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Studies on Nutrient Management in Nutricereal - Browntop Millet

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ABSTRACT: Millets are low nutrient-demanding crops, but they respond well to the addition of nutrients. So far, the exact requirements of major nutrients for Browntop millet have not been worked out and established and the productivity achieved is far below than their potential productivity. Hence, a field experiment was conducted during the *kharif* seasons of 2019 and 2020 in the red sandy loamy soil of GKVK, Bengaluru to identify the effect of different nutrient levels on yield, nutrient uptake, and available nutrients in the soil of Browntop millet cultivation. There were fourteen treatments replicated thrice under a randomised complete block design. The treatments included three nitrogen levels (20, 40 and 60 kg N ha^{-1}), phosphorus levels (20 and 30 kg P_2O_5 ha^{-1}), two levels of potassium (10 and 20 kg K_2O ha^{-1}), and one treatment as control. Among the different nutrient levels, treatment with 60 N kg ha^{-1} + 30 P_2O_5 kg ha^{-1} + 20 K_2O kg ha^{-1} (T_{12}) recorded the highest grain and straw yields (1295 and 3131 kg ha^{-1}, respectively), total uptakes of nitrogen, phosphorous and potassium (56.29, 17.98 and 63.13 kg, respectively) and post-harvest available nutrients in soil (254.81, 65.51 and 173.78 kg N, P_20_5 and K_20 per ha, respectively).

Keywords: Brown top millet, Grain yield, Nutrient levels, Nitrogen, Phosphorous Nutrient uptake, Available nutrients.

INTRODUCTION

Millets have been increasingly recognized as a viable alternative to main cereals in recent years, owing to their intrinsic health benefits as well as their climate resilience. Brown top millet, also known as Dixie signal grass and locally as korale in Kannada and a dukorralu in Telugu, is one of the rarest tiny millets. Browntop millet is one of the rarest millet crops among all the millets. It has open, spreading and indeterminate inflorescence with simple axis and staked flower and mature approximately within 75 to 90 days (Oelke *et al*., 1990). Scientists have produced a glut of information on excellent agricultural methods for millet crops however, there is relatively little information on brown top millet cultivation practices. Brown top millets are high in nutrition and dietary fiber. Browntop millet is small greenish grain, when compared to rice, wheat, jowar and nutritionally rich in dietary fiber, iron, calcium, potassium, magnesium, zinc, phosphorus, protein, and B complex Vitamin (Sarita *et al*., 2016). Brown top millet could be asubstitute crop for the farmers since itis grown under adverse environmental conditions and is best suited to moisture-stress deprived soils. However, in reality, the potential of this crop has not been attained fully. The crop's inferior yields are largely owing to its cultivation on marginal and sub-marginal soils and the lack of use of appropriate agronomic methods. A few studies have found that it has a favorable impact on nitrogen, phosphorous, and potassium interaction in relations to crop productivity and nutrient uptake, but the balance of nitrogen, phosphorous, and potassium is not appropriately practiced. Nitrogen is the most important agronomic stimulant for crop growth, but in order to get the most out of it in terms of increasing crop yield, the crop needs access to an adequate amount of potassium and phosphorous from the soil's plant accessible pool. This is because; there is a strong interaction between these nutrients in crop growth. Phosphorus is a vital nutrient for plants next to nitrogen. Phosphorus is one of the most important macronutrients for biological growth and appropriate plant development, whereas potassium is a key ion in maintaining physiological plant water relations and is an important macronutrient for plant development as well as the activation of several enzymes. Millets are low-nutrient demanding crops that respond well to the addition of N, P and K. Soil nutrient status and cultivation of improved varieties in millets need balanced fertilizer through external fertilizers. The exact requirement of major nutrients for Browntop millet is not worked out and established so far. As this millet is of short duration and has high canopy growth compared to other millets, nutrient management is critical for increasing crop plant growth and yield while also maintaining soil fertility. Hence in the present study is planned to know the optimum requirement of nitrogen, phosphorous and potassium requirement of Browntop millet and their interactions for higher performance of the crop.

MATERIAL AND METHODS:

During the *kharif* season of 2019 and 2020, the research was carried out at the Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bangalore, to investigate the impact of various nutrient levels on yield, uptake of major nutrients and available NPK in soil of Brown top millet cultivation.The soil in the trial was a red sandy loam with an acidic pH (5.95), electrical conductivity (0.25 dSm^{-1}), low organic carbon (0.36 percent), lower available nitrogen (152.80 kg/ha), higher available phosphorus (58.45 kg/ha), and medium available potassium (232.65 kg/ha), and the experiment encompassed fourteen treatments with three replicationand organized under randomized complete block design (RCBD). Treatments tested were, T_1: 20:20:10 kg $N:P_2O_5:K_2O ha^{-1}$, T_2: 20:20:20 kg $N:P_2O_5:K_2O$ ha^{-1},T_3: 20:30:10 kg $N:P_2O_5:K_2O$ ha^{-1}, T_4: 20:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}, T_5: 40:20:10 kg $N:P_2O_5:K_2O$ ha^{-1}, T_6: 40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}, T_7: 40:30:10 kg $N:P_2O_5:K_2O$ ha^{-1}, T_8: 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1}, T_9: 60:20:10 kg $N:P_2O_5:K_2O$ ha^{-1}, T_{10}: 60:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}, T_{11}: 60:30:10 kg $N:P_2O_5:K_2O$ ha^{-1}, T_{12}: 60:30:20 kg $N:P_2O_5:K_2O$ ha^{-1} , T_{13}: 40:20:0 kg $N:P_2O_5:K_2O$ ha^{-1} and T_{14}: Control. Dundukorale was sown at the planting geometry i.e., spacing of 45 × 10 cm in June month (*Kharif*) of 2019 and 2020. Data collected over both the years on crop performance are averaged and the uptake of nutrient was calculated using nutrient content in crop and crop yield and available soil N, P_2O_5 and K_2O were analyzedusing alkaline permanganate method, Olsen's method and Flame photometry (Neutral normal ammonium acetate), respectively. The data on various features was evaluated statistically using the conventional approach, and the results were confirmed at a 5% level of significance.

RESULTS AND DISCUSSION

Yield (kg ha^{-1}). The grain yield (kg ha^{-1}) at treatment *i.e.*, T_{12}, application of 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} (1295 kg ha^{-1}) was significantly superior over 40 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} (903 kg ha^{-1}) (T_{13}) and control (762 kg ha^{-1}) (T_{14}). Whereas, straw yield at T_{12} (3131 kg ha^{-1}) was found significantly higher when compared to other applications and was found on par with an application of 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 10 kg K_2O ha^{-1} (2799 kg ha^{-1}) (T_{11}) but these two treatments were significantly higher over other treatments and the control has recorded pointedly lower straw yield (1682 kg ha^{-1}) (T_{14}). However, the harvest index in Brown top millet did not vary significantly due to fertilizer levels.

The increased grain and straw yield (Table 1) was due to the interaction effects of nitrogen, phosphorus, and potassium, which resulted in a higher number of leaves per plant, leaf area, total dry matter accumulation in the plant, and its accumulation in various plant portions such as the leaf, stem, and tillers. These observations are in line with the studies made by Vimalan *et al*. (2019), who reported that a higher straw yield (4595 kg ha^{-1}) in barnyard millet was attained when NPK was applied at the rate of 60-20-15 kg ha^{-1}. Similar findings were also reported by Apoorva *et al.*, (2010), Basavarajappa *et al.*, (2002); Bhomte *et al.*, (2016), Maitra *et al.*, (2001); Radha (2019); Rakesh *et al.*, (2015), who found that NPK fertilizer boosted the grain and straw yield of crops.

Table 1: Grain yield, straw yield and harvest index as influenced by different levels of major nutrients in Brown top millet.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1: 20:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	841	1786	0.319
T_2: 20:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	850	1875	0.311
T_3: 20:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	873	1910	0.314
T_4: 20:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	918	2142	0.300
T_5: 40:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	911	2033	0.307
T_6: 40:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	914	2122	0.301
T_7: 40:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	934	2215	0.298
T_8: 40:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1044	2488	0.296
T_9: 60:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	935	2370	0.285
T_{10}: 60:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1066	2575	0.292
T_{11}: 60:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1078	2799	0.281
T_{12}: 60:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1295	3131	0.292
T_{13}: 40:20:0 $N:P_2O_5:K_2O$ kg ha^{-1}	903	1994	0.312
T_{14}: Control	762	1682	0.313
S. Em±	**65.85**	**146.28**	**0.017**
C.D. at 5%	**199.75**	**443.76**	**NS**

Nutrient content (%). Table 2 and 3 shows the findings of plant and grain sample analysis, including nitrogen (%), phosphorus (%) and potassium (%) content in plants and grains as influenced by varied levels of nutrients.

Nutrient content in plant. Per cent of nitrogen, phosphorus and potassium content in plant was not fluctuated significantly owing to different nutrient levels. However, a numerically higher per cent of nitrogen in the plant was found with the application of 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} (1.17, 0.36 and 1.68 %, respectively). Whereas, lower per cent of nitrogen, phosphorus and potassium content (1.06, 0.26 and 0.68 %, respectively) in plant was recorded with control (Table 2).

Nutrient content in grain. The content of nutrients in grain did not vary much as a result of fertilizer levels. However, using 60 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 20 kg K_2O ha^{-1} resulted in a numerically higher percentage of nitrogen, phosphorus, and potassium in grain (1.53, 0.52 and 0.80 percent, respectively). In contrast, the control grain had reduced nitrogen, phosphorus, and potassium content (1.43, 0.39, and 0.68 percent, respectively) (Table 2).

Table 2: Nutrient content (%) as influenced by different levels of major nutrients in Brown top millet.

Treatments	Plant N	Grain N	Plant P	Grain P	Plant K	Grain K
T_1: 20:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.09	1.45	0.28	0.41	1.59	0.72
T_2: 20:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.10	1.46	0.28	0.41	1.61	0.73
T_3: 20:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.11	1.47	0.29	0.42	1.60	0.72
T_4: 20:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.12	1.48	0.30	0.42	1.62	0.73
T_5: 40:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.13	1.49	0.31	0.44	1.64	0.74
T_6: 40:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.13	1.49	0.32	0.45	1.65	0.75
T_7: 40:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.14	1.50	0.33	0.45	1.64	0.74
T_8: 40:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.14	1.50	0.33	0.46	1.65	0.76
T_9: 60:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.15	1.51	0.34	0.47	1.66	0.77
T_{10}: 60:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.16	1.52	0.34	0.49	1.67	0.78
T_{11}: 60:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	1.16	1.52	0.35	0.49	1.66	0.77
T_{12}: 60:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	1.17	1.53	0.36	0.52	1.68	0.80
T_{13}: 40:20:0 $N:P_2O_5:K_2O$ kg ha^{-1}	1.13	1.50	0.31	0.43	1.57	0.70
T_{14}: Control	1.06	1.43	0.26	0.39	1.55	0.68
S. Em±	**0.05**	**0.05**	**0.03**	**0.02**	**0.05**	**0.03**
C.D. at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS-Non significant

Total Nutrient uptake (kg ha^{-1}) by the crop. The application of 60:30:20 kg $N:P_2O_5:K_2O$ ha^{-1} resulted in significantly higher total nitrogen, phosphorus and potassium uptake (56.29, 17.98, and 63.13kg ha^{-1}, respectively) than 40:30:20 kg $N:P_2O_5:K_2O$ ha^{-1} (44.09, 13.05, and 48.95, respectively), 20:30:20 kg of $N:P_2O_5:K_2O$ ha^{-1} (28.96, 7.34 and 31.37, respectively) and control (28.96, 7.34 and 31.37, respectively). However, the results obtained at 60:30:20 kg $NP_2O_5K_2O$ $ha^{-1}$and 60:30:10 kg N: P_2O_5: K_2O ha^{-1} (49.11, 15.48 and 54.82, respectively) found on par with each other (Table 3).

Table 3: Uptake of nutrient (kg ha^{-1}) as influenced by different levels of major nutrients in Browntop millet.

Treatments	Total N	Total P	Total K
T_1: 20:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	31.83	8.51	34.48
T_2: 20:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	32.98	8.78	36.30
T_3: 20:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	34.17	9.17	36.81
T_4: 20:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	37.59	10.44	41.74
T_5: 40:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	36.71	10.49	40.13
T_6: 40:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	37.59	10.97	41.81
T_7: 40:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	39.50	11.61	43.35
T_8: 40:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	44.09	13.05	48.95
T_9: 60:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	41.37	12.68	46.78
T_{10}: 60:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	45.92	13.97	51.53
T_{11}: 60:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	49.11	15.48	54.82
T_{12}: 60:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	56.29	17.98	63.13
T_{13}: 40:20:0 $N:P_2O_5:K_2O$ kg ha^{-1}	36.28	10.11	37.73
T_{14}: Control	28.96	7.34	31.37
S. Em±	**2.28**	**1.08**	**2.96**
C.D. at 5%	**6.94**	**3.29**	**7.99**

Brown top millet absorption of total nitrogen, phosphorus, and potassium was significantly higher when 60:30:20 kg N: P_2O_5: K_2O 20 ha^{-1} was applied (Table 2), as there was higher translocation to the reproductive portions. The increased uptake was due to the increased concentration of nutrients in both grain and straw, which contributed to the increased absorption. The uptake of total nitrogen, phosphorus, and potassium by plants was increased when more nitrogen, phosphorus, and potassium were applied. The findings are in line with the results of Singh *et al.* (2012).

Available soil nutrient status after the crop. Different nutrient levels had a significant impact on the available nutrient status of the soil after the harvest of brown top millet (Table 4). Application of 60:30:20 kg $N:P_2O_5:K_2O$ ha^{-1} has recorded significantly higher available nitrogen (254.81 kg ha^{-1}), phosphorus (65.51 kg ha^{-1}) and potassium (173.78 kg ha^{-1}) contentin soil after harvest of brown top millet as compared to the application of 40:20:0 kg $N:P_2O_5:K_2O$ ha^{-1} (226.24, 51.12 and 124.49 kg ha^{-1}, respectively) and control (189.20, 44.09 and 119.48 kg ha^{-1}, respectively).

The integration of farm yard manure with NPK fertilizers achieves a high degree of synchrony between nutrient release and plant demand, also enhancing available nitrogen status. The results obtained are in line with the conclusions of Gajanana *et al*., (2000); Chesti *et al*., (2013); Gajbhiye *et al*., (2017). The dissolution of native phosphorus compounds due to the presence of farm yard manure compiled with inorganic nitrogen and phosphorus synergistic effects paved the way for the retention of higher phosphorus levels in the soil. This result agrees with the findings of Prakash (2010). The uptake pattern, lesser availability and fixation might be the reason for the lower levels of potassium. The results support the findings of Vidyavathi *et al*., (2012).

Table 4: Available nutrient in soil as influenced by different levels of major nutrients in Browntop millet.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1: 20:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	211.15	48.85	137.89
T_2: 20:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	215.33	49.01	147.47
T_3: 20:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	217.70	51.07	140.84
T_4: 20:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	221.24	51.63	145.21
T_5: 40:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	223.33	52.22	146.50
T_6: 40:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	226.47	53.09	149.60
T_7: 40:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	228.36	54.35	148.66
T_8: 40:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	230.65	55.50	155.86
T_9: 60:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	234.83	57.67	156.80
T_{10}: 60:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	242.21	58.06	166.70
T_{11}: 60:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	246.35	63.59	162.69
T_{12}: 60:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	254.81	65.51	173.78
T_{13}: 40:20:0 $N:P_2O_5:K_2O$ kg ha^{-1}	226.24	51.12	124.49
T_{14}: Control	189.20	44.09	119.48
S. Em±	**3.67**	**2.13**	**5.20**
C.D. at 5%	**11.15**	**6.48**	**15.80**

Nutrient balance sheet. The net loss of nitrogen and phosphorus was pragmatic in all treatments (Table 5). Lower loss (29.85 and 30.81 kg ha^{-1}, respectively) was detected with application of 60:30:20 kg N: P_2O_5: K_2O ha^{-1}. Whereas, higher loss (64.75 and 54.06 kg ha^{-1}, respectively) was observed 60:20:10 kg N: P_2O_5: K_2O $ha^{-1}$and 20:30:10 kg N: P_2O_5: K_2O ha^{-1}, respectively. Higher loss of potassium (60.80 kg ha^{-1}) was found in control (60.80 kg ha^{-1}) followed by 20:20:10 kg N: P_2O_5: K_2O ha^{-1} (49.28 kg ha^{-1}). A positive value of potassium was detected with the application of 60:30:20 kg N: P_2O_5: K_2O ha^{-1} (5.26 kg ha^{-1}). The loss of nitrogen was mainly due to volatilization and leaching processes and this outcome is consistence with the results of Sun *et al*., (2021).

Table 5: Nutrient balance of Brown top millet as influenced by different levels of major nutrients.

Treatments	Initial status (kg ha^{-1})	Net Loss/ Gain of (nitrogen) (kg ha^{-1})	Net Loss/ Gain (phosphorus) (kg ha^{-1})	Net Loss/ Gain of (potassium) (kg ha^{-1})
T_1: 20:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-57.97	-46.94	-49.28
T_2: 20:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-52.64	-46.51	-47.88
T_3: 20:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-49.08	-54.06	-44.00
T_4: 20:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-42.12	-52.23	-44.70
T_5: 40:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-60.91	-41.59	-35.02
T_6: 40:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-56.89	-40.24	-40.24
T_7: 40:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-53.09	-48.34	-29.64
T_8: 40:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-46.21	-45.75	-26.84
T_9: 60:20:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-64.75	-33.95	-18.07
T_{10}: 60:20:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-52.82	-32.27	-13.42
T_{11}: 60:30:10 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-45.49	-35.23	-4.14
T_{12}: 60:30:20 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-29.85	-30.81	5.26
T_{13}: 40:20:0 $N:P_2O_5:K_2O$ kg ha^{-1}	249.7	-58.43	-43.07	-49.43
T_{14}: Control	249.7	-62.79	-32.87	-60.80

CONCLUSION

The use of 60:30:20 kg N: P_2O_5: K_2O ha^{-1} nutrients increased the grain and straw yields by 69.94 and 86.14 percent, respectively, over the control. From the experiment, in order to achieve the enhanced production, nutrient content and nutrient uptake and to have nutrient equilibrium in soil, 60:30:20 kg N: P_2O_5: K_2O ha^{-1} is required in Browntop millet.

FUTURE SCOPE

Since there is linear response of Browntop millet for higher doses of nitrogen, further investigation is needed for finding economic optimum dose. Intensive studies required to know the requirement of FYM and their interaction with nutrient requirements.

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