The Pharma Innovation Journal 2021; 10(12): 207-211

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 207-211

www.thepharmajournal.com
Received: 02-09-2021
Accepted: 10-11-2021

N Pavankumar
M.Sc. Student, Department of Agronomy, ANGRAU, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

S Hemalatha
Professor, Department of Agronomy, ANGRAU, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

D Subramanyam
Principal, Department of Agronomy, ANGRAU, Agricultural Polytechnic, Punganur, Andhra Pradesh, India

AR Nirmal Kumar
Assistant Professor, Department of Crop Physiology, ANGRAU, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

G Karuna Sagar
Professor and Head, Department of Agronomy, ANGRAU, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

Corresponding Author:
N Pavankumar
M.Sc. Student, Department of Agronomy, ANGRAU, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

Effect of plant geometry and nitrogen levels on growth and yield of brown top millet (*Brachiaria ramosa* L.) under Southern Agro-climatic zone of Andhra Pradesh

N Pavankumar, S Hemalatha, D Subramanyam, AR Nirmal Kumar and G Karuna Sagar

Abstract
A field experiment entitled "performance of browntop millet (*Brachiaria ramosa* L.) under varied plant geomerty and nitrogen levels" was carried out during *kharif*, 2020 on sandy loam soils of dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University. The present experiment was laid out in a random block design with factorial concept and replicated thrice. The treatments include three plant geometry viz., P_1 (30 cm x 20 cm), P_2 (45 cm x 20 cm) and P_3 (60 cm x 20 cm) and four nitrogen levels, viz., 20 kg N ha^{-1} (N_1), 40 kg N ha^{-1} (N_2), 60 kg N ha^{-1} (N_3) and 80 kg N ha^{-1} (N_4). Results of the present study revealed that browntop millet grown with P_2 (45 cm x 20 cm) plant geometry along with application of 60 kg N ha^{-1} (N_3) resulted in higher productivity (1548 kg ha^{-1}).

Keywords: Browntop millet, plant geometry, nitrogen levels, SPAD chlorophyll meter reading

1. Introduction

Browntop millet (*Brachiaria ramosa* L.) is one of the minor millet that can be grown on a variety of soils, climates and adapted to a wide range of ecological conditions. It is a drought hardy, heat tolerant, also comes up under flooded conditions in lowland areas (Bhat *et al*., 2018) [3]. It suppresses root-knot nematode in the soil. Browntop millet is an annual warm-season crop that grows 3 to 5 ft tall with fibrous roots that can penetrate up to a depth of 60 cm. Seeds are ellipsoid and tan in colour, matures approximately 75-90 days. It is known for its rapid forage production (hardly 50 days duration), act as a cover crop in plantation crops for soil erosion control and for high straw production. It contains 8.98, 1.89, 3.90 and 71.32% of protein, fat, minerals and carbohydrates respectively. Each 100 g of browntop millet provides 338 kilocalories of energy and rich source of macro and micronutrients comprised of 28 mg of calcium, 276 mg of phosphorus, 60 mg of potassium, 94.5 mg of sodium, 7.72 mg of iron, 2.75 mg of zinc and 1.23 mg of copper (Roopa, 2015) [3].

Lodging is a major problem in browntop millet causing low productivity in semi-arid regions during *kharif* when it is sown at 30 cm x 10 cm or broadcasting. Optimum spacing and nitrogen management enables the crop to experience favourable environmental conditions during various growth and developmental stages, resulting in better performance and enhanced productivity of browntop millet. Optimum nitrogen dose is required for initial establishment, vigorous growth of tillers and more number of leaves that enables the plant to operate at peak photosynthetic capacity and higher protein content of grain which in turn enhance the productivity and quality of grain. Therefore, the optimum spacing and nitrogen fertilizer dose are considered to be the most important agronomic interventions to enhance the productivity of the crop. In this context, the present study has been planned to identify the optimum plant geometry and optimum nitrogen dose for browntop millet in Southern Agro-climatic Zone of Andhra Pradesh.

2. Materials and Methods

The present field experiment was carried out at dryland farm, S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University. The experiment was laid out in a random block design with factorial concept replicated thrice with twelve treatment combinations. The treatments include three plant geometry *viz*., P_1 (30 cm x 20 cm), P_2 (45 cm x 20 cm) and P_3 (60 cm x 20 cm) and four nitrogen levels, *viz*., 20 kg N ha^{-1} (N_1), 40 kg N ha^{-1}

(N_2), 60 kg N ha^{-1} (N_3) and 80 kg N ha^{-1} (N_4). The experimental field was sandy loam in texture which is low in organic carbon (0.38%). The soil is alkaline in reaction (pH 7.7), low in available N (151.0 kg ha^{-1}), medium in available phosphorus (207.0 kg ha^{-1}) and potassium (34.0 kg ha^{-1}). The variety of browntop millet tested was GPUBT-6. A total rainfall of 859.0 mm was received in 33 rainy days during the crop growing period. Recommended dose of fertilizers was 40-20-20 kg N, P_2O_5 and K_2O ha^{-1}. The nutrients were applied in the form of urea, single super phosphate and muriate of potash. N was applied in three splits, one third of N and entire quantities of P_2O_5 and K_2O were applied as basal at the time of sowing and remaining two splits of N was applied after 30 days after sowing and at panicle initiation stage by placement method. Plants from each treatment in the plot were selected at random and tagged for taking the observation on growth paramerters *viz*, plant height, leaf area index, SPAD chlorophyll meter reading, number of tillers m^{-2}, dry matter production and yield attributes *viz*, number of panicles m^{-2}, panicle length, grain weight panicle^{-1}, test weight, grain yield and straw yield. The data collected were analyzed statistically following the procedure given by Panse and Sukhatme (1985) [10] wherever the treatmental differences were significant, critical differences were worked out at five per cent probability level. Treatment differences that were not significant are denoted as NS.

3. Results and Discussion

3.1 Growth Parameters

The data on growth parameters like plant height, leaf area index, SPAD chlorophyll meter reading, no. of tillers m^{-2} and dry matter production as influenced plant geometry and nitrogen levels are presented in Table 1.

3.1.1 Plant height

The highest plant height (133 cm) was recorded with P_1 plant geometry which was significantly higher than P_2 and P_3 plant geometry. The lowest plant height (110 cm) was recorded with the P_3 plant geometry which exhibited significant disparity with P_2. It could be attributed to the fact that higher plant density resulted in mutual shading and reduced the availability of light, particularly to lower leaves. As a result, the individual plant tends to grow taller in search of light in higher plant density up to adequate nutrient availability. Application of 80 kg N ha^{-1} resulted in taller plant stature (134 cm) which was comparable with application of 60 kg N ha^{-1}, while short statured plants (105 cm) were noticed with application of 20 kg N ha^{-1}. This might be due to increased levels of nitrogen supply increased the availability and translocation of nitrogen from culm to leaves, which enhanced the synthesis of chlorophyll in turn production of more photosynthates led to increased cell division and elongation of cells in meristamatic region with higher auxin concentration. These results were in accordance with the findings of Siddiqui *et al*. (2020) [14].

3.1.2 Leaf area index

Plant geometry P_1 recorded higher leaf area index (2.22) compared to P_2 and P_3 plant geometry. This might be due to sufficient availability of light, nutrients and moisture resulting in production of broader leaves with better plant stature in P_2 and P_3 wider plant geometry which have linear relationship with LAI, but could not compensate the leaf area plant^{-1} to unit ground area under P_1 closer plant geometry. The leaf area index was recorded higher (2.22) with application of 80 kg N ha^{-1} and was recorded lower (2.19) with application of 20 kg N ha^{-1} with significant disparity between all of other nitrogen levels. Increased leaf area index with higher levels of nitrogen might be due to increased supply of nitrogen aggravated the production of chlorophyll and leaf primordia through enhanced cell division and cell enlargement, which in turn resulted in production of higher number of healthy and robust tillers coupled with more number of leaves plant^{-1}. Similar results were reported by Natarajan *et al*. (2019) [9].

3.1.3 SPAD chlorophyll meter reading

SPAD chlorophyll meter reading is a measure of leaf greenness which in turn depends on amount of leaf chlorophyll content. The highest SPAD chlorophyll meter reading (29.5) was recorded with P_3 plant geometry which was on par with that of P_2 and P_3 plant geometry. This might be due to adequate availability of nutrients and other growth resources with less competition in wider plant geometry when compared to closer plant geometry. Significantly higher SPAD chlorophyll meter reading (30.6) was recorded with application of 80 kg N ha^{-1} which was however comparable with application of 60 kg N ha^{-1} and followed by 40 kg N ha^{-1}. Lower SPAD chlorophyll meter reading (26.2) was recorded with application of 20 kg N ha^{-1} which was statistically on par with that of 40 kg N ha^{-1}. Nitrogen is a key constituent in chlorophyll synthesis, increased nitrogen supply helps in enhanced synthesis of chlorophyll, which in turn imparts dark green colour to the leaves (Huang *et al*., 2017) [5].

3.1.4 Number of tillers m^{-2}

Significantly higher number of tillers m^{-2} (152) was recorded with P_1 plant geometry followed by P_2 with significant disparity between them. Wider plant geometry resulted in more number of healthy and robust tillers plant^{-1} due to higher availability of light, moisture and nutrients when compared to closer plant geometry. But, it could not compensate the total number of tillers m^{-2} in closer plant geometry, as the population in closer plant geometry was higher than wider plant geometry. The number of tillers m^{-2} was significantly lower (125) with P_3 plant geometry. The highest number of tillers m^{-2} (153) was recorded with application of 80 kg N ha^{-1} which was comparable with 60 kg N ha^{-1} followed by 40 kg N ha^{-1} which in turn statistically on par with that of 60 kg N ha^{-1}. This might be due to higher availability of nitrogen enhanced the cell division and cell elongation at lower region of culm primordium leads to production and development of more number of tillers. Application of 20 kg N ha^{-1} (N_1) resulted in significantly lower number of tillers m^{-2} (118) when compared to other levels tested. These findings were in conformity with Vijay *et al*. (2019) [17] and Manojgowda *et al*. (2021) [6].

3.1.5 Dry matter production

Dry matter production was recorded higher (6478 kg ha $^{-1}$) with P_1 plant geometry than the rest of the plant geometry evaluated followed by P_2 plant geometry. This might be due to closer plant geometry that resulted in higher plant population with tall plant stature, more leaf area and higher number of tillers per unit area when compared to wider plant geometry increased the assimilatory surface and photosynthetic efficiency per unit area which in turn lead to the increased accumulation of photosynthates and dry matter. This was in line with the earlier findings of Thakur *et al*. (2019) [15] and Sanjay *et al*. (2021) [12]. Plant geometry P_3

recorded significantly lower dry matter production (5611 kg ha $^{-1}$) which was in turn on par with that of P_2 plant geometry. Application of 80 kg N ha^{-1} resulted in higher dry matter production (6709 kg ha $^{-1}$) which was however comparable with 60 kg N ha^{-1}. The lowest dry matter production (5008 kg ha $^{-1}$) was registered with 20 kg N ha^{-1} which was significantly lesser than the rest of the nitrogen levels investigated. This might be due to the reason that with increased supply of nitrogen, the availability of nitrogen to the crop root system was increased and there by the plant height, leaf area, number of tillers were enhanced unit area^{-1} which intrun led to higher amount of dry matter production and accumulation (Divyashree *et al.*, 2018) [4].

3.2 Yield Attributes and Yield

Yield contributing characters, *viz*. panicles m^{-2}, panicle length (cm), grain weight panicle^{-1} (g), test weight (thousand grain weight) (g), grain yield (kg ha $^{-1}$) and straw yield (kg ha $^{-1}$) were significantly influenced by varied plant geometry and nitrogen levels presented in (Table 2).

3.2.1 Number of panicles m^{-2}

Higher number of panicles m^{-2} (124) were noticed with P_1 closer plant geometry followed by P_2 plant geometry. Significantly lower number of panicles m^{-2} (107) were observed with P_3 plant geometry. Eventhough wider plant geometry resulted in more number of productive tillers plant^{-1}, but could not compensate the number of productive tillers per unit area, which was higher in case of closer plant geometry. These findings are in conformity with Siddiqui *et al*., (2020) [14]. Among the nitrogen levels tried, application of 80 kg N ha^{-1} registered significantly higher number of panicles m^{-2} (128) which was statistically comparable with 60 kg N ha^{-1} followed by 40 kg N ha^{-1}. This might be due to increase in nitrogen levels might have increased the availability of nitrogen and absorption of other nutrients which in turn enhanced overall growth parameters, efficient translocation of photosynthates from source to sink and production of more number of panicles. Similar results were reported by Arshewar *et al*. (2018) [2].

3.2.2 Panicle length

Wider plant geometry P_3 recorded lengthier panicles (17.8cm) which were on par with that of P_2 plant geometry. Sufficient availability of light, moisture and other nutrients in wider plant geometry might have helped in better growth of floral primordium and panicles. The present findings are in accordance with Nandini and Sridhara (2019) [8]. Significantly shorter panicles (15.9cm) was noticed in P_1 plant geometry which was in turn on par with that of P_2 plant geometry. Panicle length was maximum (18.4 cm) with application of 80 kg N ha^{-1} which was comparable with 60 kg N ha^{-1} followed by 40 kg N ha^{-1}. This might be due to increased nitrogen dose resulted in robust tillers with better vegetative growth and assimilate partitioning efficiency from source to sink. These results were in conformity with the findings of Anitha *et al.* (2020) [1]. Significantly lower panicle length (14.4 cm) of browntop millet was noticed with application of 20 kg N ha^{-1}.

3.2.3 Grain weight panicle^{-1}

Grain weight panicle^{-1} was recorded higher (1.26 g) with wider plant geometry P_3 which was on par with that of P_2 plant geometry. The lowest grain weight panicle^{-1} (1.1 g) was noticed in P_1 closer plant geometry. The findings are in conformity with Natarajan *et al*. (2019) [9]. Application of 60 kg N ha^{-1} recorded maximum grain weight panicle^{-1} (1.25 g) which was statistically on par with that of 80 kg N ha^{-1} followed by 40 kg N ha^{-1}. Lower grain weight panicle^{-1} (1.04 g) was recorded in P_1 closer plant geometry.

3.2.4 Test weight

The highest test weight (3.53 g) was recorded with plant geometry P_3 which was statistically on par with that of P_2 and P_1 plant geometry. This might be due to wider plant geometry which helped in efficient utilization of available moisture, nutrients which in turn resulted in better growth and effective partitioning of photosynthates to reproductive parts. Therefore, improved yield attributes were obtained in wider plant geometry, when compared to closer plant geometry. The results were in accordance with Thakur *et al*. (2019) [15]. The lowest test weight (3.37 g) was noticed with the closer plant geometry P_1 plant geometry. Application of 80 kg N ha^{-1} recorded higher test weight (3.65 g) which was statistically on par with that of 60 kg N ha^{-1} and 40 kg N ha^{-1}. The present findings were in agreement with Munirathnam and Kumar (2015) [7]. Test weight was recorded lower (3.11 g) with application of 20 kg N ha^{-1} with significant difference to other nitrogen levels tested.

3.2.5 Grain yield

The highest grain yield (1548 kg ha^{-1}) was recorded with plant geometry P_2 which was statistically on par with that of P_3 plant geometry. This might be due to optimum plant geometry provided favourable microclimate which enables efficient utilization light, moisture and nutrients by the individual plant which in turn leads to maximum productivity. Even though all the yield attributes were maximum in wider plant geometry, panicles on late formed tillers were not attained full maturity there by reduced the grain yield per unit area when compared to optimum plant geometry P_2. Whereas severe intraplant competition and lodging at reproductive stage due to higher plant height might have negative effect on grain yield under closer plant geometry P_1. The results were in confirmity with the findings of Santosh *et al.* (2020) [13]. Significantly lower grain yield (1353 kg ha^{-1}) was recorded with the P_1 closer plant geometry. Under varied nitrogen levels tested, higher grain yield (1682 kg ha^{-1}) was recorded with the application of 60 kg N ha^{-1} which was comparable with 80 kg N ha^{-1} followed by 40 kg N ha^{-1} which inturn exhibited significant difference to both of them. Application of 80 kg N ha^{-1} resulted in more vegetative growth which in turn reduced the grain yield when compared to application of 60 kg N ha^{-1}. The grain yield was recorded lower (1075 kg ha^{-1}) with application of 20 kg N ha^{-1} (N_1). The above results are in accordance with the findings of Vimalan *et al*. (2019) [18].

3.2.6 Straw yield

Significantly higher straw yield (5262 kg ha^{-1}) was recorded at P_1 plant geometry than that of P_2 plant geometry. This might be due to closer plant geometry which resulted in taller plants with high dry matter and more plant population per unit area and ultimately increased the straw yield. These results were in accordance with the findings of Sanjay *et al*. (2021) [12]. The lowest straw yield (4294 kg ha^{-1}) was observed with the P_3 plant geometry which was statistically differed from other plant geometry tried. Application of 80 kg N ha^{-1} recorded significantly higher straw yield (5254 kg ha^{-1}) which was comparable with 60 kg N ha^{-1} followed by 40 kg N ha^{-1}.

This might be due to increased dose of nitrogen leads to higher availability of nitrogen along with enhanced absorption of other nutrients leads to higher photosynthetic efficiency which inturn increases plant height, leaf area, number of tillers and drymatter ultimately straw yield. These findings are in support of Saikishore *et al*. (2020) [11]. Significantly lower straw yield (4047 kg ha^{-1}) was recorded with application of 20 kg N ha^{-1}.

4. Conclusion

Based on the results of the field experiment, it is concluded that among the varied plant geometry and nitrogen levels investigated, adoption of plant geometry of P_2 (45 cm x 20 cm) along with the application of 60 kg N ha^{-1} (N_3) was superior in performance with respect to growth and yield attributes resulting in higher productivity of browntop millet for Southern Agro-climatic Zone of Andhra Pradesh.

Table 1: Growth parameters as influenced by varied plant geometry and nitrogen levels in browntop millet

Treatments	Plant height (cm)	Leaf area index	SPAD chlorophyll meter reading	Number of tillers m^{-2}	Dry matter production (kg ha^{-1})
Plant geometry					
P_1: 30 x 20 cm	134	2.22	27.6	153	6478
P_2: 45 x 20 cm	121	1.81	28.7	136	6024
P_3: 60 x 20 cm	110	1.58	29.5	125	5611
S.Em±	3.1	0.047	0.72	3.5	151.8
CD (P=0.05)	9	0.14	2.1	10	445
Nitrogen levels					
N_1: 20 kg ha^{-1}	105	1.47	26.2	118	5008
N_2: 40 kg ha^{-1}	118	1.80	28.1	134	5884
N_3: 60 kg ha^{-1}	129	2.02	29.7	147	6550
N_4: 80 kg ha^{-1}	133	2.19	30.6	152	6709
S.Em±	3.5	0.055	0.83	4	175.3
CD (P=0.05)	10	0.16	2.4	12	514
Interaction					
S.Em±	6.1	0.095	1.44	6.9	303.7
CD (P=0.05)	NS	NS	NS	NS	NS

Table 2: Yield attributes, grain yield and straw yield as influenced by varied plant geometry and nitrogen levels in browntop millet

Treatments	Number of panicles m^{-2}	Panicle length (cm)	Panicle weight $plant^{-1}$ (g)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Plant geometry						
P_1: 30 x 20 cm	124	15.9	9.7	3.37	1353	5262
P_2: 45 x 20 cm	116	16.5	14.5	3.46	1548	4663
P_3: 60 x 20 cm	107	17.8	19.1	3.53	1470	4294
S.Em±	2.9	0.42	0.38	0.087	36.9	119.2
CD (P=0.05)	8	1.2	1.1	0.25	108	350
Nitrogen levels						
N_1: 20 kg ha^{-1}	98	14.4	11.1	3.11	1075	4047
N_2: 40 kg ha^{-1}	113	16.2	13.9	3.47	1427	4616
N_3: 60 kg ha^{-1}	124	17.8	16.5	3.59	1682	5041
N_4: 80 kg ha^{-1}	128	18.4	16.3	3.65	1643	5254
S.Em±	3.3	0.49	0.43	0.100	42.6	137.7
CD (P=0.05)	10	1.4	1.3	0.29	125	404
Interaction						
S.Em±	5.8	0.84	0.76	0.173	75.6	238.4
CD (P=0.05)	NS	NS	NS	NS	NS	NS

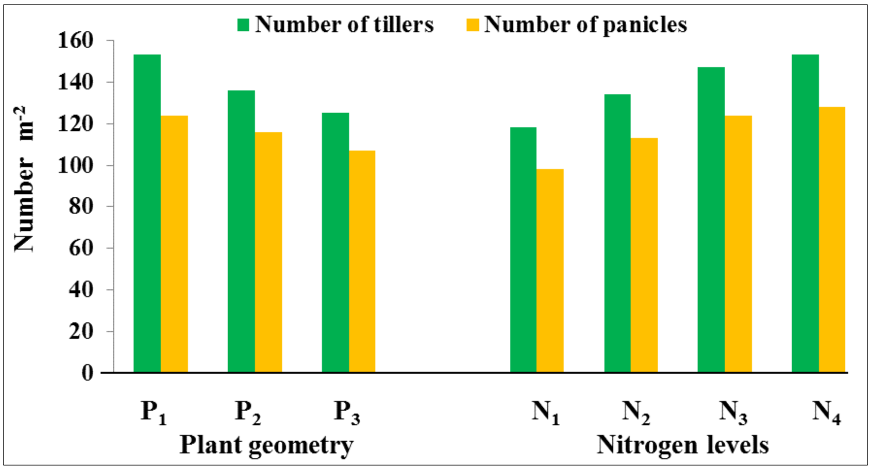

Fig 1: Number of tillers m^{-2} and number of panicles m^{-2} as influenced by varied plant geometry and nitrogen levels at harvest in browntop millet.

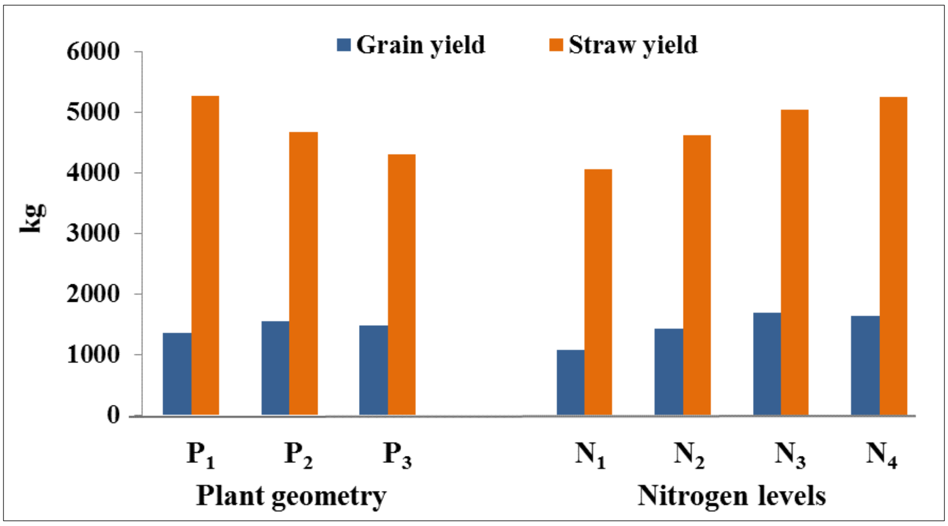

Fig 2: Grain and straw yield (kg ha^{-1}) as influenced by varied plant geometry and nitrogen levels in browntop millet.

5. Acknowledgement

I express my deep sense of gratitude to my major advisor Dr. S. Hemalatha and all the faculty members of Department of Agronomy, S.V. Agricultural College, ANGRAU, Tirupati, Andhra Pradesh for constant support and guidance to carry out the whole experiment research study.

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