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Priya Maji
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Umesha C
Assistant Professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Chirumella Joharika
Ph.D. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Saikat Shubhra Maindar
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Priya Maji
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of spacing and nitrogen on growth and yield of foxtail millet (*Setaria italica* L.)

Priya Maji, Umesha C, Chirumella Joharika and Saikat Shubhra Maindar

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Abstract
The field experiment was conducted during kharif season 2023 at the experimental field of Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The experiment was layout in Randomized Block Design with ten treatments each replicated thrice. The treatment combinations are mentioned as T_1 -25 cm x 10 cm spacing + 30 kg/ha nitrogen, T_2 - 25 cm x 10 cm spacing + 40 kg/ha nitrogen, T_3 - 25 cm x 10 cm spacing + 50 kg/ha nitrogen, T_4 - 30 cm x 10 cm spacing + 30 kg/ha nitrogen, T_5 - 30 cm x 10 cm spacing + 40 kg/ha nitrogen, T_6 - 30 cm x 10 cm spacing + 50 kg/ha nitrogen, T_7 - 35 cm x 10 cm spacing + 30 kg/ha nitrogen, T_8 - 35 cm x 10 cm spacing + 40 kg/ha nitrogen, T_9 - 35 cm x 10 cm spacing + 50 kg/ha nitrogen, T_{10} – Control (NPK 40:20:20 kg/ha). The application of 35 cm x 10 cm spacing + 40 kg/ha nitrogen recorded significantly higher Plant height (68.84 cm) (56.93), plant dry weight (6.95 g/plant), number of ear head/m2 (170.8), number of seeds/ear head (181.33), test weight (2.50 g), grain yield (1.06 t/ha).

Keywords: Foxtail millet, nitrogen, spacing, yield

Introduction

Foxtail millet (*Setaria italica* L.) is important minor millet belonging to the family Poaceae. In India, the cultivation of foxtail millet is confined to Andhra Pradesh, Karnataka, and Tamil Nadu. It's grain used for human consumption and a feed for poultry and cage birds. It is used in several food preparations like chapati, fermented bread, biscuits, malts, etc. the stalks are used as fodder. (Marwein *et al.*, 2019) [2]. Foxtail millet is believed to be originated in China. It can grow in altitudes from sea level to 2000 m. It is adapted to a wide range of elevations, soils and temperatures. In India, it is cultivated on about 0.8 lakh ha area with 0.6 lakh tonnes production in Andhra Pradesh, Karnataka, Telangana, Rajasthan, Maharashtra, Tamil Nadu and north eastern states. The area under foxtail millet in India has come down by more than half during 1990's mainly due to introduction of more profitable crops like sunflower and soybean in black soils. Foxtail millet ranks second in the world's total millet production It is rich in micro-nutrients and good for diabetic patients. It protects against cancer and related heart diseases. Foxtail millet comes under drought tolerant crop and it can be grown as a short-term catch crop. It is adapted to a wide range of elevation, soils, and temperatures. Millets are better adapted to dry, infertile soils than most other crops and are therefore often cultivated under extremely harsh conditions - for example, highest temperatures, low and erratic precipitation, short growing seasons and acidic and infertile soils with poor water-holding capacity. Most millets have strong, deep rooting systems and short life cycles, and can grow rapidly when moisture is available. Foxtail millet is an annual grass grown for human food. It is the second-most widely planted species of millet and the most important in East Asia. This is extensively grown in the arid and semi-arid regions of Asia and Africa, as well as in some other economically developed countries of the world. Nutritional composition of foxtail millet per100 g edible portion is proteins (12.3 g), carbohydrates (60.9 g), fat (4.3 g), crude fibre (8.0 g), calcium (31 mg), minerals (3.3g) and thiamine (0.59 mg). The crop water requirement of foxtail millet is less which is suitable to grow in summer season. The productivity of foxtail millet is very low compared to its potentially achievable yield owing to a lack of suitable crop management practices.

Spacing is one of the major agronomic practices which requires due attention as it is being broadcasted by the farmers. (Jyothi *et al*., 2021) [1] Varieties of foxtail millet are more responsive to nitrogenous fertilizers. Nitrogen is considered to be an important nutrient for growth and development of plants. It plays an important role in building units of proteins in the plant system. Nitrogen nutrition not only influence productivity but also quality. (Reddy *et al*., 2019) [7] population causes changes due to light intensity, humidity and temperature within canopy. Under wider spacing, plants tend to put forth a vigorous vegetative growth, while closer spacing tend to restrict the same [1-3]. Optimum population level is the one, which provides the plant with the best environment to express its full capacity under the given conditions. Nutritional demand of crop can be determined by measuring nutrient uptake which may change with changing nitrogen rates and plant population In addition, to include millets into the mainstream and exploit its nutritionally superior qualities and promote its cultivation, Government of India has declared Year 2018 as the "Year of Millets" and FAO Committee on Agriculture forum has declared Year 2023 as "International Year of Millets" [11].

Materials and Methods

The experiment was carried out during the kharif season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (Allahabad) which is located at 25o 24' 42" N latitude, 81o 50' 56" E longitude, and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5 km away from Prayagraj (Allahabad) city. The soil of the experimental field constitutes a part of central gangetic alluvium and is neutral and deep. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus, and low in potassium and zinc. The soil samples were collected randomly from 5spots at 0 to 15 cm depth with the help of auger just before layout of experiment. The soil reaction of the sandy was 15.13%, the organic Carbon was 1.48%, the available, the phosphorus was 13.6 Kg/ha, the potassium was 215.4 Kg/ha, the zinc was 0.76ppm. Foxtail millet (*Setaria italica* L.) variety 3088 were selected for sowing. Seeds were sown in line manually on 2023. Seeds were covered with the soil immediately after sowing. The spacing adopted was according to the treatment details and the seeds were drilled at 3-4 cm depth. All the treatments were applied by balancing to the initial soil test values and crop requirements to justify the crop response to the supplied nutrients in both years.

Results and Discussion

Growth Parameters

Plant height

Data in Table 1, tabulated that significantly the highest plant height (56.83) was observed in treatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen) over all the other treatments. However, treatment-6 (30 cm x 10 cm spacing + 50 kg/ha nitrogen) and treatment- 5 (30 cm x 10 cm spacing + 40 kg/ha nitrogen) were found to be significantly at par with treatment-8 (35 cm x 10 cmspacing + 40 kg/ha nitrogen) as compared to all the treatments. Increase in plant height might be due to boosting of cellular division, production of growth promoting hormones, meristematic activity combined with increase in length and size of cells and intercellular spaces producing longer plants. The results are in consonance with the findings of Ramyasri (2018) [4], Radha Kumari *et al*., (2017) [8] and Shanthi *et al*., (2017) [8]. Spacing shows the higher plant height, inthe foxtail millet. It might be due to better utilization of minerals, nutrients, water, solar radiation etc. Similar findings were also reported by Yadav *et al*., (2023) [11].

Number of tillers/m^2

The highest no. of tillers per m2 (157.33) was observed in the treatment-2 (25 cm x 10 cm spacing + 40 kg/ha nitrogen), which was significantly higher over rest of the treatments. However, the treatments 3 (25 cm x 10 cm spacing + 50 kg/ha nitrogen) was found to be statistically at par with treatment-2 (25 cm x 10 cm spacing + 40 kg/ha nitrogen). Nitrogen improves the improvement of strong cell walls and consequently, straw which might be resulted into profuse tillering. These results are already in agreement reported by Rajput (2008) [3]. Nitrogen role in increased supply of auxins, synthesis of growth promoting hormones like cytokinin enhanced the production and activation of tiller of all the shoot nodes might be the reason for production of significantly more number of tillers/m^2. These findings are in consonance with Ramyasri (2018) [4] and Raundal and Patil (2017) [6].

Plant dry weight

Treatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen) was recorded with a significantly maximum dry weight (6.95g/plant) over all the treatments. However, the treatment-2 (25 cm x10 cm spacing + 40 kg/ha nitrogen), treatment- 4, which were found to be statistically at par withtreatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen). Spacing shows the higher dry weight itmight be due to better utilization of minerals, nutrients, water, solar radiation etc. Yadav *et al*., (2023) [11]. Nitrogen application which has many important functions in plant growth and development, such as involvement in the biosynthesis of chlorophyll, respiration, chloroplast development and improves the performance of photosystems, which resulted in higher dry weight.

Crop growth rate (g/m^2/day)

At 40-60 DAS, a significant and higher crop growth rate (6.62 g/m2/day) was recorded in treatment- 2 (25 cm x 10 cm spacing + 40 kg/ha nitrogen) as compared to rest of the treatments. However, treatment-1 (25 cm x 10 cm spacing + 30 kg/ha nitrogen) were found to be statistically at par with treatment-2.

Yield attributes

Number of ear head/m^2

At harvest, the data recorded highest number of ear head/m2 (170.80) in treatment 2 [25 cm x 10 cm spacing + 40 kg/ha nitrogen]. However, treatment 1 [25 cm x 10 cm spacing + 30 kg/ha nitrogen] was statistically at par with treatment 2.

Number of seeds/ear head

At harvest, the data recorded more grains/panicle (181.33) in treatment 8 [35 cm x 10 cm spacing + 40 kg/ha nitrogen]. However, treatment 1 [25 cm x 10 cm spacing + 30 kg/ha nitrogen] was statistically at par with treatment 8.Nitrogen provides potential for many of the enzymatic transformations. Several of these enzymes are involved in chlorophyll synthesis and grain formation resulting in higher grains/panicle. Similar results are observed by Vaja *et al*. 2020 [10].

Test weight (g)

The data recorded higher test weight (2.50 g) in treatment 8 [35 cm x 10 cm spacing + 40 kg/ha nitrogen] there was no statistical difference among the treatments.

Grain yield (t/ha)
Significantly highest grain yield (1.06 t/ha) was recorded with treatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen) over all the treatments. However, treatment-9 (35 cm x 10 cm spacing + 50 kg/ha nitrogen) was found to be statistically at par with treatment-8 (35 cm x 10 cmspacing + 40 kg/ha nitrogen). The sufficient amount of sunlight promotes efficient photosynthesis activities and ultimately greater accumulation of photosynthates under wider spacing. Yadav *et al*., (2023) [11]. Nitrogen plays a major role in the biosynthesis of IAA and especially due to its role in the initiation of primordial reproductive parts portioning of photosynthetic towards them which promotes the grain yield. Rao *et al*., (2019) [5].

Straw yield (t/ha)
Application of 50 kg/ha nitrogen along with 25 cm x 10 cm spacing over all the treatments (6.99 t/ha) was recorded highest straw yield. However, the treatment-2 (25 cm x 10 cm spacing + 40 kg/ha nitrogen) were found to be statistically at par with treatment-3 (25 cm x 10 cm spacing + 50 kg/ha nitrogen). More uptake of nutrients by application of nitrogen probably favored better growth and development of crops, resulting into increased fodder yield. These findings corroborate the results of Tiwana *et al*., (2004) [9].

Harvest index (%)
Significantly highest harvest index (24.58%) was recorded in treatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen) over all the treatments. However, the treatment-9 (35 cm x 10 cm spacing + 50kg/ha nitrogen) were found to be statistically at par with treatment-8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen).

Table 1: Effect of Spacing and Nitrogen on Growth Attributes of Foxtail millet

S. No.	Treatments	Plant height (cm) 80 DAS	Plant dry weight (g/plant) 80 DAS	Number of Tillers/m2 60 DAS	CGR (g/m2/day) 40-60 DAS
1.	25 cm x 10 cm spacing + 30 kg/ha nitrogen	52.14	6.25	152.00	6.19
2.	25 cm x 10 cm spacing + 40 kg/ha nitrogen	54.02	6.69	157.33	6.62
3.	25 cm x 10 cm spacing + 50 kg/ha nitrogen	50.02	5.61	154.67	5.56
4.	30 cm x 10 cm spacing + 30 kg/ha nitrogen	52.86	6.68	126.67	5.47
5.	30 cm x 10 cm spacing + 40 kg/ha nitrogen	55.25	6.22	117.78	5.08
6.	30 cm x 10 cm spacing + 50 kg/ha nitrogen	56.08	6.39	128.88	5.28
7.	35 cm x 10 cm spacing + 30 kg/ha nitrogen	55.03	6.66	108.57	4.62
8.	35 cm x 10 cm spacing + 40 kg/ha nitrogen	56.93	6.95	116.18	4.88
9.	35 cm x 10 cm spacing + 50 kg/ha nitrogen	54.14	6.62	114.28	4.73
10.	Control (NPK 40:20:20) 30 x 10 cm	53.89	6.39	128.88	5.28
	F-Test	S	S	S	S
	Sem (±)	1.03	0.33	0.24	0.30
	CD (P=0.05)	2.17	0.69	152.00	0.64

Table 2: Effect of Spacing and nitrogen on yield attributes of Foxtail millet

S. No.	Treatments	Number of earhead/m^2	Number of seeds/earhead	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
1.	25 cm x 10 cm spacing + 30 kg/ha nitrogen	157.33	148.33	2.37	1.01	6.33	13.72
2.	25 cm x 10 cm spacing + 40 kg/ha nitrogen	170.80	128.33	2.34	1.02	6.55	13.45
3.	25 cm x 10 cm spacing + 50 kg/ha nitrogen	117.07	138.67	2.33	0.88	6.99	11.28
4.	30 cm x 10 cm spacing + 30 kg/ha nitrogen	121.67	128.67	2.37	1.02	5.07	16.78
5.	30 cm x 10 cm spacing + 40 kg/ha nitrogen	134.44	111.00	2.29	0.97	5.60	14.73
6.	30 cm x 10 cm spacing + 50 kg/ha nitrogen	127.78	139.67	2.25	1.02	5.29	16.20
7.	35 cm x 10 cm spacing + 30 kg/ha nitrogen	98.10	132.33	2.25	1.03	3.69	22.51
8.	35 cm x 10 cm spacing + 40 kg/ha nitrogen	149.52	181.33	2.50	1.06	3.30	24.58
9.	35 cm x 10 cm spacing + 50 kg/ha nitrogen	88.10	144.00	2.36	1.04	3.53	22.75
10.	Control (NPK 40:20:20) 30 x 10 cm	115.00	137.00	2.36	1.01	4.25	19.49
	F-Test	S	S	S	S	S	S
	Sem (±)	20.12	7.38	0.09	4.02	7.38	1.59
	CD (P=0.05)	42.27	15.50	0.18	8.45	15.50	3.34

Conclusion
Based on experimental findings it is concluded that Treatment - 8 (35 cm x 10 cm spacing + 40 kg/ha nitrogen) performed better in growth and yield attributes and hence, can be recommended to the farmers.

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