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Influence of Fertilizer Nutrition and Row Spacing on Productivity and Profitability of Browntop millet (*Brachiaria ramosa* L.)

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ABSTRACT

A study was taken up to establish optimum fertilizer dose and optimum plant density for obtaining maximum grain as well as fodder yields. The results obtained from the two year study revealed that yield attributing characters, grain yield, fodder yield, plant nutrient uptake, net income and benefit cost ratio were significantly high at 50-25-0 kg NPK/ha as compared to other doses. Among four different row spacings, 60cm row spacing was superior for getting maximum grain yield, plant nutrient uptake, net returns and benefit cost ratio. However, for getting maximum fodder yield, close row spacing of 22.5cm was found to be optimum. Per cent chaffy grains per panicle decreased significantly at 50-25-0 kg NPK/ha and at 60cm row spacing. After two years of experiment, it was found that soil available potassium has shown drastic depletion from initial status compared to soil available N and P_2O_5 due to maximum plant uptake and absence of potassium application through fertilizer. From this study it was concluded that 50-25-0 kg NPK/ha at 60cm row spacing was found as optimum to maximize grain yield and 50-25-0 kg NPK/ha at 22.5cm row spacing was identified as optimum to maximize fodder yield in light textured soils.

Key words: *Browntop millet, Fertilizer levels, Plant density, Productivity and Profitability*

Browntop millet is originated in South East Asia (Clayton, 2006). In India, Browntop millet cultivation is mostly confined to the isolated parts of Andhra Pradesh, Karnataka and Tamil Nadu in South India (Kimata *et al*., 2000). It is short duration hardy crop, requires less water for its growth and development. It quickly covers the ground due to profuse growth and hence it can be grown as a cover crop in light soils or on hill slopes to prevent soil erosion. It is mainly grown as a fodder crop in dry tracts of Southern India. As a grain crop, Browntop millet has an excellent nutritive value. It is gluten free, good source of crude fibre (8.2g/100g) and have considerable amounts of iron (7.7mg/100g), zinc (2.75 mg/100g) and antioxidants (Roopa, 2015). By realizing its nutritional value, a tremendous demand has been created for Browntop millet among the consumers during recent times particularly in South India. However, its production is far below the actual demand.

Browntop millet responds very well to the fertilizers. Insufficient nutrition affect the growth and yield, while excess nutrition increase the vegetative phase and thereby lead to the extension of crop duration. Hence, identification of optimum fertilizer dose is very much important to enhance the productivity of the crop. All India Co- ordinated Research Project on Small Millets has recommended a spacing of 22.5cm×10cm or 30cm×10cm for all the small millet crops. Owing to its profuse growth habit unlike other small millets, Browntop millet needs standardization of optimum row spacing and optimum fertilizer dose. As an underutilized millet, it has not received any importance towards development of standard agronomic practices so far. Further, optimum row spacing also enhances the yield. Proper row spacing maximize the light interception, penetration, light distribution in crop canopy and average light utilization efficiency of the leaves in the canopy and, thus, affects yield of a crop (Hussain *et al*., 2003). Hence, this study was formulated to fix up the optimum row spacing and also to establish the optimum dose of chemical fertilizers particularly in light textured soils.

MATERIAL AND METHODS

A field experiment was conducted for two consecutive seasons i.e., *kharif* 2018 and 2019 at

Agricultural Research Station, Vizianagaram, Andhra Pradesh, India. The climate of experimental site was hot humid and located at 180.07' N latitude and 83.26' E longitude at an altitude of 58.22 meters above mean sea level. Normal annual rainfall of the region is 1200mm with 80-85% of the total rainfall received during South-west monsoon period. The soil of the experimental site was deep red loamy belongs to the order typic Haplustalfs. The soil had P^H 7.2, organic carbon 0.46%, soil available nitrogen 195 kg/ha, phosphorus 86kg/ha and potassium 270kg/ha. Experiment was conducted in split-plot design with three replications. Recommended dose of fertilizer (RDF) for other small millets as per AICRP on Small millets is 40-20-0 kg NPK/ha was taken as a standard reference. Fertilizer levels were assigned to main plots (F_1:30-15-0 kg NPK/ha, F_2: 40-20-0 kg NPK/ha, F_3: 50-25-0 kg NPK/ha) and row spacings were assigned to sub plots (S_1: 22.5cm; S_2: 30cm; S_3:45cm; S_4:60cm). Plant to plant spacing of 10cm within a row was common for all the row spacings.

Browntop millet cultivar GPUBT-6 was used in the experiment. Sowing was done on 8th July during 2018 and 15th July during 2019. Respective doses of N, P fertilizers were applied in the form of urea and single super phosphate in respective treatments. Entire quantity of phosphatic fertilizer was applied as basal and nitrogen was applied in two split doses as basal and at 30days after sowing. Seed rate depended upon spacing were used for sowing. Thinning and gap filling followed by inter-cultivation were done at 15 days after sowing to remove excess plant population and weeds. Observations were taken from five randomly selected plants in each plot. Grain yield and straw yield were taken after threshing, cleaning and drying. Prevailing market price of output, inputs, labour wages, machinery and fuel during respective years were considered to calculate the cost of cultivation, gross returns, net returns and benefit cost ratio. Data recorded on various parameters were subjected to Fisher's method of analysis of variance.

RESULTS AND DISCUSSION

Effect on growth and yield attributes

All the growth and yield attributing characters were markedly influenced by fertilizer levels. Days to 50% flowering and days to maturity were extended significantly but marginally from 30-15-0 kg NPK/ha (43.4 days) to 50-25-0 kg NPK/ha (46.4 days) (Table.1). Ye *et al*. (2019) also reported delay in rice flowering time by 1-4 days with increased N application from 0.00 kg/ha to 180.00 kg/ha. In 50-25-0 kg NPK/ha, plant height (175cm), number of branches per plant (13.1) and panicles per plant (15.5) were significantly higher as compared to lower fertilizer doses. Panicle length in 50-25-0 kg NPK/ha was also significantly higher than 30-15-0 kg NPK/ha, however, it was on par with 40-20-0 kg NPK/ha. These results were corroborated with the results of Ye *et al*. (2019), who reported a significant increase in number of panicles/hill, panicle length and number of grains per panicle in paddy with increased NPK fertilizer application over control. Drymatter production per plant was higher with 50-25-0 kg NPK/ha (32.5 g/plant), which is 43.8% and 16.1% as compared to 30-15-0 kg NPK/ha and 40-20-0 kg NPK/ha (Table.1).These results are in agreement with Raundal and Patil (2017), who reported 51.9% increase of dry matter in 150%RDF compared to 75% RDF in little millet. Per cent of chaffy grains per panicle significantly decreased with increase in the fertilizer dose from 30-15-0 kg NPK/ha to 50-25-0 kg NPK/ha. This might be ascribed to under-nourishment in lower fertilizer doses. Nitrogen availability affected the biomass remobilization to the ear in maize was reported by D'Andrea *et al*. (2008). Leaf spot disease caused by *Bipolaris sps,* was not significant to cause economic loss at all the three fertilizer levels, however, the disease incidence was lesser in 30-15-0 kg NPK/ha (13.8%) as compared to higher doses. Higher vegetative growth from increased fertilizer dose might have favoured more disease occurrence. Plants grown under conditions of low nitrogen availability are better defended against pathogens because there is an increase in the synthesis of defense related compounds (Hoffland *et al*., 2000). At high nitrogen rates, defense related compounds like lignin, silica and phenolic contents decreases and low molecular weight organic nitrogen compounds, which acted as a substrate for parasites increases (Dordas, 2008).

Among different spacings, days to 50% flowering and days to maturity were significantly extended with increase in inter row spacing from 22.5cm to 60cm (Table.1). Higher competition among the plants for nutrition, space and other resources in close spacing might be the reason for early flowering and maturity. Bullock *et al*. (1988) has proved that when plant experience stress conditions in its surroundings, it sends input signals into the network to maximize the chances of reproduction by either advancing or delaying flowering. In wider spacing each and every plant will get enough resources for growth and development and hence it takes more time to enter into reproductive phase when compared to the plants under stress. At harvest, plant height at 22.5cm row spacing was significantly high and showed an increase of 11.1%, 6.7% and 3.2% compared to 60cm, 45cm, 30cm row spacings, respectively. Heavy competition in closer spacing might be the reason for linear increase in the growth of the plants. Mussa *et al*.(2017) reported 7.6% increase in sorghum plant height in 30cm row spacing compared to 60cm row spacing. Planting a crop in a pattern that reduces the spacing of plants within and between rows can increase plant biomass and leaf area index (Bullock *et al*., 1988).

Number of branches per plant, number of panicles per plant and length of the panicle were significantly higher in 60cm row spacing as compared to 22.5cm, 30cm, 45cm row spacings. Dry matter production per plant in 60cm row spacing was 118.3%, 68.3%, 18.3% higher than 22.5cm, 30cm, 45cm row spacings, respectively (Table.1). However, the total drymatter production per hectare was minimum in 60cm row spacing due to low plant population per unit area as compared to closer spacings. Chaffiness per cent per panicle in 60 cm row spacing was lower by 5.8%, 50.2% and 56.5%, respectively, over 45cm, 30cm and 22.5cm row spacings (Table.2). These results are in agreement with the findings of Koireng *et al*. (2019) and Das *et al*. (2017) who reported highest poor filled spikelets in close spacing of paddy. Leaf spot disease was significantly higher in closer row spacings (22.5cm and 30cm) compared to wider row spacings (60cm and 45cm) (Table.1). Humid microclimate in closer spacing might be the reason for high disease occurrence and spread.

Effect on yield and economics

Among different fertilizer levels, grain yield (1254 kg/ha) and fodder yield (7635 kg/ha) were higher in 50-25-0 kg NPK/ha as compared to lower NPK levels (Table.2). Higher growth and yield attributes in 50-25-0 kg NPK/ha might be the reason for higher grain and fodder yields. Divyasree *et al*. (2018) reported higher grain and straw yield of little millet at 30-20-10 kg NPK/ha over lower NPK levels. Similar results were reported by Vimalan *et al*. (2019). Considering the economics, net income and benefit cost ratio were significantly higher (Rs.39317 /ha and 2.31 respectively) in 50-25-0 kg NPK/ha compared to lower doses due to higher grain yield. Benefit cost ratio in 50-25-0 kg NPK/ha was 68.6% and 31.3% higher than 30-15-0 kg NPK/ha and 40-20-0 kg NPK/ha, respectively (Table.2).

Grain yield increased significantly with increase in the row spacing from 22.5cm to 60cm. 60cm row spacing recorded higher yield (1303 kg/ha) and the magnitude of yield increase was 17.1%, 39.7% and 55.9%, respectively, compared to 45cm, 30cm and 22.5cm row spacings. Higher growth and yield attributes, lower chaffiness of grains and low disease incidence in wider row spacing might be the reason for higher grain yield. Sangeeta and Surakod (2018) also reported 60% increase in grain yield of pearl millet with increase in spacing from 60cm×10cm to 120cm×5 cm. Buri *et al*. (2016) and Das and Yaduraju (2011) also found similar results in paddy and wheat, respectively. In contrast to this, fodder was significantly higher in 22.5cm row spacing and it was 5.8%, 17.2% and 33.1% higher than 30cm, 45cm and 60cm row spacings, respectively (Table.2). Higher plant density per unit area in closer spacing compensated the reduction in per plant drymatter accumulation. Similar results were also obtained by Koireng *et al*. (2019) in paddy. Considering the economics, net income and benefit cost ratio were significantly higher in 60cm×10cm spacing as compared to 45cm×10cm, 30cm×10cm and 22.5cm×10cm spacings.

Effect on plant nutrient uptakes and soil available nutrients

Among three fertilizer levels, plant uptake of nitrogen, phosphorus and potassium were significantly higher in 50-25-0 kg NPK/ha compared to 40-20-0 kg NPK/ha and 30-15-0 kg NPK/ha, however plant potassium uptake in 40-20-0 kg NPK/ha was on par with 50-25-0 kg NPK/ha (Table.2).These results were in agreement with the results reported by Divyasree *et al*. (2018) in little millet; Vimalan *et al*. (2019) in barnyard millet and Das and Yaduraju (2011) in wheat. Higher nutrient availability due to increased dose of fertilizers might be the reason for higher plant nutrient uptake. Soil available N and P_2O_5 in 50-25-

0 kg NPK/ha were significantly higher compared to lower fertilizer levels. Due to higher plant nitrogen uptake, soil available N was decreased noticeably compared to initial soil available N in all the fertilizer levels except 50-25-0 kg NPK/ha. In case of P_2O_5, high initial soil P_2O_5 availability coupled with phosphorus fertilizer applications might be the reason for high plant uptake as well as high soil available P_2O_5. However, soil available K_2O was decreased in all the three fertilizer levels to an extent of 18.2%, 16.2% and 14.7%, respectively in 50-25-0 kg NPK/ha, 40-20-0 kg NPK/ha and 30-15-0 kg NPK/ha compared to initial soil available K_2O. Continuous removal of potassium for maintenance of crop growth and absence of potassium application through fertilizers would finally lead to rapid potassium depletion in soil. Chen *et al*. (2006) also reported similar results in wheat. Hence, potassium nutrient may be applied to the crop in order to enhance potassium uptake by plant as well as to maintain soil available K_2O status at par with initial status.

Phosphorus uptake in 60cm row spacing was significantly higher; however, it was on par with 45cm row spacing. Soil available N, P_2O_5 and K_2O were not affected significantly by various spacings.

Interaction effect

Interaction effect of fertilizer levels and row spacings was significant for yield attributing parameters and yield. Higher dose of NPK (50-25-0 kg NPK/ha) coupled with 60cm row spacing had significant effect on the grain yield improvement compared to their independent effects (Fig.1). Similarly 50-25-0 kg NPK/ha at 22.5cm row spacing was superior in enhancing the straw yield (Fig.2). Synergetic influence of fertilizer levels and row spacings on yield attributing parameters might have contributed to higher grain yield as evidenced from the Pearson correlation matrix between yield attributes and yield (Table.3).

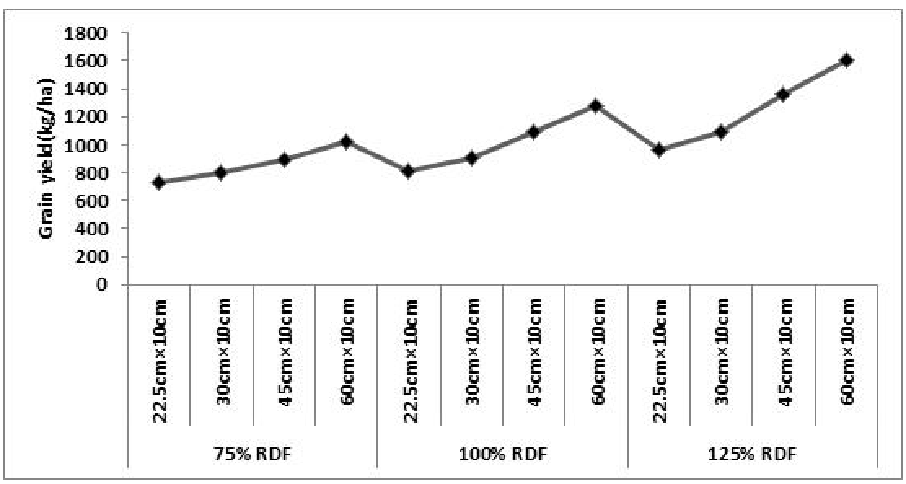

Fig 1 Interaction effect of fertilizer levels and row spacings on grain yield of Browntop millet

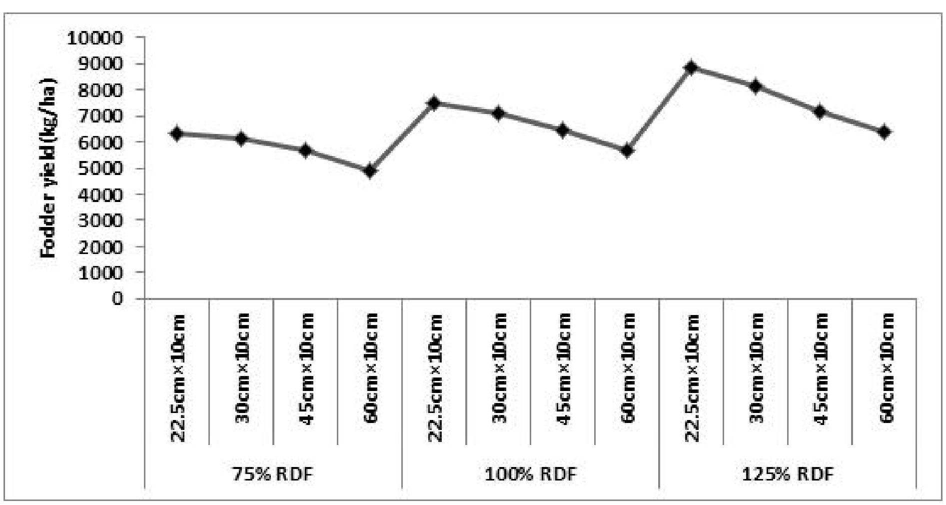

Fig 2 Interaction effect of fertilizer levels and row spacings on fodder yield of Browntop millet

Table 1.Effect of different fertilizer levels and row spacings on growth and yield attributes of Browntop millet

Treatments	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches/ plant	Panicles/ plant	Panicle length(cm)	Dry matter (g/plant)	Test weight (g)	% Chaffiness / panicle	Leaf spot disease (%)
Fertilizer levels (F):										
F1: 30-15-0 kg NPK/ha	43.4	79.1	155.5	7.6	9.2	12.9	22.6	2.74	18.8	13.8
F2: 40-20-0 kg NPK/ha	44.6	81.3	165.6	11	12.6	15.1	28	3.17	16.2	17.9
F3: 50-25-0 kg NPK/ha	46.4	84.4	175	13.1	15.5	15.9	32.5	3.4	13.1	18.3
S.Em±	0.14	0.24	1.92	0.24	0.49	0.53	0.5	0.07	0.37	0.87
LSD (P=0.05)	0.54	0.95	7.56	0.94	1.92	2.1	1.95	0.28	1.47	3.42
Row Spacings(S):										
S1:22.5cm	43.9	79.7	173.7	6.8	7.1	11.5	17.5	2.9	22.3	21
S2:30cm	44.3	80.7	168.6	7.3	8.2	12.4	22.7	3.03	21	20.3
S3:45cm	45.3	82.4	162.7	12.5	14.6	16.6	32.3	3.19	11.1	13.7
S4:60cm	45.7	83.6	156.4	15.6	19.9	18.2	38.2	3.28	9.7	11.6
S.Em±	0.25	0.17	1.42	0.44	0.35	0.4	0.49	0.08	0.69	1.09
LSD (P=0.05)	0.75	0.51	4.21	1.31	1.04	1.19	1.45	0.24	2.06	3.24
Interaction	NS	NS	NS	S	S	NS	S	S	NS	NS

Table 2. Effect of different fertilizer levels and row spacings on yield, economics , plant nutrient uptake of Browntop millet and soil available nutrients.

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Net income (Rs/ha)	B:C	Plant nutrient uptake(kg/ha)			Soil available nutrients(kg/ha)		
					Nitrogen	Phosphorus	Potassium	N	P_2O_5	K_2O
Fertilizer levels (F):										
F1: 30-15-0 kg NPK/ha	862	5768	22370	1.37	43	8.1	39.3	185.4	81.7	230.3
F2: 40-20-0 kg NPK/ha	1023	6677	29265	1.76	54	11.2	45.6	190	86.9	226.3
F3: 50-25-0 kg NPK/ha	1254	7635	39317	2.31	69.1	14.4	53.5	193.7	89.2	220.9
S.Em±	17.9	121.7	805.5	0.05	0.94	0.14	2.46	0.9	0.72	1.33
LSD (P=0.05)	70.3	477.8	3162.9	0.19	3.67	0.57	9.66	3.55	2.84	5.22
Row spacings(S):										
S1:22.5cm	836	7541	20348	1.18	53.5	9.9	49	188	84.6	223.3
S2:30cm	933	7130	25067	1.48	54.7	10.4	47.9	189	85.5	224.7
S3:45cm	1113	6435	33483	2.01	56.2	11.9	45.2	190.4	86.5	227.2
S4: 60cm	1303	5667	42371	2.6	57	12.7	42.3	191.4	87.1	228.2
S.Em±	21.2	58.4	952.1	0.06	0.99	0.43	2.71	1.71	1.14	2.22
LSD (P=0.05)	62.9	173.7	2829	0.17	NS	1.29	NS	NS	NS	NS
Interaction	S	S	S	S	NS	NS	NS	NS	NS	NS

Table 3.Correlation matrix depicting relationship among yield attributes and grain yield

Variable	DM	Br	Pan	PL	DMP	Chaf	TW	GY
DM	1							
Br	.982*	1						
Pan	.984*	.997**	1					
PL	.989*	.993**	.985*	1				
DMP	1.000**	.983*	.983*	.991**	1			
Chaf	-.967*	-.976*	-.960*	-.993**	-.973*	1		
TW	.995**	.961*	.961*	.978*	.995**	-.962*	1	
GY	.994**	.985*	.993**	.979*	.992**	-0.95	.980*	1

*, **. Correlation is significant at the 0.05, 0.01 level (2-tailed)
DM: Days to maturity; Br: Branches/plant; Pan: Panicles/plant; PL: Panicle length, DMP: Dry matter/plant (g); Chaf:% Chaffiness / panicle; TW: Test weight; GY: Grain yield

Browntop millet is one of the important dual purpose crops which can be used for grain as well as fodder in dry land areas with poor soil nutritional status. From this study, it can be concluded that highest grain yield can be achieved with 50-25-0 kg NPK/ha at 60cm row spacing and highest fodder yield can be possible with 50-25-0 kg NPK/ha at 22.5cm row spacing in light textured soils. However, potassium nutrient must be applied along with nitrogen and phosphorus not only to support good performance of the crop but also for maintaining soil available potassium status without being depleted in the long run.

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