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Impact of Varying Levels of Plant Density and Nitrogen on Nutrient Uptake of Finger Millet (*Eleusine coracana* L.)

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ABSTRACT

Finger millet responds well to N application since many of the soils in the semi-arid regions of Asia are deficient in major nutrients, mainly due to continuous cropping, low use of mineral fertilizer. Therefore, 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 C. 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, S_2- 30 cm × 15 cm, S_3- 25 cm × 15 cm). Results indicated that the highest uptake of N, P and K was recorded with N_4 (150 % RDN) which was significantly higher over other treatments. The next best treatment was N_3 (100 % RDN). The lowest uptake of N, P and K was recorded with N_1 (0 % RDN). The highest uptake of N, P and K was recorded with S_1 (solid rows× 15 cm) at tillering and flowering stages which was significantly higher over other treatments and with S_3 (25 cm × 15 cm) at harvest. The lowest uptake of N, P and K was recorded with S_2 (30 cm × 15 cm) at all the growth stages.

Keywords Finger millet, Nitrogen, Plant density, Plant height, Drymatter, Leaf area, Yield.

INTRODUCTION

Among the small millets, finger millet ranked fourth globally based on its importance after sorghum, pearl millet and foxtail millet respectively containing highest amount of calcium (344 mg%) and potassium (408 mg%). It is one of the important millets occupying highest area under cultivation among small millets (Reddy and Singh 2021). Finger millet is known for drought tolerance and can adapt to a wide range of soil and climatic conditions though it prefers fertile,

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well-drained sandy to sandy loam soils, with a pH ranging from 5 to 7 (Triveni *et al.* 2018) and is an important crop in drought prone regions because of its outstanding ability to withstand adverse weather conditions (Munirathnam and Ashok 2015). Among the other millets, finger millet has a high amount of calcium (0.38%), fiber (18%), phenolic compounds (0.3–3.0%) and sulphur containing amino acids (Thilakarathna and Manish 2015). 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). 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). 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).

Nitrogen is applied in large quantity for most annual crops as it is one of the most yield limiting nutrients for crop production playing an important role in building units of proteins in the plant system thus, nutrition not only influences productivity but also quality (Krishna *et al.* 2019). Finger millet responds well to N application since many of the soils in the semi-arid regions of Asia are deficient in N (Malinda *et al.* 2015). The authors claimed that the economic optimum rate of N fertilizer for finger millet was 43.5 kg ha^{-1} under rainfed conditions. 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.

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) 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). Also crop establishment method is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil and above ground by harvesting maximum possible solar radiation and in turn better photosynthates formation.

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 nutrient uptake 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 × 15 cm, S_2- 30 cm × 15 cm, S_3- 25 cm × 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 × 15 cm and T_9, T_{10}, T_{11} and T_{12} was sown with 25 cm × 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%

Table 1. Nitrogen uptake (kg ha^{-1}) by plant as influenced by plant densities and levels of nitrogen.

Treatments	Tillering	Flowering	Harvest Grain	Straw	Total
Nitrogen levels (% RDN)					
N_1- 0	19.3	49.8	24.7	35.9	60.6
N_2- 50	26.3	63.5	32.4	48.3	80.7
N_3-100	31.8	83.4	47.3	64.8	112.1
N_4-150	33.1	86.5	48.4	65.8	114.2
SEm±	0.5	3.5	0.9	0.4	1.2
CD (P=0.05)	1.6	10.3	2.9	1.4	3.7
Plant density levels					
S_1-Solid rows	29.8	77.0	36.9	54.1	91.1
S_2-30 cm × 15 cm	25.3	65.3	37.4	51.6	89.1
S_3-25 cm × 15 cm	27.8	70.1	40.2	55.4	95.6
SEm±	0.4	3.0	0.8	0.4	1.1
CD (P=0.05)	1.4	8.9	2.5	1.2	3.2
Interaction					
SEm±	0.9	6.05	1.7	0.8	2.2
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	7.6	18.8	15.4	13.3	15.4

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 was applied (N, P and K @ 40 : 30 : 30 kg ha^{-1}). Plant samples collected at tillering, flowering and at harvest stages were sun dried and then packed in labelled brown paper bags. These samples were oven dried for 36-48 hrs at 60–65^oC till constant weight is obtained. The oven dried plant samples were grinded and finely ground samples were kept in labelled butter paper bags. Samples were analyzed for N, P and K content by adapting standard procedures at PG laboratory of the Department of Agronomy. The values of N, P and K contents for grain and straw were recorded treatment wise and then N, P and K uptakes were determined for grain and straw yields of each treatment.

RESULTS AND DISCUSSION

Nitrogen uptake

In finger millet, nitrogen application has been found to increase the growth, dry matter production and yield underdry/rainfed conditions. At all the growth stages i.e., tillering, flowering and harvest N_4 (150 % RDN) recorded the highest N uptake which was on par with N_3 (100% RDN) and the lowest N uptake was recorded with N_1 (0 % RDN).

Among the three plant densities the highest N uptake was recorded with S_1 (solid rows) at tillering, flowering and S_3 (25 cm × 15 cm) recorded the highest N uptake at harvest. The lowest N uptake was recorded with S_2 (30 cm × 15 cm) at all the growth stages i.e., at tillering, flowering and at harvest. However, there was no significant difference between S_3 (25 cm × 15 cm) and S_1 (solid rows × 15 cm) (Table 1).

Phosphorus uptake

Phosphorus also plays a vital role in increasing the yield. It is an important nutrient in energy transfer for the living cells by means of high-energy phosphate bonds of ATP. Phosphorus deficit is the most important restrictive factor in plant growth because it promotes root development that in turn enhances uptake of other essential elements.

At all the growth stages i.e., tillering, flowering and harvest N_4 (150 % RDN) recorded the highest P uptake which was on par with N_3 (100 % RDN) and the lowest P uptake was recorded with N_1 (0% RDN) and among the three plant densities the highest P uptake was recorded with S_1 (solid rows × 15 cm) at tillering, flowering and S_3 (25 cm × 15 cm) recorded the highest P uptake at harvest. The lowest P uptake was recorded with S_2 (30 cm × 15 cm) at all the growth stages i.e., at tillering, flowering and at harvest. However, S_3 (25 cm × 15 cm) was statistically on par with S_1 (solid rows × 15 cm) (Table 2).

Potassium uptake

Potassium is an essential major plant nutrient with numerous functions. It helps in grain filling, grain weight, strengthens straw, increases disease resistance and helps the plant better to with stand stress. N_4 (150% RDN) recorded the highest K uptake which was on par with N_3 (100% RDN) at all the growth stages i.e., tillering, flowering and harvest and the

Table 2. Phosphorus uptake (kg ha^{-1}) by plant as influenced by plant densities and nitrogen levels.

Treatments	Tiller-ing	Flow-ering	Har-vest Grain	Straw	Total
Nitrogen levels (% RDN)					
N_1- 0	1.4	2.6	1.7	4.4	6.2
N_2- 50	1.8	4.2	2.8	6.9	9.7
N_3-100	2.4	6.3	4.7	10.4	15.1
N_4-150	2.5	6.5	5.1	10.9	16.1
SEm±	0.04	0.3	0.1	0.3	0.2
CD (P=0.05)	0.1	1.0	0.3	1.0	0.8
Plant density levels					
S_1-Solid rows	2.1	5.6	3.8	8.4	12.3
S_2-30 cm × 15 cm	1.8	4.3	3.03	7.1	10.1
S_3-25 cm × 15 cm	2.14	4.8	4.01	9.0	13.0
SEm±	0.03	0.2	0.1	0.3	0.2
CD (P=0.05)	0.1	0.8	0.3	0.9	0.7
Interaction					
SEm±	0.06	0.59	0.2	0.61	0.49
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	13.5	15.1	14.1	18.4	13.3

Table 3. Potassium uptake (kg ha^{-1}) by plant as influenced by plant densities and nitrogen levels.

Treatments	Tiller-ing	Flow-ering	Har-vest Grain	Straw	Total
Nitrogen levels (% RDN)					
N_1- 0	9.0	25.6	6.9	26.7	33.7
N_2- 50	11.8	32.1	11.3	40.8	52.2
N_3-100	15.1	41.7	18.4	58.8	77.2
N_4-150	15.6	43.4	19.5	59.8	79.4
SEm±	0.1	0.60	0.4	0.7	0.9
CD (P=0.05)	0.3	1.7	1.3	2.1	2.7
Plant density levels					
S_1-Solid rows	13.8	37.3	14.3	49.0	63.4
S_2-30 cm × 15 cm	11.8	33.0	12.0	41.4	53.5
S_3-25 cm × 15 cm	12.9	36.8	15.8	49.1	65.0
SEm±	0.1	0.52	0.3	0.6	0.8
CD (P=0.05)	0.3	1.54	1.1	1.8	2.3
Interaction					
SEm±	0.2	1.04	0.7	1.2	1.6
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	10.1	8.07	19.9	13.7	16.3

lowest K uptake was recorded with N_1 (0 % RDN) (Table 3). Among the three plant densities the highest K uptake was recorded with S_1 (solid rows × 15 cm) at tillering, flowering and S_3 (25 cm × 15 cm) recorded the highest K uptake at harvest. The lowest K uptake was recorded with S_2 (30 cm × 15 cm) at all the growth stages i.e., at tillering, flowering and at harvest. However, S_3 (25 cm × 15 cm) was statistically on par with S_1 (solid rows × 15 cm) (Table 3).

At tillering and flowering stages, the uptake of nitrogen, phosphorus and potassium followed the trend of dry matter accretion under varied planting patterns and nitrogen levels. Even though the uptake-of nutrient per plant was higher under wider spacing the total nutrient uptake per unit area was high under closer spacing S_1 (solid rows × 15 cm) at 60 DAS combined with high level of nitrogen. At harvest uptake of nutrient per unit area was more under S_3 (25 cm × 15 cm) because of a greater number of tillers m^{-2} and higher dry matter production. These results are in close conformity with the findings of Ramachandrappa *et al.* (2018),

N_4 (150 % RDN) with recommended dose of P and K recorded the highest uptake of nitrogen, phosphorus and potassium as increased uptake of nutrients in plant system is a consequence of availability of nutrients, decomposition of organic matter applied resulting in mineralization of insoluble phosphate into more soluble phosphates and solubilising the native, fixed or non-ex- changeable form of potassium into soil and increased absorption of K by crop plants along with N particularly. These results agree to the findings of Gautam *et al.* (2020) and Divyashree *et al.* (2018). Application of lower level of nitrogen recorded lower growth, contents and uptake of nutrients resulted in lower grain yield. Further progressively increase in levels of N application helped to enhance growth, accordingly the contents and uptake. N_3 (100% RDN) with recommended dose of P and K application resulted to obtain moderate yield and further increase in the N levels with recommended dose of P and K achieved maximum growth and uptake of nutrients.

CONCLUSION

N_4 (150% RDN) among nitrogen levels and S_3 (spacing of 25 cm × 15 cm) among spacings resulted in the highest amount of nutrient uptake which is a combined effect of availability of nutrients and less competition between the plants for nutrients provided due to wider spacing. The interaction effect between the nitrogen levels and plant densities was found to be non-significant.

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