Original Research Article

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

Abstract

A field experiment was conducted during *kharif*, 2019 at College Farm, Professor Jayashankar Telangana State Agricultural University, Telangana. The present study was conducted to know the effect of different planting densities and nitrogen levels on the growth and yield of Finger millet. 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 planting density (S_1-solid rows × 15 cm, S_2- 30 cm × 15 cm, S_3- 25 cm × 15 cm). Results indicated that S_1-solid rows × 15 cm recorded highest plant height, number of tillers m^{-2}, dry matter production (g m^{-2}) and S_3- 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. It was concluded that planting density of 25 cm × 15 cm among spacings and 100% N among nitrogen levels proved to be a viable option for getting higher productivity and profit under rainfed conditions of central agro climatic zone of Telangana.

Key words

Finger millet, Nitrogen, planting 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. Some previous research results suggested 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 planting 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 planting densities (S_1-solid rows × 15 cm, S_2- 30 cm × 15 cm, S_3- 25 cm × 15 cm). The recommended dose of NPK fertilizer is N, P and K @ 40: 30: 30 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 × 15 cm and T_9, T_{10}, T_{11} and T_{12} was sown with 25cm × 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 ear head, 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 N_4 (150 % RDN) which was comparable with N_3 (100% RDN) and the shortest plants were recorded with N_1 (0 % RDN) at all growth stages. Among the different planting densities tested, the tallest plants were produced with S_1 (solid rows × 15 cm) and the shortest plants were recorded with S_3 (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 led 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].

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 N_4 (150 % RDN) but there was no significant increase beyond N_3 (100% RDN). However, the highest dry matter production was seen in N_4 (150 % RDN) and the lowest dry matter production was recorded in N_1 (0 % RDN). Dry matter production of finger millet recorded was significantly influenced by different plant densities. Among the different planting densities tested S_1 (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 S_2 (30 cm × 15 cm) at all the growth stages.

The increase in nitrogen levels increased plant height, tillers per plant and leaf area indicating higher chlorophilic area improving photosynthetic efficiency of plant which in turn resulted in highest dry matter accumulation. Sima, 2019 [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 (cm^{-2}) plant^{-1} which increased the photosynthetic efficiency of finger millet and eventually increased the dry matter production m^{-2}. Ramachandrappa *et al*., 2018 [12].

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

Treatment	Tillering	Flowering	Harvest
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
Planting 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

Total number of Tillers m^{-2}:

Significantly there was an increase in number of tillers m^{-2} with increasing nitrogen levels where N_4 (150 % RDN) had the supremacy over all the other levels of nitrogen and the lowest number of tillers m^{-2} was recorded with N_1 (0 % RDN) at all the growth stages. Among the different planting densities tested S_1 (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 S_3 (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.).

Table 2. Dry matter production (g m^{-2}) of finger millet at different growth stages as influenced by planting 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
Planting 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

Leaf Area (cm^2)

As presented in Table 4, 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 increase in leaf area plant^{-1} significantly increased with increasing nitrogen levels up to N_4 (150 % RDN) but there was no significant increase beyond N_3 (100% RDN). However, the highest leaf area plant^{-1} was seen in N_4 (150 % RDN) and the lowest leaf area plant^{-1} was recorded in N_1 (0 % RDN). The increase in 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 resulted to increase in the photosynthetic efficiency of finger millet plant with higher photosynthesis accumulation and effective translocation which accounts for higher dry matter accumulation. Sima, 2019[15].

Table 3. Total number of tillers m^{-2} of finger millet at different growth stages as influenced by planting 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
Planting 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

Among the different planting densities tested S_1 (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 area plant^{-1} was recorded with S_2 (30 cm × 15 cm) at all the growth stages. Decreased plant population due to wider spacing in treatments with S_3 (25 cm × 15 cm) and S_2 (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 (Table 4). The results obtained were in consonance with those of Prakasha *et al.*, 2018[14] and Ramachandrappa *et al.*, 2018[12].

Table 4. Leaf area (cm^2) $plant^{-1}$ of finger millet at different growth stages as influenced by planting 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
Planting 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

Yield

Grain yield (kg ha^{-1})

As presented in Table 5, significantly highest grain yield was recorded under N_4 -150 % RDN (1888 kg ha^{-1}) followed by N_3 -100 % RDN (1871 kg ha^{-1}) and the lowest grain yield was recorded with N_1 - 0 % RDN (1389 kg ha^{-1}). Higher grain yield with N_4-150 % RDN was due to the improved growth and yield attributes under adequate availability of nitrogen Pradhan *et al*. 2015 [16]. Among the different planting densities tested, highest grain yield (1778 kg ha^{-1}) was obtained with S_3 -25 cm × 15 cm and lowest grain yield (1587 kg ha^{-1}) with S_1-solid rows × 15 cm. Wider spacing and adequate nitrogen helped towards better photosynthesis, growth and higher seed yield (Table 5). 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].

Stover yield (kg ha^{-1})

Among the different nitrogen levels, the highest straw yield (see Table 5) was recorded with N_4 -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 N_1-0 % RDN.

Table 5. Grain yield and straw yield of finger millet as influenced by planting 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

Higher straw yield under N_4-150 % RDN could be attributed to adequate supply of nitrogen that promoted higher biomass production as reported by Triveni *et al.*, 2018 [2]. With respect to planting density, highest straw yield (4779 kg ha^{-1}) was registered in S_3- 25 cm × 15 cm and the lowest straw yield (4449 kg ha^{-1}) was recorded with S_1-solid rows × 15 cm (see Table 5). 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) as reported by Kalaraju *et al.*, 2011[18].

Conclusion

From the results of the experiment, it could be concluded that there was marked variations on the productivity of finger millet due to different planting densities and nitrogen levels. Planting density of 25 cm × 15 cm spacing among spacings and 100% N among nitrogen levels proved to be a viable option for getting higher productivity and profit under rainfed conditions of central agro climatic zone of Telangana.

References:

1. Wanyera, N.M.W., Mgonja, M. A., Lenne, J. M., Manyasa, E and Sreenivasa P. Finger millet (*Eleusine coracana* (L.) Gaertn) in Uganda. In Finger millet blast management in East Africa. Creating opportunities for improving production and utilization of finger millet. Proceedings of the First International Finger Millet Stakeholder Workshop, 13−14 September 2005, S. Nairobi, Kenya: International Crops Research Institute for the Semi-Arid Tropics. (2007)

2. Triveni, U., SandhyaRani, Y., Patro, T. S. S. K., Anuradha, N and Divya, M. Fertilizer responsiveness of short duration improved finger millet genotypes to different levels of NPK fertilizers. Indian Journal of Agriculture Research. 2018; 52(1): 97-100.

3. Munirathnam, P and Ashok Kumar, K. Response of white ragi varieties to nitrogen under rainfed situation in vertisols of Andhra Pradesh. Annals of Plant and Soil Research 2015; 17 (2): 142-145.

4. Thilakarathna, M.S and Manish, N.R. A Review of Nutrient Management Studies Involving Finger Millet in the Semi-Arid Tropics of Asia and Africa. Agronomy. 2015; 5: 262-290.

5. Kumar, P.D., Sagar, M., Shankar, T and Pushpalatha, G. Effect of Crop Geometry and Age of Seedlings on Productivity and Nutrient Uptake of Finger Millet (*Eleusine coracana* L. Gaertn). International Journal of Agriculture, Environment and Biotechnology. 2019;12(3): 267-272.

6. Agricultural Statistics at a glance Telangana. Directorate of Economics and Statistics. Government of Telangana, Hyderabad. 2015-16

7. Season and Crop Report, Telangana. Directorate of Economics and Statistics. Government of Telangana, Hyderabad-500004. 2015-16.

8. Mane, M. J., Mahadkar, U. V., Sagavekar, V. V., Jagtap, D. N., & Dhekale, J. S. Economics of finger millet (*Eleusine Coracana* (L) Gaertn) as influenced by land situations, various planting geometry and levels of fertilizer under lateritic soil of konkan region International Journal of Chemical Studies. 2019; 7(6): 838-847.

9. Nandhini, K.M and Sridhara, S. Response of Growth, Yield and Quality Parameters of Foxtail Millet Genotypes to Different Planting Density. International Journal of Current Microbiology and Applied Sciences. 2019; 8(2): 1765-1773.

10. Rajesh, K. System of crop intensification in finger millet (*Eleusine coracana* (L.) Gaertn.) under irrigated condition. M. Sc. (Ag.) Thesis, TNAU, Coimbatore**.** 2011.

11. Andrew K., Peter K and David, M. Effect of Fertilization and Spacing on Growth and Grain Yields of Finger Millet (*Eleusine Coracana* L.) in Ainamoi, Kericho County, Kenya. International Journal of Advanced Research and Publications. 2018; 2(10).

12. Ramachandrappa, B.K. Thimmegowda, M.N. Narayan Hebbal. Yield and economics of finger millet with establishment methods under different planting geometry and nutrient source. Indian Journal of Dryland Agriculture Research and Development. 2018; 33(1): 54-58.

13. Hebbal, N., Ramachandrappa, B. K., Mudalairiyappa and Thimmegouda, M.N. Yield and Economics of Finger Millet with Establishment Methods under Different Planting Geometry and Nutrient Source. Indian Journal of Dryland Agricultural Research and Development. 2018; 33(1): 54-58.

14. Prakasha, G., Kalyana Murthy, K. N., Prathima, A.S and Rohani N.M. Effect of Spacing and Nutrient Levels on Growth Attributes and Yield of Finger Millet (*Eleusine coracana* L. Gaertn) Cultivated under Guni Planting Method in Red Sandy Loamy Soil of Karnataka, India. International Journal of Current Microbiology and Applied Sciences. 2018; 7(05):1337-1343.

15. Sima, K., Anand, R and Singh, C.S. Quality of finger millet as influenced by nitrogen levels and genotypes. International Archive of Applied Sciences and Technology. 2019; 10(3): 36-39.

16. Pradhan, A. Sao. A. Patel, D.P. Nag, S.K. and Mukherjee, S.C. Effect of establishment methods and nitrogen levels on finger millet. Annals of Agriculture Research. 2015; 36(1):107-113.

17. Chavan, I.B., Jagtap, D.N. and Mahadkar, U.V. Effect of different establishment

techniques, levels, and time of application of nitrogen on partitioning of dry matter in finger millet. Farming and Management. 2018; 3(2): 104-109.

18. Kalaraju, K., Deva Kumar, N., Nagaraja, N and Ningappa, K. B. Effect of methods of planting on growth and yield of finger millet genotypes under organic farming. Research on Crops. 2011; 10(1): 20-24.