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Spacing and seed rate management improves yield and farm economics of foxtail millet

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Abstract

Foxtail millet (*Setaria italica* L.) is gaining importance as a climate-resilient and nutritionally rich crop in dryland regions of India. Optimum plant population that is determined by appropriate spacing and seed rate plays a key role in enhancing yield and profitability. A field experiment was conducted during *kharif* 2024 at Farm of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola. The experiment was conducted with six treatments and four replications. The treatments were S1- 30 cm x 5 cm with seed rate 6.0 kg ha⁻¹, S2- 30 cm x 10 cm with seed rate 3.0 kg ha⁻¹, S3- 30 cm x 15 cm with seed rate 2.0 kg ha⁻¹, S4- 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹, S5- 45 cm x 10 cm with seed rate 2.0 kg ha⁻¹, S6- 45 cm x 15 cm with seed rate 1.5 kg ha⁻¹. The variety used was PDKV-Yashashri. Data on grain yield, straw yield were recorded and economic analysis was carried out. Results revealed that grain and straw yield per hectare was maximum with treatment S4- 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹. Economic analysis indicated that maximum gross monetary returns, net monetary returns and benefit - cost ratio were recorded with sowing of foxtail millet at 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹, thus proving to be the most economical spacing and seed rate for foxtail millet cultivation under semi-arid conditions.

Keywords: Millet, seed rate, spacing, foxtail millet, yield, economics

1. Introduction

Foxtail millet (*Setaria italica* L.) is a minor 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 has the heritage of Asian origin and was domesticated in Central China during ancient period (Miller *et al.*, 2016) ^[7] where its cultivation dates back to 5000 BC. It belongs to family Poaceae and subfamily Panicoideae.

Foxtail millet is a key ingredient in several culinary dishes such as, malts, fermented bread, biscuits and chapati (Marwein *et al.*, 2019) ^[6]. It is known by various names in different regions, including Kangni and Kakum (Hindi), Kang (Gujarati), Navane (Kannada), Kaon dana (Bengali), Rala (Marathi), Kavalai and Thina (Tamil), Korralu (Telugu), Kangam (Oriya) and Shol (Kashmir) in India. 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) ^[4]. In patients with type-II diabetes, it regulates blood glucose level, lower serum lipids and reduce glycosylated haemoglobin (Thathola *et al.*, 2010) ^[15]. Apart from this, it is used for the treatment of dyspepsia, rheumatism and stomachache (Singh *et al.*, 2017) ^[12].

The research seeks to explore the benefits and challenges of different spacing and seed rate practices in foxtail millet cultivation. By optimizing plant population as well as resource use efficiency, the study contributes to sustainable agriculture, particularly in drought prone and marginal lands where foxtail millet is a key crop. Understanding the impact of spacing and seed rate also helps in developing climate resilient cultivation strategies which could ensure better adaptation to changing rainfall patterns as well as temperature extremes. Additionally, our findings will support efforts to enhance yield, grain quality and economic feasibility, ultimately strengthening food security and promoting the wider adoption of foxtail millet as a climate-smart crop. The study of foxtail millet is essential due to its significant contribution to nutrition, agriculture and socio-economic development. Its resilience to adverse climate changes, nutritional benefits and role in sustainable farming systems make it an important crop for

addressing global food security. The aim of this study was to assess the effect of spacing and seed rate on yield and economics of foxtail millet under semi-arid conditions. Cultivating plants with the desired density has a positive effect on crop yield components, so that suitable yields will be achieved by optimum plant density (Ullah *et al.*, 2005)^[16]. In foxtail millet farming, factors like row spacing and seed rate are important for crop productivity. Proper plant density improves 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 and low yield, while too many plants cause lodging and poor light penetration, reducing photosynthesis and yield. Therefore, optimizing row spacing and seed rate is essential.

2. Materials and Methods

2.1 Trial site description

Field experiment was carried out at Farm of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola during *kharif*,

2024. The experimental site is located at 20° 70' North latitude and 77° 03' East longitude. The cropping pattern followed on the experimental site during the preceding two years is given in table 1.

Table 1: Cropping history of experimental site

Year	Season	
	<i>Kharif</i>	<i>Rabi</i>
2021-2022	Groundnut	Onion
2022-2023	Groundnut	Onion
2023-2024	Present investigation	

The soil at the experimental site was medium black with clayey texture. It was observed from the values presented in table 2 that the experimental soil was low in available nitrogen, medium in available phosphorous and high in available potassium. Organic carbon content was medium and soil reaction was slightly alkaline.

Table 2: Mechanical and chemical composition of the soil at experimental site

Sr. No.	Particular	Values	Analytical method adopted
A.	Physical properties		
1	Bulk density (Mg m ⁻³)	1.28	Clod method (Piper, 1966) ^[11]
B.	Chemical properties		
1	Available nitrogen (kg ha ⁻¹)	181.67	Alkaline KMnO ₄ method (Subbiah and Asija, 1956) ^[13]
2	Available phosphorus (kg ha ⁻¹)	16.64	Olsen's method (Olsen and Sommers, 1982) ^[8]
3	Available potassium (kg ha ⁻¹)	368.3	Flame photometric method (Jackson, 1967) ^[3]
4	Organic carbon (g kg ⁻¹)	4.60	Walkley and Black rapid titration method (Jackson, 1967) ^[3]
5	Soil pH	7.91	Glass electrode pH meter (Jackson, 1967) ^[3]
6	EC (dS m ⁻¹)	0.29	Electrical conductance method (Jackson, 1973) ^[2]

Akola is located in the subtropical region at 20° 70' North latitude and 77° 03' East longitude and at an altitude of 286 m to 305 m above MSL. It has a semi-arid type of climate with average annual rainfall of 995.6 mm.

2.2 Trial layout and treatments

The experiment was laid out in Randomized Block Design (RBD) with six treatments and four replications. The details of the treatment and symbols used to denote each treatment is given in table 3.

Table 3: 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

2.3 Trial management

After harvesting the previous crop, the land was ploughed once, harrowed twice and made ready for sowing. Seeds were obtained from seed research station, Buldhana, Maharashtra. The seed was mixed with sand in different ratio (seed: sand equal to 1:1.5, 1:2, 1:2.5, 1:3,1:3,1:3 in S1, S2, S3, S4, S5, S6 treatments respectively) for even distribution of seed within the plots and sown by dibbling. The row to row and plant to plant spacing was maintained as per the treatments. The seeds were immediately covered properly after sowing followed by water application. Recommended dose of nitrogen, phosphorous and potassium

were applied through Urea, SSP and MOP. Half dose of N and full dose of P and K were applied as basal whereas remaining half dose of N was applied as top dressing at 35 DAS.

Two hoeing and one hand weeding was done to control the weeds.

Border rows were harvested first, followed by crop from the net plot. The plants were cut close to the ground, tied in bundles and labelled. The bundles were taken to the threshing floor. After complete drying for 5 to 6 days, crop from each net plot was threshed, winnowed, cleaned separately and grain weight was recorded.

2.4 Data collection and Statistical analyses

2.4.1 Grain yield

After harvest, the produce was threshed and seed produced from each net plot was dried to constant weight, threshed, winnowed and weighed to record grain yield per plot and further converted into hectare yield by multiplying with hectare factor and expressed as kg ha⁻¹.

2.4.2 Straw yield

The straw obtained from the net plot area after harvesting of the spikes were weighed after sun drying to a constant weight, converted to hectare by multiplying with hectare factor and expressed as kg ha⁻¹.

2.4.3 Harvest index

It is the ratio of economic yield to the total biological yield. It was calculated by using the following formula and expressed in percentage.

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

2.4.4 Economics

2.4.4.1 Cost of cultivation (Rs ha⁻¹)

The total cost of cultivation (Rs ha⁻¹) was calculated for each treatment based on the inputs used during the experiment and their prevailing market prices.

2.4.4.2 Gross returns (Rs ha⁻¹)

The total value of the produce namely grain and straw yield was calculated treatment wise and gross monetary returns was calculated based on market prices.

$$\text{Gross returns} = \text{Grain yield (kg ha}^{-1}\text{)} \times \text{Grain price (Rs kg}^{-1}\text{)} + \text{Fodder yield (kg ha}^{-1}\text{)} \times \text{Fodder price (Rs kg}^{-1}\text{)}$$

2.4.4.3 Net returns (Rs ha⁻¹)

Net returns ha⁻¹ were calculated by deducting the cost of cultivation of respective treatments from gross monetary returns for the corresponding treatments.

$$\text{Net returns} = \text{Gross return (Rs ha}^{-1}\text{)} - \text{Cost of cultivation (Rs ha}^{-1}\text{)}$$

2.4.4.4 Benefit- cost ratio (B: C)

The benefit-cost ratio (rupees earned per rupee invested) was calculated for each treatment by dividing the gross returns of each treatment by the cost of cultivation using the following formula.

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

2.4.5 Statistical analysis

The experimental data collected during the course of the experiment was statistically analyzed with randomized block design by adopting standard statistical technical analysis of variance (Gomez and Gomez, 1984) [1]. With every significant result, critical difference at p=0.05 level was used to compare the treatment means.

3. Results and Discussion

Data regarding grain yield (kg ha⁻¹) as influenced by different treatments are presented in table 4. The mean grain yield was 1550 kg ha⁻¹. Significant variation in grain yield per hectare was noted among the treatments. The highest grain yield (2260 kg

ha⁻¹) was recorded in treatment S4 (spacing 45 cm × 5 cm with seed rate 4.0 kg ha⁻¹), which was significantly superior to all other treatments. This was followed by S2 (1890 kg ha⁻¹). However, the lowest grain yield was obtained in treatment S6 (937 kg ha⁻¹). Higher grain yield per hectare in S4 might be attributed to the favourable plant population and improved source-sink relationship resulting in better grain filling and hence higher yield. The wider row spacing (45 cm) with moderate seed rate (4.0 kg ha⁻¹) might have enabled optimal plant growth and resource utilization which leads to stronger and healthier plants. Similar results were reported by Yadav *et al.* (2023) [17] in foxtail millet and Swathi *et al.* (2020) [14] in pearl millet, emphasizing the benefits of moderate plant density in millets.

The maximum straw yield was also observed in S4 (5850 kg ha⁻¹), followed by S1 (4325 kg ha⁻¹) whereas the minimum straw yield was noted in S6 (3140 kg ha⁻¹). Straw yield indicated that the overall biomass production was higher under high seed rate. Increased straw yield under S4 (spacing 45 cm × 5 cm with seed rate 4.0 kg ha⁻¹) could be linked to greater vegetative growth due to adequate spacing and high plant population due to less plant to plant spacing, resulting in higher tiller number and plant biomass. Among different spacing and seed rate, dry matter accumulation was maximum at close spacings (S1 and S4) which was due to more biomass accumulation due to high number of plants per unit area. Although wider spacing promoted individual plant growth resulting in more dry matter accumulation per plant, total dry matter accumulation per unit area was more with higher plant density. These results are in line with the findings of Jyothi *et al.* (2021) [4] in foxtail millet and Swathi *et al.* (2020) [14] in pearl millet.

The maximum harvest index (33.66%) was recorded in S2 (spacing 30 cm × 10 cm with seed rate 3.0 kg ha⁻¹) which was at par with S3. The lowest harvest index (23.11%) was recorded in S6.

Harvest index (HI) reflects the proportion of economic yield (grain) to biological yield (grain + straw) which was highest in S2 (33.66%), closely followed by S3 (29.05%). Despite reporting lower grain and straw yield, S2 had the best HI thus indicating better partitioning of assimilates towards reproductive parts. However, the lowest harvest index was observed in S6 (23.11%), depicting a lesser proportion of grain in total biomass. These differences might be attributed to varied plant spacing and seed rate and hence the competition level further affecting assimilate allocation to sink. The result is in accordance with finding of Maji *et al.* (2024) [5] in foxtail millet and Swathi *et al.* (2020) [14] in pearl millet.

Table 4: Grain yield (kg ha⁻¹), straw yield (kg ha⁻¹) and harvest index (%) of foxtail millet as influenced by different treatments

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
S1 - 30 cm x 5 cm with seed rate 6.0 kg ha ⁻¹	1571	4325	26.73
S2 - 30 cm x 10 cm with seed rate 3.0 kg ha ⁻¹	1890	3726	33.66
S3 - 30 cm x 15 cm with seed rate 2.0 kg ha ⁻¹	1308	3207	29.05
S4 - 45 cm x 5 cm with seed rate 4.0 kg ha ⁻¹	2260	5850	27.95
S5 - 45 cm x 10 cm with seed rate 2.0 kg ha ⁻¹	1333	3697	26.63
S6 - 45 cm x 15 cm with seed rate 1.5 kg ha ⁻¹	937	3140	23.11
S.E. (m) ±	78	187	1.64
CD (P=0.05)	236	565	4.94
GM	1550	3991	27.85

The data pertaining to gross monetary returns, net monetary returns and benefit cost ratio are presented in table 5. The data unveiled that the mean gross monetary returns of Rs. 81487 ha⁻¹ was obtained when average selling price of foxtail millet was considered as Rs 5000 q⁻¹.

Among different treatments, S4 (45 cm x 5 cm with seed rate 4.0 kg ha⁻¹) registered highest gross monetary returns (Rs. 118835 ha⁻¹). The lowest gross monetary returns was observed in treatment S6 (45 cm x 15 cm with seed rate 1.5 kg ha⁻¹).

Table 5: Gross monetary returns, cost of cultivation, net monetary returns and benefit cost ratio of foxtail millet as influenced by different treatment

Treatment	GMR (Rs ha ⁻¹)	COC (Rs ha ⁻¹)	NMR (Rs ha ⁻¹)	B: C
S1 - 30 cm x 5 cm with seed rate 6.0 kg ha ⁻¹	82860	34804	48055	2.38
S2 - 30 cm x 10 cm with seed rate 3.0 kg ha ⁻¹	98256	36672	61585	2.67
S3 - 30 cm x 15 cm with seed rate 2.0 kg ha ⁻¹	68613	32884	35729	2.08
S4 - 45 cm x 5 cm with seed rate 4.0 kg ha ⁻¹	118835	39094	79741	3.04
S5 - 45 cm x 10 cm with seed rate 2.0 kg ha ⁻¹	70359	33045	37314	2.13
S6 - 45 cm x 15 cm with seed rate 1.5 kg ha ⁻¹	50000	30480	19520	1.64
S.E. (m) ±	3841	-	3340	-
CD (P=0.05)	11578	-	10069	-
GM	81487	34497	46991	2.32

The data shows that the treatment S4 (45 cm x 5 cm with seed rate 4.0 kg ha⁻¹) registered the highest cost of cultivation (Rs. 39094 ha⁻¹). The lowest gross monetary returns was observed in treatment S6 (45 cm x 15 cm with seed rate 1.5 kg ha⁻¹).

It was found that sowing of seeds at spacing 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹ (S4) resulted in highest net monetary returns (Rs. 79741 ha⁻¹). However, treatment S6 (45 cm x 15 cm with seed rate 1.5 kg ha⁻¹) reported lowest net monetary returns. The data shows that, sowing of seeds at spacing 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹ (S4) resulted in highest benefit- cost ratio of 3.04. However, treatment S6 (45 cm x 15 cm with seed rate 1.5 kg ha⁻¹) reported lowest benefit- cost ratio (1.64).

Sowing of foxtail millet seeds at spacing 45 cm x 5 cm with seed rate 4.0 kg ha⁻¹ (S4) led to highest favourable plant population and improved source-sink relationship resulting in highest grain yield and straw yield which further resulted in highest benefit-cost ratio per hectare in foxtail millet cultivation. This treatment improves productivity making it an ideal spacing and seed rate for maximizing economic benefits in foxtail millet cultivation under the given agro-climatic conditions. The results are in accordance with the findings of Swathi *et al.* (2020) [14] in pearl millet.

4. Conclusion

This study showed that the spacing and seed rate used in foxtail millet have a strong impact on both crop performance and overall profitability. Among all the treatments, sowing at 45 cm x 5 cm with a seed rate of 4.0 kg ha⁻¹ (S4) consistently gave the best results, producing the highest grain and straw yields. This was mainly because the plant population under this spacing allowed better resource use and a more balanced source-sink relationship, which helped the plants grow well and fill grains more efficiently. Although the highest harvest index was observed in S2, the overall yield and economic benefits were still greatest in S4, which recorded the highest gross returns, net returns, and benefit-cost ratio. Based on these findings, using a spacing of 45 cm x 5 cm and a seed rate of 4.0 kg ha⁻¹ can be recommended as the most effective planting method for maximizing both productivity and profit in foxtail millet under the given agro-climatic conditions.

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Conflict of Interest

The authors declare no conflict of interest.

References

- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons; 1984.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt Ltd; 1973.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice-Hall of India Pvt Ltd; 1967. p. 498.
- Jyothi KN, Sumathi V, Subramanyam D, Sudhakar P, Krishna TG, Sagar GK. Productivity and profitability of foxtail millet (*Setaria italica* L.) as influenced by varied agrotechniques under southern agro-climatic zone of Andhra Pradesh. *Pharma Innov J*. 2021;10(7):907-911.
- Maji P, Chirumella J, Maindar SS. Effect of spacing and nitrogen on yield and economics of foxtail millet (*Setaria italica* L.). *Int J Adv Biochem Res*. 2024;8(7 Suppl):626-628. doi:10.33545/26174693.2024.v8.i7Sh.1602.
- Marwein BS, Singh R, Chhetri P. Effect of integrated nitrogen management on yield and economics of foxtail millet genotypes. *Int J Curr Microbiol Appl Sci*. 2019;8(8):2543-2546.
- Miller NF, Spengler RN, Frachetti M. Millet cultivation across Eurasia: origins, spread, and the influence of seasonal climate. *Holocene*. 2016;26:1-10. doi:10.1177/0959683616641742.
- Olsen SR, Sommers LE. Phosphorus. In: Page AL, editor. *Methods of soil analysis. Part 2: Chemical and microbiological properties*. Madison (WI): American Society of Agronomy and Soil Science Society of America; 1982. p. 403-430.
- Padmaja M, Awasarmal VB, Kausalye SP, Rajkumar Y. Effect of crop geometry and fertilizer levels on growth and yield of kharif finger millet (*Eleusine coracana* (L.) Gaertn). *Int J Res Agron*. 2024;7(12):519-522. doi:10.33545/2618060X.2024.v7.i12g.2204.
- Patel NA, Raj AD, Surve V, Sankhala PM, Parmar VT. Effect of spacing and hybrid on quality of summer pearl millet (*Pennisetum glaucum* L.) under South Gujarat conditions. *Int J Plant Soil Sci*. 2023;35(15):145-150.
- Piper CS. Soil and plant analysis. Bombay: Hans Publishers; 1966.
- Singh RK, Muthamilarasan M, Prasad M. Foxtail millet: an introduction. In: Prasad M, editor. *The foxtail millet genome*. Cham: Springer; 2017. p. 1-9. doi:10.1007/978-3-319-65617-5_1.
- Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Curr Sci*. 1956;25:259-260.
- Swathi B, Murthy VRK, Rekha MS, Lalitha KJ. Performance of pearl millet as influenced by plant geometry and sowing windows. *J Pharmacogn Phytochem*. 2020;9(2):1898-1900.

15. Thathola A, Srivastava S, Singh G. Effect of foxtail millet (*Setaria italica*) supplementation on serum glucose, serum lipids and glycosylated hemoglobin in type 2 diabetics. Diabetol Croat. 2010;40:23-28.
16. Ullah MJ, Karim M, Mia MS, Shamsuddoha M, Begum NJ. Effect of nitrogen, row spacing and potassium uptake pattern of foxtail millet. Karnataka J Agric Sci. 2005;18(4):896-902.
17. Yadav B, Singh R, Indu T, Pradhan A. Effect of spacing and potassium levels on growth and yield of foxtail millet (*Setaria italica* L.). Int J Plant Soil Sci. 2023;35(5):46-52.