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Effect of fertilizer levels and plant spacing on yield attributes and yield of foxtail millet (*Setaria italica* L.)

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Abstract

An experiment entitled “Response of Foxtail Millet (*Setaria italica* L.) to Fertilizer Levels and Spacings” was conducted at PG Research Farm RCSI College of Agriculture, Kolhapur during the *kharif* season of 2023. The experiment was conducted in a split plot design with three main plot treatments of plant spacings and five levels of fertilizer as subplots treatments. The experiment was conducted with the objectives of studying the combined effect of fertilizer levels and spacings on growth and yield of foxtail millet, studying the nutrient status of soil and plant and to find the better economics of the foxtail millet cultivation. The highest yield attributes viz., no. of panicles, length of panicles, weight of panicle, seed yield per plant and test weight of foxtail millet were recorded with spacing 60 cm x 10 cm along with fertilizer application of 100% GRDF (40:20:00 N, P₂O₅, K₂O Kg + FYM @ 5 t ha⁻¹) and due to this enhanced parameters grain yield and straw yield of foxtail millet was recorded highest when foxtail millet cultivated with spacing 60 x 10 cm and fertilizer application of 100% GRDF (40:20:00 N, P₂O₅, K₂O Kg + FYM @ 5 t ha⁻¹) among the various treatment combination used in foxtail millet crop.

Keywords: Foxtail millet, fertilizer levels, spacing, growth, yield attributes and yield

Introduction

Foxtail millet [*Setaria italica* (L.)] often known as Italian millet, German millet or *Rala* in Marathi belongs to the family of poaceae. It is one of the oldest cultivated millets in the world, mostly grown in Asia and Africa continents. Foxtail millet ranks second in the world millet production and continues to play a vital role in world agriculture, giving food to millions of people dependent on poor or marginal soils in temperate, subtropical and tropical Asia (Hariprasanna, 2016) [4]. In India, foxtail millet is mostly cultivated in Rajasthan, Maharashtra, Tamilnadu, Karnataka and Andhra Pradesh, contributing about 79 percent of the total area (Munirathnam *et al.* 2006) [11]. In India 9.10 million ha areas is under foxtail millet cultivation with production of 7.3 MT and productivity of 780 kg ha⁻¹ (Monisha *et al.* 2019) [8]. Nitrogen is the major nutrient required by the millets for higher growth, yield attributes and yield (Prasad *et al.* 2014) [14]. Studies of Hasan *et al.* (2013) [5] and Basavarajappa *et al.* (2002) [2] indicated that there was a good response of foxtail millet to varied levels of nitrogen. Beside nitrogen phosphorus is of paramount Importance for increasing yield. Phosphorus plays an important role in energy transfer in the living cells by means of high-energy phosphate bonds of ATP. Thus, it is considered important for formation and translocation of carbohydrate, fatty acids, glyceroids and other essential intermediate compounds. Therefore, there is need to work out optimum combination of nitrogen and phosphorus fertilization for foxtail millet under prevailing agroclimatic conditions. It is worth mentioning that nutrient management through organic sources plays a major role in maintaining Soil health as it improves the status of soil organic matter, beneficial microbes and enzymes besides improving soil physical and chemical properties (Raviraja *et al.* 2020) [15]. Cultivation of plants with desirable density has positive effect on crop yield components, so that the suitable yield will be achieved by optimum plant density (Ullah *et al.* 2005) [16]. However, maintenance of optimum planting density is always a big problem to the farmers and they maintain sub-standard plant density, results in high weeds infestation, poor radiation use efficiency and low yield, while dense plant population on the other hand may cause lodging, poor light penetration in the canopy, reduce photosynthesis due to shading

of lower leaves and drastically reduce the yield (Jettner, 1998) [6].

Materials and Methods

An experiment entitled “Response of foxtail millet (*Setaria italica* L.) to fertilizer levels and spacings” was conducted at PG Research Farm RCSM College of Agriculture, Kolhapur during the *kharif* season of 2023. The experiment was conducted in a split plot design with three main plot treatments of plant spacings and five levels of fertilizer as subplots treatments. The experimental soil was black vertisol with silty loam in texture, having pH of 7.80, electrical conductivity of 0.25 d Sm⁻¹, organic carbon content of 0.53 per cent and available N, P₂O₅ and K₂O 325.85, 29.56 and 247.45 kg ha⁻¹ respectively. The foxtail millet variety DHFT-109-3 was sown by line sowing at a spacing of 30 x 10 cm, 45 x 10 cm, 60 x 10 cm between rows during the 27th meteorological week. A total 44 rainy days with 673.6 mm rainfall was measured during the experimental period. A minimum temperature of 17.3°C and maximum 33.3°C was recorded during the entire experimental period. The application of fertilizer were done according to the treatments. No incidence of pests and diseases were noticed during the experimental period. The experimental field measured 6.00 m by 3.00 m in gross area and net plot for different spacing was different, net plot for spacing 30 x 10 cm, 45 x 10 cm, 60 x 10 cm were 5.40 m x 2.80 m, 5.10 m x 2.80 m and 4.80 m x 2.80 m respectively.

Results and Discussion

A) Yield Attributing Characters

1) Mean Number of Panicles per Running Meter

a) Effect of Spacing: The mean number of panicles per running meter was significantly influenced due to spacings. Wider plant spacing of 60 x 10 cm noted significantly highest number of panicles per running meter (42.8) over rest of other spacings. Also, higher growth attributes namely leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. Wider plant spacing reduced interplant competition for resources like light water and nutrients, increased light penetration, promoting healthy growth of crop, increases root expansion which increases nutrient uptake. The results are also reported by Mownika *et al* (2021) [9], Kumar *et al.* (2022) [7].

b) Effect of Fertilizer Levels: The mean number of panicles per running meter was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted higher number

of panicles per running meter (38.0) which was at par with 125% RDF (37.2) over rest of the other fertilizer levels. Furthermore, higher leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. This is mainly because GRDF provides nutrient in the balanced proportion while RDF provide only major nutrients. Hence GRDF leads to improved crop growth, development, yield attributes and yield directly. The results are also reported by Mownika *et al* (2021) [9], Nigade *et al.* (2014) [12], Kumar *et al.* (2022) [7].

c) Interaction Effect: The mean number of panicles per running meter was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing of 60 x 10 cm and application of 100% GRDF produced higher mean number of tillers per running meter (44.3) and was statistically on par with 60 x 10 cm and 125% RDF (43.3), 60 x 10 cm and 100% RDF (42.7) and 60 x 10 cm and 75% RDF (42.0), 60 m x 10 cm and absolute control (41.7) wider spacing showed higher mean number of panicles per running meter over the closer spacings of 30 x 10 cm and 45 x 10 cm. The combination of wider plant spacing and 100 per cent GRDF reduced interplant competition for resources like light water and nutrients, increased light penetration, promoting healthy growth for crop, also increases root expansion which increases nutrient uptake. The combination of absolute control along with different plant spacing typically produce lower mean number of panicles per running meter as insufficient and inadequate nutrients for the crop growth leading to poor performance of the crop plants. Similar result was reported by Mownika *et al* (2021) [9], Kumar *et al.* (2022) [7].

2) Mean Length of Panicle (cm)

a) Effect of Spacing: The mean length of panicles per plant was significantly influenced due to different plant spacings. Plant spacing of 60 x 10 cm noted significantly highest mean length of panicles per plant (23.90 cm) over rest of other plant spacings. Wider plant spacing reduced plant competition for vital resources like light water and nutrients, increased light penetration which promoted healthy growth of crop, which increases nutrient uptake. Also, higher growth attributes namely leaf area, numbers of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The results are in line with Yadav *et al.* (2023) [18], Kumar *et al.* (2022) [7].

Table 1: Mean yield attributing characters of foxtail millet as influenced by different treatments

Treatment	Mean number of panicles per running meter	Mean length of panicle (cm)	Mean weight of panicle plant ⁻¹ (g)	Mean seed yield plant ⁻¹ (g)	Mean test weight (g)
Main plot: Spacing					
S ₁ : 30 X 10 cm	25.10	12.99	13.70	10.04	2.55
S ₂ : 45 X 10 cm	36.40	18.72	19.78	16.05	3.67
S ₃ : 60 X 10 cm	42.80	23.90	24.96	20.68	4.32
S.E.(m) ±	0.70	0.73	0.85	0.63	0.06
CD @ 5%	2.80	2.87	3.35	2.50	0.26
CV%	8.10	15.27	16.99	15.86	7.47
Sub-plot: Fertilizer levels					
F ₁ : 125% RDF	37.20	20.44	21.33	17.07	3.73
F ₂ : 100% RDF	35.10	18.92	19.92	16.04	3.54
F ₃ : 75% RDF	33.00	17.94	18.93	15.38	3.34
F ₄ : 100% GRDF	38.00	22.74	23.37	19.37	3.83
F ₅ : Absolute Control	30.50	12.63	13.85	10.11	3.12
S.E.(m) ±	0.70	0.70	0.68	0.69	0.07
CD @ 5%	2.00	2.06	2.00	2.03	0.20
CV%	6.05	11.45	10.59	13.39	6.41

Interaction Effect: S X F					
S.E.(m) ±	1.20	1.30	1.19	1.20	0.13
CD @ 5%	3.50	3.81	3.47	3.51	0.37
CV%	6.05	12.21	10.59	13.39	6.41
General Mean	34.8	18.53	19.48	15.59	3.51

b) Effect of Fertilizer Levels: The mean length of panicles per plant was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted significantly highest mean length (22.74 cm) of panicles per plant over rest of the other fertilizer levels. This is mainly because GRDF provides nutrient in the balanced proportion while RDF provide only major nutrients. Hence GRDF leads to improved crop growth, development, yield attributes and yield directly. The results are in line with Yadav *et al.* (2023) ^[18], Nigade *et al.* (2014) ^[12], and Kumar *et al.* (2022) ^[7].

c) Interaction Effect: The mean length of panicles per plant was significantly influenced due to different treatments combination of spacing and fertilizer levels. GRDF produced higher mean length of panicle (26.21 cm) and was statistically on par with 60 x 10 cm and 125% RDF (25.66), 60 x 10 cm and 100% RDF

(25.06), 60 x 10 cm and 75% RDF (24.95), 45 x 10 cm and 100% GRDF (23.83) in that order. Wider spacing showed higher mean length of panicles over the closer spacing of 30 x 10 cm and 45 x 10 cm. The combination of wider plant spacing and 100% GRDF reduced interplant competition for resources like light water and nutrients, increased light penetration, promoting healthy growth for crop, also increases root expansion which increases nutrient uptake. Also, higher growth attributes namely leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The combination of absolute control along with different plant spacing typically produce shorter length of panicle as insufficient and inadequate nutrients for the crop growth leading to poor performance of the crop plants. Similar result was reported by Yadav *et al.* (2023) ^[18], Kumar *et al.* (2022) ^[7].

Table 1.1: Yield attributing characters of foxtail millet as influenced by interaction effect between spacings and fertilizer levels

Interaction Combinations (S X F)	Mean number of panicles per running meter	Mean length of panicle (cm)	Mean weight of panicle plant ⁻¹ (g)	Mean seed yield plant ⁻¹ (g)	Mean test weight (g)
S ₁ F ₁	29.80	13.88	14.54	10.78	2.98
S ₁ F ₂	24.60	12.40	13.40	9.40	2.46
S ₁ F ₃	21.70	11.48	12.48	8.81	2.12
S ₁ F ₄	31.00	16.50	16.36	13.08	3.10
S ₁ F ₅	18.30	10.71	11.71	8.16	2.07
S ₂ F ₁	38.40	20.60	21.60	17.26	3.84
S ₂ F ₂	38.10	18.76	19.76	16.09	3.81
S ₂ F ₃	35.50	17.21	18.20	15.20	3.63
S ₂ F ₄	38.80	23.83	24.83	20.85	3.88
S ₂ F ₅	31.70	13.19	14.54	10.85	3.17
S ₃ F ₁	43.30	25.66	27.85	23.17	4.37
S ₃ F ₂	42.70	25.06	26.62	22.62	4.33
S ₃ F ₃	42.00	24.95	26.13	22.13	4.29
S ₃ F ₄	44.30	26.21	28.91	24.19	4.50
S ₃ F ₅	40.70	13.98	15.31	11.31	4.03
SEm±	1.20	1.30	1.19	1.20	0.13
CD @ 5%	3.50	3.81	3.47	3.51	0.37
CV (%)	6.05	12.21	10.59	13.39	6.41
General Mean	34.8	18.53	19.48	15.59	3.51

3) Weight of Panicle per plant

a) Effect of Spacings: The mean weight of panicles per plant was significantly influenced due to different plant spacings. Plant spacing of 60 x 10 cm noted significantly highest mean weight of panicles per plant (24.96 g) over rest of other plant spacings. Wider plant spacing reduced plant competition for vital resources like light water and nutrients, increased light penetration which promoted healthy growth of crop, which increases nutrient uptake. Also, higher growth attributes namely leaf area, numbers of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The results are in line with Anandha *et al.* (2020) ^[1], Prakasha *et al.* (2017) ^[13].

b) Effect of Fertilizer Levels: The mean weight of panicles per plant was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted significantly highest mean weight of panicles per plant (23.37 g) over rest of the other fertilizer levels. This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of

RDF which provide only major nutrients. Further GRDF provides major and minor nutrient required for the crop growth, development, increased yield attributes and yield directly. Also, higher growth attributes namely leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The results are in line with Anandha *et al.* (2020) ^[1], Mubeena *et al.* (2019) ^[10], Prakasha *et al.* (2017) ^[13].

c) Interaction Effect: The mean weight of panicles per plant was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing of 60 x 10 cm and application of 100% GRDF produced higher mean weight of panicle (28.91 g) and was statistically on par with 60 x 10 cm and 125% RDF (27.85 g), 60 x 10 cm and 100% RDF (26.62 g), 60 x 10 cm and 75% RDF (26.13 g) wider spacing showed higher mean weight of panicles over the closer spacings of 30 x 10 cm and 45 x 10 cm in that order. The combination of wider plant spacing and 100% GRDF reduced interplant competition for resources like light water and nutrients,

increased light penetration, promoting healthy growth for crop, also increases root expansion which increases nutrient uptake. Also, higher growth attributes namely leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The combination of absolute control along with different plant spacing typically produce lower weight of panicle as insufficient and inadequate nutrients for the crop growth leading to poor performance of the crop plants. Similar result was reported by Anandha *et al.* (2020) ^[1], Prakasha *et al.* (2017) ^[13].

4) Mean Seed Yield per Plant

a) Effect of Spacing: The mean seed yield per plant was significantly influenced due to different plant spacings. Plant spacing of 60 x 10 cm noted significantly highest mean seed yield per plant (20.68 g) over rest of other plant spacings. Wider plant spacing reduced plant competition for vital resources like light water and nutrients, increased light penetration which promoted healthy growth of crop, which increases nutrient uptake. The lowest seed yield was observed with 30 x 10 cm it might be due to more competition within plants, which leads to taller plants. The results are in line with those reported by Mownika *et al.* (2021) ^[9], Yadav *et al.* (2023) ^[18].

b) Effect of Fertilizer Levels: The mean seed yield per plant was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted significantly highest mean seed yield per plant (19.37 g) over rest of the other fertilizer levels. This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of RDF which provide only major nutrients. Further GRDF provides major and minor nutrient required for the crop growth, development, increased yield attributes and yield directly. The significantly lowest seed yield was observed with absolute control (10.11 g) this might be due to insufficient and inadequate fertilizer nutrient supply. The results are in line with those reported by Mownika *et al.* (2021) ^[9], Yadav *et al.* (2023) ^[18], Mubeena *et al.* (2019) ^[10].

c) Interaction Effect: The mean seed yield per plant was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing 60 x 10 cm and application of 100% GRDF produced higher mean seed yield per plant (24.19 g) and was statistically on par with 60 x 10 cm and 125% RDF (23.17 gm), 60 x 10 cm and 100% RDF (22.62 g), 60 x 10 cm and 75% RDF (22.13 g), 45 x 10 cm and 100% GRDF (20.85 g) wider spacing showed higher mean seed yield per plant over the closer spacings of 30 x 10 cm and 45 x 10 cm. The combination of wider plant spacing and 100% GRDF reduced interplant competition for resources like light water and nutrients, increased light penetration, promoting healthy growth for crop, also increases root expansion which increases nutrient uptake. Also, higher growth attributes namely leaf area, numbers of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The combinations of absolute control along with different plant spacing typically produce lower seed yield per plant as insufficient and inadequate nutrients for the crop growth leading to poor performance of the crop plant. Similar results were reported by Yadav *et al.* (2023) ^[18].

5) Test Weight

a) Effect of Spacing: The mean test weight was significantly influenced due to different plant spacings. Plant spacing of 60 x

10 cm noted significantly highest mean test weight (4.32 g) over rest of other plant spacings. Wider plant spacing reduced plant competition for vital resources like light water and nutrients, increased light penetration which promoted healthy growth of crop, which increases nutrient uptake. The results are in line with Kumar *et al.* (2022) ^[7], Prakasha *et al.* (2017) ^[13].

b) Effect of Fertilizer Levels: The mean test weight was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted significantly highest mean test weight (3.83 g) which is on par with 125% RDF (3.73 g) over rest of the other fertilizer levels. This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of RDF which provide only major nutrients. Further GRDF provides major and minor nutrient required for the crop growth, development, increased yield attributes and yield directly. The results are in line with those reported by Mownika *et al.* (2021) ^[9], Nigade *et al.* (2014) ^[12], Kumar *et al.* (2022) ^[7], Mubeena *et al.* (2019) ^[10], Prakasha *et al.* (2017) ^[13].

c) Interaction Effect: The mean test weight was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing of 60 x 10 cm and application of 100% GRDF produced higher mean test weight (4.50 gm) and was statistically on par with 60 x 10 cm and 125% RDF (4.37 g), 60 x 10 cm and 100% RDF (4.33 g), 60 x 10 cm and 75% RDF (4.29 g), 60 x 10 cm and absolute control (4.13 g). Wider spacing showed higher mean test weight over the closer spacings of 30 x 10 cm and 45 x 10 cm. The combination of wider plant spacing and 100% GRDF reduced interplant competition for resources like light water and nutrients, increased light penetration, promoting healthy growth for crop, also increases root expansion which increases nutrient uptake. Also, higher growth attributes namely leaf area, number of tillers, dry matter accumulation as well as nutrient uptake values were found to be higher. The combination of absolute control along with different plant spacings and fertilizer levels typically produce lower test weight as insufficient and inadequate nutrients for the crop growth leading to poor performance of the crop plants. Similar result was reported by Kumar *et al.* (2022) ^[7], Prakasha *et al.* (2017) ^[13].

B) Yield Studies

1) Grain Yield (kg per plot and quintal per hectare)

a) Effect of Spacing: The mean grain yield per plot and quintal per hectare was significantly influenced due to different plant spacings. Plant spacing of 60 x 10 cm noted significantly highest mean grain yield per plot and quintal per hectare (3.79 kg per plot and 25.87 q per ha respectively) over rest of other plant spacings. This may be result due to better growth parameters influenced the yield viz., mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrient. Significantly lowest grain yield kg per plot and q per ha was recorded with spacing 30 x 10 cm (2.18 kg per plot and 15.21 q per ha) this may be due to closer spacing. The results are in line with Anandha *et al.* (2020) ^[1], Kumar *et al.* (2022) ^[7], Prakasha *et al.* (2017) ^[13].

b) Effect of Fertilizer Levels: The mean grain yield per plot and quintal per hectare was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted higher mean grain yield per plot (3.75 kg per plot) and quintal per hectare (25.23 q per ha) over rest of the other fertilizer levels which was

at par with 125 per cent RDF (23.34 q per ha) except for grain yield kg per plot at 125% RDF and closely followed by 100% RDF the difference between later two treatments were statistically on par with each other. This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of RDF which provide only major nutrients. The grain yield may have been boosted as a result of better growth parameters viz. mean leaf area, number of tillers, dry matter accumulation, yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. Significantly, lowest mean grain yield per plot and quintal per hectare was observed with absolute control (2.18 kg per plot and 15.08 q per ha respectively) which was closely followed by 75% RDF (2.46 kg per plot and 17.63 q per ha respectively) this may be result due to the inadequate and insufficient application of fertilizer which influenced the yield viz., reduced mean leaf area, lower number of tillers, decreased dry matter accumulation, less number of panicles, reduced weight of panicles, lower length of panicles, less test weight and seed yield. The similar results have been reported by Divyashree *et al.* (2018) [3], Mownika *et al.* (2021) [9], Munirathnam *et al.* (2006) [11], Nigade *et al.* (2014) [12], Anandha *et al.* (2020) [1], Kumar *et al.* (2022) [7], Upadhaya *et al.* (2022) [17], Prakasha *et al.* (2017) [13].

c) Interaction Effect: The mean grain yield per plot and quintal per hectare was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing of 60 x 10 cm and application of 100% GRDF produced higher mean grain yield per plot and quintal per hectare (4.77 kg per plot and 32.23 q per ha respectively) and was statistically on par with the treatment combinations 60 x 10 cm and 125% RDF (4.46 kg per plot and 29.88 q per ha respectively) and 60 x 10 cm and 100% RDF (4.38 kg per plot and 29.20 q per ha respectively). Wider spacing showed higher mean grain yield per plot and quintal per hectare over the closer spacings of 30 x 10 cm and 45 x 10 cm. The mean grain yield per plot and quintal per hectare may be resulted due to better growth parameters which influenced the crop yield viz., mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. Significantly lowest mean grain yield kg per plot and q per ha was produced by treatment combination of spacing of 30 x 10 cm and absolute control (1.76 kg per plot and 13.23 q per ha respectively) which was at par with spacing 30

x 10 cm and 75% RDF (1.82 kg ha⁻¹ and 14.00 q per ha respectively), 30 x 10 cm and 100% RDF (1.96 kg ha⁻¹ and 14.53 q per ha respectively), 45 cm x 10 cm and absolute control (2.21 kg ha⁻¹ and 14.50 q per ha respectively) over the rest of treatment combination. The combination of absolute control along with different plant spacing typically produce lower grain yield per plot and quintal per hectare which may be mainly due to insufficient and inadequate supply of nutrients to the crop growth leading to poor performance of the crop plants. Similar result was reported by Mownika *et al.* (2021) [9], Anandha *et al.* (2020) [1], Kumar *et al.* (2022) [7], Prakasha *et al.* (2017) [13].

2) Straw Yield (kg per plot and quintal per hectare)

a) Effect of Spacing: The mean straw yield per plot and quintal per hectare was significantly influenced due to different plant spacings. Plant spacing of 60 x 10 cm noted significantly highest mean straw yield per plot and quintal per hectare (5.88 kg per plot and 38.94 q per ha respectively) over rest of other plant spacings. This may be result due to better growth parameters influenced the straw yield viz. mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. The results are in line with Kumar *et al.* (2022) [7], Prakasha *et al.* (2017) [13].

b) Effect of Fertilizer Levels: The mean straw yield per plot and quintal per hectare was significantly influenced due to different fertilizer levels. Application of 100% GRDF noted higher mean straw yield per plot and quintal per hectare (5.65 kg per plot and 39.35 q per ha respectively) over rest of the other fertilizer levels which was at par with 125% RDF (5.37 kg per plot and 37.42 q per ha respectively). This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of RDF which provide only major nutrients. This may be result into better growth parameters influenced the yield viz. mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. Significantly lowest mean straw yield kg per plot and q per ha was produced by absolute control (4.13 kg per plot and 28.95 q per ha respectively). Similar finding was also observed by Divyashree *et al.* (2018) [3], Mownika *et al.* (2021) [9], Munirathnam *et al.* (2006) [11], Nigade *et al.* (2014) [12], Kumar *et al.* (2022) [7], Upadhaya *et al.* (2022) [17], Prakasha *et al.* (2017) [13].

Table 2: Grain, straw yield and harvest index of foxtail millet as influenced by different treatment

Treatment	Grain yield (Kg/plot)	Grain yield (q/ha)	Straw yield (Kg/plot)	Straw yield (q/ha)	Harvest Index (%)
Main plot: Spacing					
S ₁ : 30 X 10 cm	2.18	15.21	4.06	30.22	33.48
S ₂ : 45 X 10 cm	2.83	20.65	4.97	34.83	37.22
S ₃ : 60 X 10 cm	3.79	25.87	5.88	38.94	39.92
S.E.(m) ±	0.06	0.66	0.11	0.74	--
CD @ 5%	0.25	2.62	0.41	2.93	--
CV%	8.68	12.59	8.31	8.34	--
Sub-plot: Fertilizer levels					
F ₁ : 125% RDF	3.20	23.34	5.37	37.42	38.41
F ₂ : 100% RDF	3.10	21.58	5.13	35.73	37.65
F ₃ : 75% RDF	2.46	17.63	4.56	31.85	35.63
F ₄ : 100% GRDF	3.75	25.23	5.65	39.35	39.07
F ₅ : Absolute Control	2.18	15.08	4.13	28.95	34.25
S.E.(m) ±	0.10	0.79	0.11	0.80	--
CD @ 5%	0.31	2.31	0.34	2.35	--
CV%	11.03	11.54	7.08	6.97	--

Interaction Effect: S X F					
S.E.(m) ±	0.18	1.37	0.20	1.39	--
CD @ 5%	0.53	4.00	0.59	4.07	--
CV%	11.03	11.54	7.08	6.97	--
General Mean	2.93	20.57	4.97	34.66	37.00

c) Interaction Effect: The mean straw yield per plot and quintal per hectare was significantly influenced due to different treatments combination of spacings and fertilizer levels. Treatment combination of spacing of 60 x 10 cm and application of 100% GRDF produced higher mean straw yield per plot and quintal per hectare (6.88 kg per plot and 45.52 q per ha respectively) and was statistically on par with 60 x 10 cm and 125% RDF (6.52 kg per plot and 43.12 q per ha respectively) and 60 x 10 cm and 100% RDF (6.40 kg per plot and 42.37 q per ha respectively). Wider spacing showed higher mean straw yield per plot and quintal per hectare over the closer spacings of 30 x 10 cm and 45 x 10 cm. This may be resulted due to better growth parameters influenced the yield viz., mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. The combination of absolute control along with different plant spacing typically produce lower straw yield per plot and quintal per hectare as insufficient and inadequate supply of nutrients to the crop leading to poor performance in yield. Significantly lowest mean straw yield kg per plot was produced by treatment combination of spacing of 30 x 10 cm and absolute control (3.80 kg per plot) which was at par with spacing 30 x 10 cm and 75% RDF (3.89 kg per plot), 30 x 10 cm and 100% RDF (3.97 kg per plot), 45 x 10 cm and absolute control (4.11 kg per plot), 30 x 10 cm and 125% RDF (4.27 kg per plot) over the rest of treatment

combination. Significantly lowest mean straw yield quintal per ha was produced by treatment combination of spacing of 30 x 10 cm and absolute control (28.32 quintal per ha) which was at par with spacing 45 x 10 cm and absolute control (28.80 quintal per ha), 30 x 10 cm and 75% RDF (28.96 quintal per ha), 30 x 10 cm and 100% RDF (29.53 quintal per ha), 60 x 10 cm and absolute control (29.73 quintal per ha), 30 x 10 cm and 125% RDF (31.79 quintal per ha) in that order over the rest of treatment combination. Similar result was reported by Kumar *et al.* (2022)^[7], Prakasha *et al.* (2017)^[13].

3) Harvest Index

a) Effect of Spacing: Plant spacing of 60 x 10 cm noted highest (39.75) mean harvest index over rest of other plant spacings. The result is in line with Kumar *et al.* (2022)^[7].

b) Effect of Fertilizer Levels: Application of 100% GRDF noted higher mean harvest index (38.86). This is mainly because GRDF provides nutrient in the balanced proportion as compared to only application of RDF which provide only major nutrients. This may be result into better growth parameters influenced the yield viz. mean leaf area, number of tillers, dry matter accumulation, also better yield attributes viz. number of panicles, weight of panicles, length of panicles, test weight and seed yield this increase the plant uptake of nutrients. The result is closely relating with Kumar *et al.* (2022)^[7], Upadhaya *et al.* (2022)^[17].

Table 2.1: Grain and straw yield of foxtail millet as influenced by interaction effect between spacings and fertilizer levels

Interaction Combinations (S X F)	Grain yield (Kg/plot)	Grain yield (q/ha)	Straw yield (Kg/plot)	Straw yield (q/ha)
S ₁ F ₁	2.38	16.80	4.27	31.79
S ₁ F ₂	1.96	14.53	3.97	29.53
S ₁ F ₃	1.82	14.00	3.89	28.96
S ₁ F ₄	2.36	17.50	4.37	32.51
S ₁ F ₅	1.76	13.23	3.80	28.32
S ₂ F ₁	3.20	23.35	5.33	37.37
S ₂ F ₂	2.96	21.03	5.04	35.29
S ₂ F ₃	2.46	18.40	4.66	32.65
S ₂ F ₄	3.48	25.97	5.71	40.03
S ₂ F ₅	2.21	14.50	4.11	28.80
S ₃ F ₁	4.46	29.88	6.52	43.12
S ₃ F ₂	4.38	29.20	6.40	42.37
S ₃ F ₃	3.11	20.50	5.13	33.95
S ₃ F ₄	4.77	32.23	6.88	45.52
S ₃ F ₅	2.68	17.53	4.49	29.73
SEm±	0.18	1.37	0.20	1.39
CD @ 5%	0.53	4.00	0.59	4.07
CV (%)	11.03	11.54	7.08	6.97
General Mean	2.93	20.57	4.97	34.66

Conclusion

The results of this experiment conclusively demonstrate the significance of optimal spacing and fertilizer application on the growth and yield of foxtail millet. The highest yield attributes of foxtail millet was recorded with spacing 60 cm x 10 cm along with fertilizer application of 100% GRDF (40:20:00 N, P₂O₅, K₂O Kg + FYM @ 5 t per ha) due to this the yield of foxtail millet was recorded highest when spacing 60 cm x 10 cm along with fertilizer application of 100% GRDF (40:20:00 N, P₂O₅, K₂O Kg + FYM @ 5 t per ha) among the various treatment combination

used in foxtail millet crop. The highest grain and straw yields were achieved with a spacing of 60 cm x 10 cm and fertilizer application of 100% GRDF, indicating the potential for improved productivity and profitability in foxtail millet cultivation. These findings have important implications for farmers and agricultural practitioners seeking to optimize foxtail millet production, and highlight the importance of integrated nutrient management and spatial arrangement in achieving sustainable and productive agricultural systems

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Disclaimers

All opinions and conclusions in this article are those of the authors and do not necessarily reflect the views of their institutions. The authors are solely responsible for the accuracy and completeness of the content and disclaim any liability for direct or indirect losses arising from its use.

Conflict of Interest

The authors declare no conflicts of interest, and no external funding or sponsorship influenced the study design, data collection, analysis, publication decision, or manuscript preparation.

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