basis.

3.3 Leaf Area Index

The Leaf Area Index (LAI) is a crucial physiological parameter that represents the leaf surface area per unit ground area**,** directly influencing photosynthetic capacity, light interception and crop growth performance**.** The LAI values recorded at 30 DAS, 60 DAS and 90 DAS for the 2022-23 and 2023-24 cropping seasons are presented in Fig. 3. The data reveal a progressive increase in LAI from 30 DAS to 90 DAS, irrespective of the sowing method and nutrient management treatments. The increasing trend of LAI with advancing crop growth stages can be attributed to leaf expansion, canopy development, and efficient utilization of available resources**.** The decreased number of leaves $plant^{-1}$ and poor leaf area at higher seed rate might be attributed due to inter-plant competition for the space, water, nutrient and light. The higher seed rate of 150 kg ha^{-1} could not influence the LAI and light interception (Harishankar *et al.,* 2017).

Fig. 3a. Leaf area index of wheat as influenced by sowing methods and nutrient management (2022-23) at different time intervals

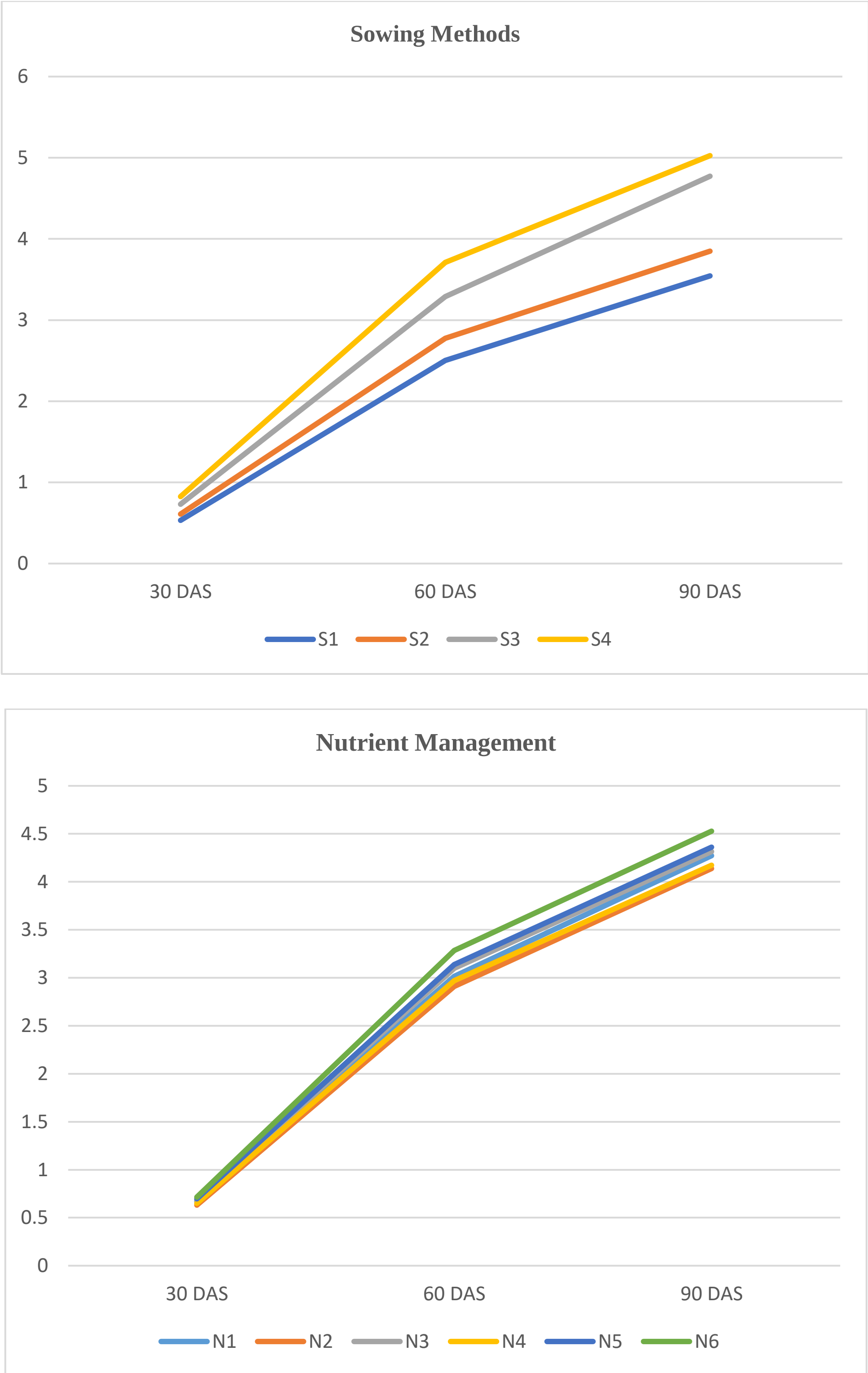
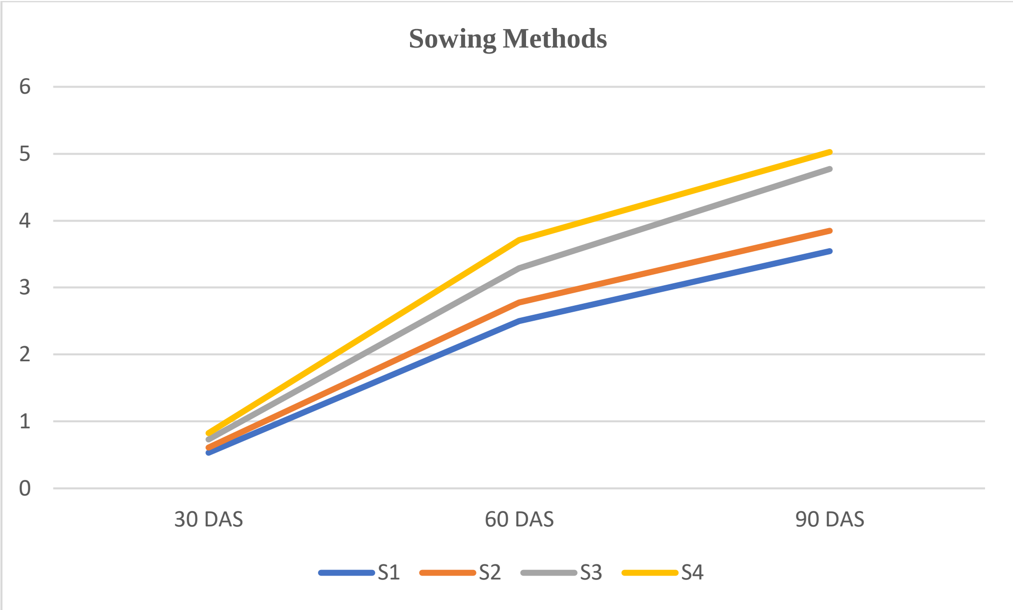


Fig. 3b. Leaf area index of wheat as influenced by sowing methods and nutrient management (2023-24) at different time intervals



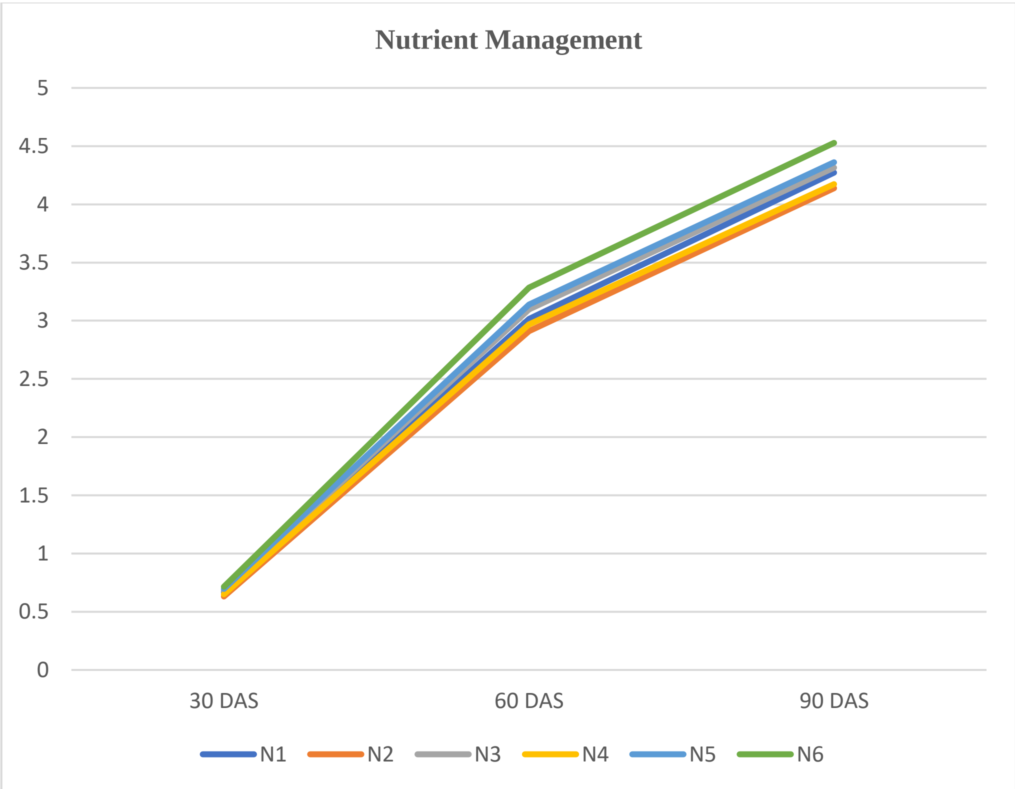


Fig. 3c. Leaf area index of wheat as influenced by sowing methods and nutrient management (mean) at different time intervals

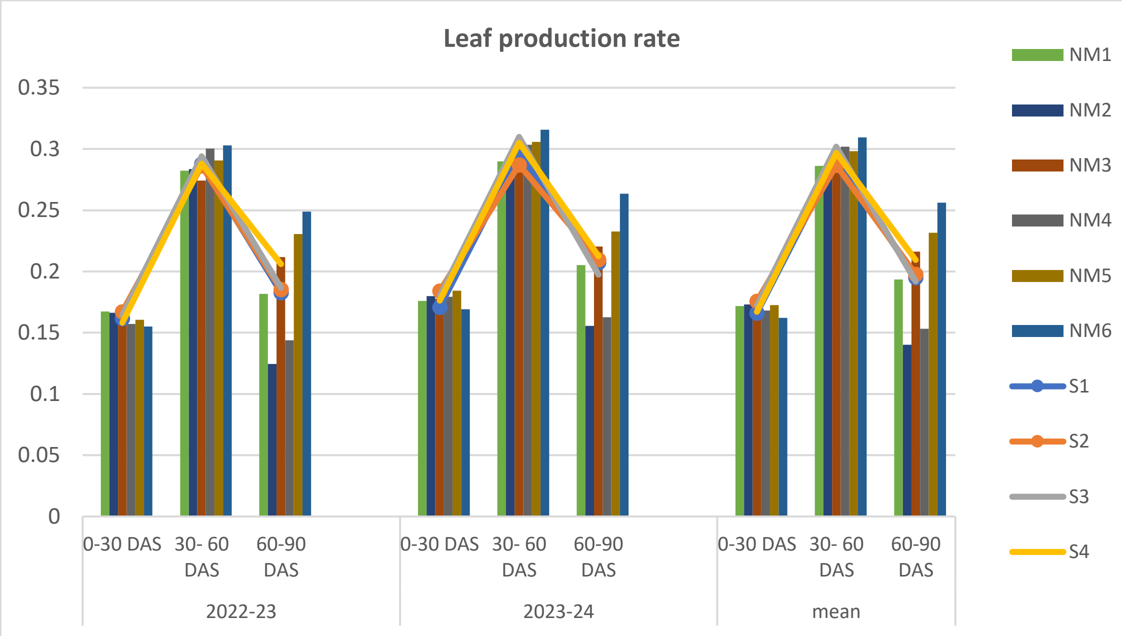


Fig. 4. Leaf production rate of wheat as influenced by sowing methods and nutrient management at different time intervals

The influence of sowing methods on LAI was statistically significant at all growth stages (60 and 90 DAS) during both years and on a mean basis. However, at 30 DAS, the differences were relatively smaller, though a trend of increasing LAI with improved sowing techniques was observed. The highest LAI at 90 DAS was recorded under criss-cross with 150% seed rate (S_4). This was followed by line sowing with 150% seed rate (S_3). The superior LAI values in these treatments indicate better plant canopy coverage, efficient light interception and enhanced photosynthetic activity due to an optimised plant population and spatial arrangement. At 60 DAS, criss-cross with 150% seed rate (S_4) exhibited the highest, significantly outperforming other sowing methods. The lowest LAI was consistently recorded under line sowing (S_1), at 90 DAS, which was significantly lower than line sowing with 150% seed rate (S_3) and criss-cross with 150% seed rate (S_4). Similar finding was observed by Kumari and Kataria (2023).

Nutrient management exhibited a significant impact on LAI at 60 and 90 DAS, reflecting the critical role of adequate nutrient supply in canopy expansion and light interception efficiency. The highest LAI was observed under 125% RDN (N_6) across all growth stages. The superior performance of 125% RDN (N_6) can be attributed to higher nitrogen availability, which enhances chlorophyll content, leaf expansion and overall vegetative growth. At 90 DAS 100% RDN + Azotobactor + PSB + 4 foliar sprays of 10% cow urine at 20 days intervals (N_5) recorded LAI values comparable to 125% RDN (N_6). This suggests that the integration of biofertilizers and organic amendments can effectively improve nutrient uptake and leaf area expansion. 75% RDN + Azotobactor +PSB (N_2) consistently recorded the lowest LAI, suggesting that reduced nitrogen supply limits leaf area expansion and canopy development.

The interaction effect between sowing methods and nutrient management on LAI was non-significant at all growth stages (30, 60, and 90 DAS) during both years and on a mean basis. This suggests that the effects of sowing methods and nutrient management operated independently in influencing LAI development, with no significant synergistic or antagonistic interactions observed.

3.4 Leaf Production Rate (leaves day^{-1})

Leaf production rate was recorded at 0-30, 30-60 and 60-90 DAS as influenced by sowing method and nutrient management during both the year and mean basis are presented in Fig. 4. Different sowing method and nutrient management practices failed to have a significant effect on 0-30 DAS during both years and mean basis.

As regards to sowing method, statistically significant higher leaf production rate was recorded under treatment criss-cross sowing (S_2) method which was at par with line sowing (S_1) and lower number of leaf production rate was recoded under treatment line sowing with 150% seed rate (S_3) during both the year and on mean basis at 60 and 90 DAS.

Different nutrient management treatments had a significant influence on the leaf production rate at different growth durations of crop growth during both years and on a mean basis. Higher leaf production rate was recorded under 125% RDN (N_6) which was at par with 100% RDN + Azotobactor + PSB + 4 foliar sprays of 10% cow urine at 20 days interval (N_5) and lowest rate was found under treatment 75% RDN + Azotobactor + PSB (N_2) during both the year and on mean basis at 30-60 DAS and 60-90 DAS. Nitrogen, essential for chlorophyll synthesis, enzyme activation, and protein metabolism, plays a crucial role in leaf development (Fageria and Baligar, 2005). The balanced supply of nutrients plays an important role for rapid growth and development of a crop. Organic manures supply both macro and micro-nutrients and also improve the availability of native nutrients (Raghuwanshi and Rajiv, 1994).

Interaction effect between sowing methods and nutrient management was found non-significant at all time intervals during both years and on a mean basis.

4. CONCLUSION

The present study demonstrated that both sowing methods and nutrient management practices significantly influenced the growth dynamics of wheat. Criss-cross sowing with a 150% seed rate (S4) consistently outperformed other sowing methods by enhancing crop growth rate (CGR), relative growth rate (RGR), leaf area index (LAI), and leaf production rate (LPR), owing to better plant distribution, canopy coverage, and efficient light interception. Among nutrient management treatments, applying 125% of the recommended dose of nitrogen (N6) produced superior results across most growth parameters, highlighting the importance of adequate nitrogen availability for optimum growth and canopy development. The integrated use of biofertilizers and organic foliar sprays (N5) also showed promise, often yielding values comparable to the higher nitrogen level.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Bhatnagar, G. S., Parwal, M. K. and Dhakar, L. L. (1990). Response of wheat to different crop geometries and seed rate in southern Rajasthan. *International Journal of Tropical Agriculture, 8*(3): 214-216.

Chanda, S.V. and Singh, Y.D. (2002). Integrated nutrient management in pigeonpea (*Cajanus cajan* L.) and its residual effect on succeeding wheat (*Triticum aestivum* L.) crop. *Annals of Agricultural Research, 23*(1): 99–102.

Dhingra, K. K., Grewal, D. S. and Dhillon, M. S. (1987). Bi-directional method of sowing helps to increase crop yields. *Indian Farming,* 37(4): 21-22.

Fageria, N. K., & Baligar, V. C. (2005). Enhancing nitrogen use efficiency in crop plants. *Advances in Agronomy, 88*, 97-185.

Harishankar, Pali. G. P. & Tomar, G. S. (2017). Growth and yield of wheat (*Triticum aestivum L.*) As influenced by methods of sowing and seed rates. *Progress. Res. Int. J., 12*: 401-403.

Kumari, P., & Kataria, R. K. (2023). Influence of Sowing Pattern and Seed Rate on Plant Growth and Yield in Wheat. *International Journal of Plant & Soil Science, 35*(18): 574–583.

Kumawat, R. N. (1997). Productivity of wheat (*Triticum aestivum* L.) as influenced by isoproturon & 2, 4-D mixture under different methods of sowing. M. Sc. (Ag.) Thesis, Dept of Agronomy, RAU Campus, RCA, Udaipur.

Raghuwanshi, R. K. S, Umat Rajiv. (1994) Integrated nutrient management in sorghum (*Sorghum bicolor*)- wheat

(*Triticum aestivam*) cropping system. *Indian Journal of Agronomy. 39*(2): 193–197.

Silva, D. B. D. A. and Gomes, A. C. (1990). Spacing and sowing density in irrigated wheat *in* the cerrado region. *Pesquisa Agropecuaria Brosileiza, 25*(3): 305-315.

Watson, D. J. 1952. The physiological basis of variation in yield. *Adv. Agron. 4*:pp 101-145.

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