

Original Research Article

RESPONSE OF FINGER MILLET (*Eleusine coracana* L.) TO VARYING LEVELS OF PLANT DENSITY AND NITROGEN

Abstract

A field experiment “**Response of Finger millet (*Eleusine coracana* L.) to varying levels of plant density and nitrogen**” was conducted during *kharif*, 2019 at College Farm, Professor Jayashankar Telangana State Agricultural University, Telangana. The soil of experimental site was loamy sand type, slightly acidic in pH (6.43), non-saline in EC (0.15 dSm⁻¹), low in organic carbon (0.42%), low in available N (201.6 kg ha⁻¹), medium in available P (25.3 kg ha⁻¹), low in available K (236.25 kg ha⁻¹). The experiment was laid out in randomized block design with factorial concept and replicated thrice with 12 treatments combinations consisting of four nitrogen levels (0 %, 50%, 100% and 150% RDN) and three levels of plant density (S₁-solid rows × 15 cm, S₂- 30 cm × 15 cm, S₃- 25 cm × 15 cm). Results indicated that S₁-solid rows × 15 cm recorded highest plant height, number of tillers m⁻², drymatter production (g m⁻²) and S₃- 25 cm × 15 cm recorded highest leaf area plant⁻¹ and yield. Application of 150% RDN recorded highest plant growth parameters, grain yield and straw yield. However, it was on par with 100% RDN.

Key words

Finger millet, Nitrogen, plant density, plant height, dry matter, leaf area, Yield.

Introduction

Among small millets, finger millet is one of the most nutritious crops, with high levels of methionine, an essential amino acid lacking in diets of millions of the poor living on starchy foods Wanyera 2007[1]. Finger millet is known for drought tolerance and can adapt to a wide range of soil and climatic conditions though it prefers fertile, well-drained sandy to sandy loam soils, with a pH ranging from 5 to 7 Triveni *et al.* 2018 [2] and is an important crop in drought prone regions because of its outstanding ability to withstand adverse weather conditions Munirathnam and Ashok, 2015 [3]. Among the other millets, finger millet has a high amount of calcium (0.38%), fibre (18%), phenolic compounds (0.3–3.0 %), and sulphur containing amino acids Thilakarathna and Manish 2015 [4]. The combined potential of millets as both resilient crops for resource constrained farmers and as a nutritious food stuff for growing populations, is now considered as a nutritious cereal in the world of escalating malnourished population and it can play a major role in nutritional security Kumar *et al.* 2019

[5]. In India finger millet is cultivated in an area of 1.27 million ha with a production of 2.61 million t and productivity is 1489 kg ha⁻¹. Agriculture Statistics at a Glance 2017 [6]. Telangana contributes 0.01 lakh ha area with a production of 0.01 lakh tones, with an average productivity of 559 kg ha⁻¹ Season and Crop report Telangana, 2015-16 [7].

Among the agronomic factors, crop geometry is the most important one to attain higher production through better utilization of above ground and below ground resources Kumar *et al.* 2019 [5] and to know the suitable land situation and planting geometry for the maximization of yield as finger millet put forth luxuriant growth during *kharif* season Mane *et al* 2019 [8]. The ideal crop geometry must be adopted for getting optimum plant stand in the field which results in higher yield Nandini and Sridhara 2019 [9] higher net returns and gross returns Rajesh 2011 [10]. Wider spacing was superior to narrow spacing resulting in increased number of productive tillers plant⁻¹ Andrew *et al* 2018 [11] and enhanced grain and straw yield Ramachandrappa *et al* 2018 [12]. Moreover, the ideal crop geometry can reduce the seed rate, healthy stand in the main field and significant higher yield. Hebbal *et al* 2018 [13].

Finger millet suffers from low yields although is valued by traditional farmers as a low fertilizer input crop due to continuous cropping, low use of mineral fertilizer, poor recycling of crop residues, and low rates of organic matter application. Most of the soils in the semi-arid tropics, where finger millet is grown, are deficient in major and micronutrients Prakasha *et al* 2018 [14] leading to poor productivity Thilakarathna and Manish 2015 [4]. Therefore, it is important to optimize nutrient management practices and other related factors affecting finger millet cultivation in order to attain better yields under the comparatively marginal local growing conditions. The results suggest that application of the correct dose of N fertilizer is important to maximize the profits of poor finger millet farmers. The importance of applying N starts with seed germination, a challenge for small seed crops like finger millet especially under nutrient deficient conditions.

Hence, identification of optimal planting density and N dose in finger millet helps to achieve potential yields and nutritional security of the people in drought-prone regions of India. Consequently, an experiment was conducted to study the effect of planting density and N levels on yield and economics of finger millet in Southern Telangana Zone.

Materials and methods

The experiment was conducted during *Kharif*, 2019-2020 at College farm, Plot no. B-17, Block-B, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the response of Finger millet (*Eleusine coracana* L.) to varying levels of plant density and nitrogen. The geographical location of the experimental site was 17°19' 19.2" N Latitude, 78°24' 39.2" E Longitude with an altitude of 542.3 m above mean sea level.

The variety of finger millet was Sri chaithanya. The experiment was laid out in randomized block design with factorial concept and replicated thrice with 12 treatments combinations consisting of four nitrogen levels (0 %, 50%, 100% and 150% RDN) and three plant densities (S_1 -solid rows \times 15 cm, S_2 - 30 cm \times 15 cm, S_3 - 25 cm \times 15 cm). The recommended dose of fertilizer is 40: 30: 30-N: P_2O_5 : K_2O kg ha⁻¹ and N was applied in two equal splits (at sowing and 30 DAS), total P and K was applied as basal (at sowing). Soil of the experimental field was loamy sand in texture.

Experimental details

The field was ploughed twice with tractor drawn cultivator followed by levelling with rotavator. T_1 , T_2 , T_3 and T_4 was sown in solid rows with 15 cm in between the rows, T_5 , T_6 , T_7 and T_8 was sown with a spacing of 30 cm \times 15 cm and T_9 , T_{10} , T_{11} and T_{12} was sown with 25cm \times 15 cm. 0% RDN was applied in T_1 , T_5 and T_9 , 50% RDN in T_2 , T_6 and T_{10} , 100% RDN in T_3 , T_7 and T_{11} and 150% RDN in T_4 , T_8 and T_{12} . The recommended dose of fertilizers applied (N, P, and K @ 40: 30: 30 kg ha⁻¹). Intercultural operations like gap filling, thinning and weeding was done timely. Crop was entirely grown under rainfall. The crop was harvested at proper stage of maturity as determined by visual observations. Border rows from all sides of each plot were first harvested followed by net plot. Fresh and dry weights of grain and stover were weighed separately. Biometric observations recorded were plant height, dry matter production, Leaf area plant⁻¹, ear heads m⁻², finger length, weight of earhead, grain and stover yield.

Results and Discussion

Plant height (cm)

Plant height of finger millet recorded at tillering, flowering and harvest stages was significantly influenced by different nitrogen levels. (Table 1.) The tallest plants were produced with N₄ (150 % RDN) which was comparable with N₃(100% RDN) and the shortest plants were recorded with N₁ (0 % RDN) at all growth stages. Among the different plant densities tested the tallest plants were produced with S₁ (solid rows × 15 cm) and the shortest plants were recorded with S₃ (25 cm × 15 cm) at all growth stages. The increase in plant height might be due to enhanced rate of translocation of nitrogen from culms to leaves, which lead to improved production of photosynthates. Further, at higher levels of nitrogen, availability of nitrogen is increased and nitrogen, being one of the main constituents of proteins and nucleic acids markedly influences cell division and cell enlargement resulting in increased plant height Munirathnam and Ashok, 2015 [3].

Table 1. Plant height (cm) of finger millet at different growth stages as influenced by plant densities and nitrogen levels

Treatment	Tillering	Flowering	Harvest
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Nitrogen levels (% RDN)			
N ₁ - 0	28.74	66.10	100.02
N ₂ - 50	31.20	69.29	107.33
N ₃ -100	35.52	73.4	116.07
N ₄ -150	36.21	74.36	118.46
SEm±	0.78	0.41	0.95
CD (P=0.05)	2.32	1.22	2.80
Plant density levels			
S ₁ -Solid rows	34.08	72.56	115.2
S ₂ -30 cm × 15 cm	32.97	70.73	109.81
S ₃ -25 cm ×15 cm	31.50	69.13	107.08
SEm±	0.68	0.35	0.82
CD (P=0.05)	2.01	1.05	2.43
Interaction			
SEm±	1.36	0.71	1.64
CD (P=0.05)	NS	NS	NS
CV %	13.97	6.55	9.29

Dry matter production (g m⁻²)

Dry matter production of finger millet recorded at tillering, flowering and harvest stages was significantly influenced by different nitrogen levels (Table 2.). The increase in dry matter production significantly increased with increasing nitrogen levels up to N₄ (150 % RDN) but there was no significant increase beyond N₃ (100% RDN). However, the highest dry matter production was seen with N₄ (150 % RDN) and the lowest dry matter production was recorded with N₁ (0 % RDN). Dry matter production of finger millet recorded was significantly influenced by different plant densities. Among the different plant densities tested S₁ (solid rows × 15 cm) recorded the highest dry matter production at all the growth stages i.e., at tillering, flowering and harvest and the lowest dry matter production was recorded with S₂ (30 cm × 15 cm) at all the growth stages.

The increasing nitrogen levels increased plant height, tillers per plant and leaf area indicating higher chlorophyll area improving photosynthetic efficiency of plant which in turn resulted in highest dry matter accumulation. Sima, 2011 [15]. Increased plant population due to closer spacing in treatments with spacing of solid rows × 15 cm resulted in more number of plants unit area⁻¹ and leaf area (cm²) plant⁻¹ which increased the photosynthetic efficiency of finger millet and eventually increased the dry matter production m⁻². Ramachandrappa *et al.* 2018 [12].

Total number of Tillers m⁻²:

Significantly there was an increase in number of tillers m⁻² with increasing nitrogen levels where N₄ (150 % RDN) had the supremacy over all the other levels of nitrogen and the lowest number of tillers m⁻² was recorded with N₁ (0 % RDN) at all the growth stages. Among the different plant densities tested S₁ (solid rows) recorded the highest number of tillers m⁻² at all the growth stages i.e., at tillering, flowering and harvest and the lowest number of tillers m⁻² was recorded with S₃ (25 cm × 15 cm) at all the growth stages. The increased tiller number might be due to enhanced translocation of nutrients at higher levels of nitrogen Munirathnam and Ashok, 2015 [3] and the individual plants have effectively utilized the available resources such as space, foraging area for root system, light utilization etc. under wider spaced treatments and thus enhanced the tiller production. (Table 3.)

Leaf Area (cm²)

Leaf area plant⁻¹ of finger millet recorded at all the stages was significantly influenced by different nitrogen levels at all the growth stages i.e., at tillering, flowering and harvest. The

Table 2. Dry matter production (g m^{-2}) of finger millet at different growth stages as influenced by plant densities and nitrogen levels

Treatment	Tillering	Flowering	Harvest
Nitrogen levels (% RDN)			
N ₁ - 0	52.04	150.58	313.99
N ₂ - 50	60.48	173.94	367.13
N ₃ -100	69.05	204.61	442.37
N ₄ -150	70.93	208.17	447.87
SEm±	0.88	4.22	7.38
CD (P=0.05)	2.60	12.46	21.79
Plant density levels			
S ₁ -Solid rows	65.69	191.93	414.12
S ₂ -30 cm × 15 cm	60.10	177.91	373.61
S ₃ -25 cm × 15 cm	63.59	183.13	390.79
SEm±	0.76	3.65	6.39
CD (P=0.05)	2.25	10.79	18.87
Interaction			
SEm±	1.52	7.31	12.78
CD (P=0.05)	NS	NS	NS
CV %	5.53	9.58	8.94

increase in leaf area plant⁻¹ significantly increased with increasing nitrogen levels upto N₄ (150 % RDN) but there was no significant increase beyond N₃ (100% RDN). However, the highest leaf area plant⁻¹ was seen with N₄ (150 % RDN) and the lowest leaf area plant⁻¹ was recorded with N₁ (0 % RDN). The increasing nitrogen levels increased plant height, tillers per plant and leaf area indicating higher chlorophilic area improving photosynthetic efficiency of plant. Nitrogen nutrition affects the number of thylakoids per unit leaf area that result in increased the photosynthetic efficiency of finger millet plant with higher photosynthesis accumulation and effective translocation which accounts for higher dry matter accumulation. Sima, 2011[15] Among the different plant densities tested S₁ (solid rows × 15 cm) recorded the highest leaf area plant⁻¹ at all the growth stages i.e., at tillering, flowering and harvest and the lowest leaf

Table 3. Total number of tillers m⁻² of finger millet at different growth stages as influenced by plant densities and nitrogen levels

Treatment	Tillering	Flowering	Harvest
Nitrogen levels (% RDN)			
N ₁ - 0	31.44	85.11	104.66
N ₂ - 50	37.44	94.11	120.44
N ₃ -100	49.44	104.33	131.66
N ₄ -150	52.88	107.11	136.00
SEm±	2.36	2.08	3.68
CD (P=0.05)	6.96	6.16	10.88
Plant density levels			
S ₁ -Solid rows	49.66	110.25	139.08
S ₂ -30 cm × 15 cm	3.50	89.00	112.08
S ₃ -25 cm × 15 cm	41.25	93.75	118.41
SEm±	2.04	1.80	3.19
CD (P=0.05)	6.03	5.33	9.43
Interaction			
SEm±	4.08	3.61	6.38
CD (P=0.05)	NS	NS	NS
CV %	17.93	8.51	11.47

area plant⁻¹ was recorded with S₂ (30 cm × 15 cm) at all the growth stages. Decreased plant population due to wider spacing in treatments with S₃ (25 cm × 15 cm) and S₂ (30 cm × 15 cm) increased the number of leaves and tillers per plant and eventually increased leaf area (cm⁻²) plant⁻¹ due to proper interception of light, less competition for resources for the growth of the plant. The results obtained were in consonance with those of Prakasha *et al.* 2018[14] and Ramachandrappa *et al.* 2018[12]. (Table 4)

3.2 Yield

3.2.1 Grain yield (kg ha⁻¹)

Significantly highest grain yield was recorded under (1888 kg ha⁻¹) followed by N₃ -100 % RDN (1871 kg ha⁻¹) and the lowest grain yield was recorded with N₁ - 0 % RDN (1389 kg ha⁻¹)

Table 4. Leaf area (cm²) plant⁻¹ of finger millet at different growth stages as influenced by plant densities and nitrogen levels

Treatment	Tillering	Flowering	Harvest
Nitrogen levels (% RDN)			
N ₁ - 0	38.7	187.7	154.8
N ₂ - 50	49.7	204.9	182.3
N ₃ -100	66.5	229.8	212.7
N ₄ -150	67.3	232.6	213.3
SEm±	1.3	4.6	4.2
CD (P=0.05)	3.9	13.6	12.4
Plant density levels			
S ₁ -Solid rows	50.1	206.6	180.6
S ₂ -30 cm × 15 cm	55.2	213.2	190.1
S ₃ -25 cm ×15 cm	61.3	221.4	201.6
SEm±	1.1	3.9	3.6
CD (P=0.05)	3.4	11.2	10.7
Interaction			
SEm±	2.3	7.9	7.2
CD (P=0.05)	NS	NS	NS
CV %	8.6	8.9	12.7

¹). Higher grain yield with N₄-150 % RDN was due to the improved growth and yield attributes under adequate availability of nitrogen Pradhan *et al.* 2015 [16]. Among the different plant densities tested, highest grain yield (1778 kg ha⁻¹) was obtained with S₃ -25 cm × 15 cm and lowest grain yield (1587 kg ha⁻¹) with S₁-solid rows × 15 cm. Wider spacing and adequate nitrogen helped towards better photosynthesis and growth and reflected in higher seed yield. On the other hand, higher plant population in solid spacing resulted in heavy competition amongst the plants for moisture, nutrients and solar radiation and finally lead to marked reduction in the yield Chavan *et al* 2018 [17]. (Table 5)

3.2.2 Stover yield (kg ha⁻¹)

Among the different nitrogen levels, the highest straw yield was recorded with N₄ -150 % RDN (5133 kg ha⁻¹) which was statistically significant over all the other treatments and the

lowest straw yield (3833 kg ha⁻¹) with N₁-0 % RDN. Higher straw yield under N₄-150 % RDN could

Table 5. Grain yield and straw yield of finger millet as influenced by plant densities and nitrogen levels

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
Nitrogen levels (% RDN)		
N ₁ - 0	1389	3833
N ₂ - 50	1570	4452
N ₃ -100	1871	5097
N ₄ -150	1888	5133
SEm±	40.64	60.98
CD (P=0.05)	119.98	180.01
Plant density levels		
S ₁ -Solid rows	1587	4449
S ₂ -30 cm × 15 cm	1671	4655
S ₃ -25 cm ×15 cm	1778	4779
SEm±	35.2	52.81
CD (P=0.05)	103.9	155.89
Interaction		
SEm±	70.40	105.62
CD (P=0.05)	NS	NS
CV %	10.46	5.50

be attributed to adequate supply of nitrogen that promoted higher biomass production Triveni *et al* 2018 [2].

With respect to plant density, highest straw yield (4779 kg ha⁻¹) was registered in S₃- 25 cm × 15 cm and the lowest straw yield (4449 kg ha⁻¹) was recorded with S₁-solid rows × 15 cm. Higher straw yield recorded under wider spacing may be attributed to adequate space that helped in better photosynthesis and growth (number of tillers and dry matter production) Kalaraju *et al* 2011 [18]. (Table 5)

Conclusion

From the results of the experiment, it could be concluded that among N levels tested, N₄-150% N recorded the highest growth attributes and yield and among plant densities, S₃-25 cm × 15 cm recorded highest yield attributes, yield and monetary returns and the interaction effect between the nitrogen levels and plant densities was found to be non-significant on growth attributes and yield.

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