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# Effect of spacing and seed rate on growth of foxtail millet (*Setaria italica* L.)

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**Abstract**
An investigation was carried out with six spacing and seed rate treatments in order to study the effect of spacing and seed rate on growth attributes of foxtail millet. The research was conducted during *kharif* season of 2024 at Farm of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola. The experiment was planned in Randomized Block Design with six treatments and four replications. The treatments were S1-30 cm x 5 cm with seed rate 6.0 kg per hectare, S2-30 cm x 10 cm with seed rate 3.0 kg per hectare, S3-30 cm x 15 cm with seed rate 2.0 kg per hectare, S4-45 cm x 5 cm with seed rate 4.0 kg per hectare, S5-45 cm x 10 cm with seed rate 2.0 kg per hectare, S6-45 cm x 15 cm with seed rate 1.5 kg per hectare. The soil at experimental site was medium black with clayey texture.
Growth attributes were recorded at 25 DAS, 50 DAS, 75 DAS and at harvest. Sowing of foxtail millet at spacing 45 cm x 15 cm with seed rate 1.5 kg per hectare (S6) recorded maximum value of growth attributes viz., plant height, total number of tillers $m^{-2}$, leaf area and dry matter accumulation per plant. The findings suggest that appropriate adjustment of spacing and seed rate significantly enhances the growth performance of foxtail millet under field conditions.

**Keywords:** Growth, foxtail millet, spacing, seed rate

## Introduction

Foxtail millet (*Setaria italica* L.), a $C_4$ plant, is a small millet crop known for its short growing period and significant economic value, especially in semi-arid and arid regions due to its resilience to drought and adaptability to marginal soils. Foxtail millet is a key ingredient in several culinary dishes, such as malts, fermented bread, biscuits, and chapati (Marwein *et al.*, 2019) [4]. Foxtail millet cultivation is common in China, Africa, some parts of India, Russia, and is grown for silage and hay in South and North America (Singh *et al.*, 2017) [8]. In India, foxtail millet is cultivated in Rajasthan, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Telangana, Bihar, Uttar Pradesh and to some extent in Uttarakhand.

Due to its low glycemic index (GI) and excellent nutritional profile in terms of dietary fibre (6.7%), protein (11.2%) and low fat (4%), there is an increasing demand for foxtail millet particularly by the people suffering from diabetes in recent years (Jyothi *et al.*, 2021) [2]. In patients with type-II diabetes, it helps regulate blood glucose levels, lower serum lipids, and reduce glycosylated haemoglobin (Thathola *et al.*, 2010) [10]. Apart from this, it is used for the treatment of dyspepsia, rheumatism, poor digestion and stomach-ache (Singh *et al.*, 2017) [8].

The study of foxtail millet is essential due to its significant contribution to nutrition, agriculture and socio-economic development. Its resilience to climate challenges, nutritional benefits and role in sustainable farming systems make it a critical crop in order to address global food security. In foxtail millet farming, factors like row spacing and seed rate are important for crop growth. Proper plant density improves growth and yield by maximizing the use of environmental resources. However, farmers often struggle to maintain the right plant density. Too few plants lead to weed problems, low vegetative growth and yield, while too many plants cause lodging and poor light penetration thus reducing photosynthesis and vegetative growth. Therefore, optimizing row spacing and seed rate is essential.

## Materials and Methods

A field experiment was conducted to study the effect of spacing and seed rate on growth of foxtail millet (*Setaria italica*)" was conducted during *kharif* season of 2024 at Farm of Agronomy, All India Coordinated Research Project on Weed Management (AICRP-WM), Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola.

The experiment was laid out in a randomized block design with six treatments and four replications consisting of six spacing and seed rate treatments. The experimental site is located at 20° 70' North latitude 77° 03' East longitude and 307.42 m altitude. The plot size was 3.60 m × 4.20 m (gross) and 2.70 m × 3.40 m (net). The variety used was PDKV-Yashashri (BFTM-82). Soil samples (0-30 cm depth) were analyzed before sowing for chemical properties: pH (7.91), EC (0.29 dS $m^{-1}$), organic carbon (4.6 g $kg^{-1}$), available nitrogen (181.67 kg $ha^{-1}$), phosphorus (16.64 kg $ha^{-1}$), potassium (368.3 kg $ha^{-1}$) and bulk density (1.28 Mg $m^{-3}$) using standard methods. During the crop growth period ($30^{th}$ MW to $42^{nd}$ MW), total rainfall was 515.6 mm, with temperatures ranging from 33.9 °C to 18.6 °C.

**Table 1:** Treatment details

| | |
|---|---|
| S1 | 30 cm x 5 cm with seed rate 6.0 kg per hectare |
| S2 | 30 cm x 10 cm with seed rate 3.0 kg per hectare |
| S3 | 30 cm x 15 cm with seed rate 2.0 kg per hectare |
| S4 | 45 cm x 5 cm with seed rate 4.0 kg per hectare |
| S5 | 45 cm x 10 cm with seed rate 2.0 kg per hectare |
| S6 | 45 cm x 15 cm with seed rate 1.5 kg per hectare |

## Results and Discussion

The plant height of foxtail millet was significantly differ treatment wise at 50 DAS, 75 DAS (Table 2).

The mean plant height of foxtail millet increased progressively with successive stages of crop growth from 27.16 cm at 25 DAS to 124.24 cm at harvest. The rate of increase in plant height was more pronounced between 25 DAS to 75 DAS, with a sharp rise observed particularly between 50 and 75 DAS. Thereafter, the growth rate slowed down gradually as the crop approached maturity.

Maximum plant height (97.26 cm, 126.51 cm and 131.81 cm at 50 DAS, 75 DAS and harvest respectively) was recorded in treatment S6 (45 cm × 15 cm with seed rate 1.5 kg/ha), which was at par with S3, S4 and S5, while minimum height was observed under S1 (30 cm × 5 cm with seed rate 6.0 kg/ha).

The reason for this could be attributed to lesser competition for solar radiation, moisture and nutrient among the plants in case of wider spacing. In wider spacing, optimum plant population provided better resource utilization due to minimum inter and intra plant competition or available nutrients thereby enhancing vegetative growth. The result obtained during the investigation are in close accordance with the findings of Natarajan *et al.* (2019) [6] in finger millet and Swathi *et al.* (2020) [9] in pearl millet. Number of tillers $m^{-2}$ were recorded periodically at 50 DAS, 75 DAS and at harvest throughout the investigation period (Table 2).

The mean number of tillers $m^{-2}$ increased progressively from 50 DAS (31.82) to harvest (66.83) with the highest increase observed from 75 DAS to harvest. Maximum number of tillers $m^{-2}$ (57.07, 75.24 and 97.26 at 50 DAS, 75 DAS and harvest respectively) was recorded under treatment S4 (Spacing 45 cm × 5 cm with seed rate 4.0 kg/ha) which was significantly superior to all other treatments, whereas the lowest number of tillers was noted in S6 (Spacing 45 cm × 15 cm with seed rate 1.5 kg/ha) at harvest.

The closer intra-row spacing (5 cm) in S4 likely resulted in a higher initial plant population, thereby ensuring a greater number of plants per unit area producing tillers. Furthermore, the moderate seed rate (4.0 kg/ha) seems to have provided an optimal balance between plant density and resource availability (sunlight, nutrients and water) thus minimizing excessive competition. In contrast, minimum number of total tillers per unit area in S6 maybe due to wider spacing and relatively low seed rate which might have led to a significantly reduced plant population density. Although wider spacing encouraged tillering of individual plant, the overall tiller number per unit area was limited due the sparse plant population.

These findings clearly indicate that a combination of moderate seed rate with closer intra-row spacing optimizes the plant population and resource use efficiency, thereby maximizing tiller production per unit area in foxtail millet. Excessively wide spacing or low seed rates although beneficial for individual plant growth but reduce the total number of tillers per unit area. The result obtained during the investigation are in close accordance with the finding of Nandini and Sridhara (2019) [5].

Leaf area $plant^{-1}$ was recorded periodically at 25 DAS, 50 DAS, 75 DAS and harvest throughout the study period.
(Table 2).

The data revealed that as the crop growth is increasing, there is progressive increase in leaf area $plant^{-1}$, reaching the maximum at 75 DAS, followed by a slight decline at harvest. The leaf area $plant^{-1}$ differed significantly across treatment at 50 DAS, 75 DAS and at harvest except at 25 DAS.

At 50 DAS, the treatment S6 (45 cm × 15 cm with seed rate 1.5 kg/ha) recorded the highest leaf area $plant^{-1}$ (50.05 $cm^2$) and was significantly superior to all other treatments. The lowest leaf area $plant^{-1}$ was observed in treatment S1 that is spacing of 30 cm × 5 cm with seed rate 6.0 kg/ha (35.67 $cm^2$).

However, at 75 DAS, the highest leaf area $plant^{-1}$ (86.68 $cm^2$) was recorded again in the treatment S6, which was at par with spacing of 45 cm x 10 cm with seed rate 2.0 kg/ha that is S5 (86.41 $cm^2$) and 45 cm x 5 cm with seed rate 4.0 kg/ha that is S4 (78.96 $cm^2$). The same trend continued at harvest, where S6 (62.44 $cm^2$) continued to maintain highest leaf area $plant^{-1}$. However, the lowest leaf area $plant^{-1}$ at harvest was observed in treatment S1 that is spacing of 30 cm × 5 cm with seed rate 6.0 kg/ha (46.82 $cm^2$). This indicate the positive influence of wider spacing and optimum seed rate on the growth of individual plant.

The increase in leaf area $plant^{-1}$ under wider spacing might be due to reduced competition among plants for light as well as nutrients thus enabling better vegetative growth. These results are in conformity with the findings of Padmaja *et al.* (2024) [7] in finger millet and Chaudhari *et al.* (2020) [1] in pearl millet.

The total dry matter accumulation $plant^{-1}$ was recorded periodically at an interval 25 DAS throughout the investigation period (Table 2).

The data revealed that mean dry matter accumulation of foxtail millet was increased progressively up to harvest stage. The total dry matter accumulation $plant^{-1}$ of foxtail millet was varied significantly across the treatments at 50 DAS, 75 DAS and at harvest except 25 DAS.

At 50 DAS, dry matter accumulation increased significantly, with S6 (spacing 45 cm × 15 cm with seed rate 1.5 kg/ha) recording the highest value (11.84 g plant$^{-1}$), followed by S5 (9.61 g) and S4 (8.82 g). The lowest accumulation was observed in S1 (5.62 g). The trend of increasing dry matter plant$^{-1}$ with wider spacing and lower seed rate continued across stages.

At 75 DAS, the differences among the treatments became more pronounced. Treatment S6 (spacing 45 cm × 15 cm with seed rate 1.5 kg/ha) recorded the highest accumulation (23.74 g plant$^{-1}$), which was at par with treatment S5 (spacing 45 cm × 10 cm with seed rate 2.0 kg/ha) and S4 (spacing 45 cm × 5 cm with seed rate 4.0 kg/ha). S1 continued to register the least accumulation (9.85 g plant$^{-1}$).

At harvest, S6 (spacing 45 cm × 15 cm with seed rate 1.5 kg/ha) registered a significantly higher total dry matter accumulation per plant of 31.12 g. However, S1 accumulated lowest (11.93 g) dry matter plant$^{-1}$. The higher total dry matter accumulation plant$^{-1}$ might be due to the higher dry matter accumulation in all plant parts in the respective treatments. The consistent superiority of wider spacing treatment can be attributed to minimum plant competition, improved aeration as well as better resource availability (solar radiation, nutrients and moisture), resulting in enhanced biomass production plant$^{-1}$. These findings are in conformity with Dereje *et al.* (2016) in finger millet, Lokesh *et al.* (2023) [3] in foxtail millet and Swathi *et al.* (2020) [9] in pearl millet.

**Table 1:** Plant height (cm), total number of tillers m-2, leaf area (cm2) and total dry matter accumulation per plant (g) of foxtail millet at various growth stages as influenced by different treatments

| Treatments | Plant Height (cm) | | | | Total number of tillers m$^{-2}$ | | | Leaf area (cm$^{2}$) plant$^{-1}$ | | | | Total dry matter accumulation (g) plant$^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 DAS | 50 DAS | 75 DAS | At Harvest | 50 DAS | 75 DAS | At Harvest | 25 DAS | 50 DAS | 75 DAS | At Harvest | 25 DAS | 50 DAS | 75 DAS | At Harvest |
| S1-30 cm x 5 cm with seed rate 6.0 kg/ha | 26.73 | 84.67 | 111.22 | 115.85 | 29.85 | 46.12 | 68.42 | 14.69 | 35.67 | 59.89 | 46.82 | 0.80 | 5.62 | 9.85 | 11.93 |
| S2-30 cm x 10 cm with seed rate 3.0 kg/ha | 26.49 | 89.94 | 117.39 | 121.84 | 19.44 | 33.46 | 55.10 | 15.17 | 37.94 | 69.16 | 48.31 | 0.92 | 7.90 | 16.43 | 19.60 |
| S3-30 cm x 15 cm with seed rate 2.0 kg/ha | 26.54 | 94.03 | 119.69 | 124.99 | 18.60 | 29.59 | 52.77 | 15.42 | 40.80 | 75.35 | 56.49 | 0.95 | 8.44 | 17.98 | 21.18 |
| S4-45 cm x 5 cm with seed rate 4.0 kg/ha | 27.74 | 91.10 | 118.06 | 122.12 | 57.07 | 75.24 | 97.26 | 15.57 | 39.44 | 78.96 | 56.16 | 0.93 | 8.82 | 21.51 | 21.69 |
| S5-45 cm x 10 cm with seed rate 2.0 kg/ha | 28.32 | 94.16 | 123.13 | 128.87 | 45.08 | 56.85 | 78.88 | 17.05 | 44.07 | 86.41 | 61.80 | 0.98 | 9.61 | 22.58 | 27.21 |
| S6-45 cm x 15 cm with seed rate 1.5 kg/ha | 27.14 | 97.26 | 126.51 | 131.81 | 20.91 | 33.17 | 48.53 | 17.27 | 50.05 | 86.68 | 62.44 | 1.10 | 11.84 | 23.74 | 31.12 |
| S.E. (m)± | 1.63 | 2.54 | 3.07 | 3.27 | 1.62 | 1.68 | 2.38 | 0.69 | 1.43 | 2.68 | 2.09 | 0.06 | 0.47 | 0.84 | 0.67 |
| CD at 5% | NS | 7.65 | 9.26 | 9.86 | 4.88 | 5.06 | 7.17 | NS | 4.31 | 8.08 | 6.29 | NS | 1.42 | 2.52 | 2.03 |
| GM | 27.16 | 91.86 | 119.33 | 124.24 | 31.82 | 45.74 | 66.83 | 15.86 | 41.33 | 76.07 | 55.34 | 0.95 | 8.70 | 18.68 | 22.12 |

## Conclusion

The present investigation clearly indicated that spacing and seed rate have a significant influence on the growth parameters of foxtail millet (*Setaria italica*). Among the different treatment, highest plant height, leaf area and total dry matter per plant was recorded in treatment S6 (45 cm × 15 cm with seed rate 1.5 kg/ha). Total number of tillers m$^{-2}$ was highest under treatment S4 (Spacing 45 cm × 5 cm with seed rate 4.0 kg/ha) which was significantly superior to all other treatments. Although wider spacing encouraged tillering of individual plant, the overall tiller number per unit area was limited due the sparse plant population. Wider row spacing with moderate seed rate provided adequate space as well as resources for individual plants, consequently leading to reduced competition and promotion of better vegetative growth.

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