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Effect of Different Levels of Fertilizers on Productivity and Nutrient Dynamics of Browntop Millet

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Baljigapade, Chikkaballapur taluk and district, which comes under the Eastern Dry Zone of Karnataka during *Kharif* season 2018. The experimental plot in the field was laid out following a randomized complete block design (RCBD) with fourteen treatments and three replications. The treatments included two levels of N and P_2O_5 (20 and 30 kg ha^{-1}) and three levels of K_2O (10,20 and 30 kg ha^{-1}). Farmyard manure was applied at the rate of 6.25 t ha^{-1} to all the treatments except absolute control. Results indicated that application of 30 kg N+30 kg P_2O_5+30 kg K_2O ha^{-1} with Farm Yard Manure (FYM) increased the micronutrient availability in soil N (150.29 kg ha^{-1}), P_2O_5 (17.60 kg ha^{-1}), K_2O (160.84 kg ha^{-1}). Application of FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5 +20 kg K_2O ha^{-1} significantly increased growth, yield, macronutrient content and uptake by brown top millet grain and straw against absolute control. The grain yield of browntop millet was increased by 61.46 percent in T_{10} and 59.07 percent in T_9 as compared to the absolute control.

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Keywords: Browntop millet; npk level; macronutrients; grain yield; straw yield; nutrient content and uptake.

1. INTRODUCTION

Browntop millet (*Brachiaria ramosa* (L.) an introduced annual grass that originated in South-East Asia. It is grown in Africa, Arabia, China and Australia, Clayton et al. [1]. It was introduced to the United States from India in 1915 [2]. In the US, it is mainly grown in the South-East for hay, pasture and game bird feed. The brown top has grown in rainfed tracts of Tumakuru, Chitradurga and Chikkaballapura districts of Karnataka state. The crop is popular in this region in terms of cultivation and consumption. This millet is grown in a variety of soils and climates. Like other millets, it is a hardy crop and well suited for dry land [3]. Browntop millet is an annual warm-season species that grows 1 to 3 feet tall. The inflorescence is indeterminate, open, spreading with a simple axis and stalked flowers. It has 3-15 inflorescences and white flowers. Seeds are ellipsoid and tan in color; they mature in approximately 60 days [4]. Browntop millet, which goes by the scientific name *Brachiaria ramosa* (L.) and it has a limited cultivation largely confined to southern India. Domestic and wild/weedy forms of browntop millet are found in agricultural systems, often within the same field. Although its distribution is highly relict today, restricted to parts remote parts of Andhra Pradesh, Karnataka, and Tamil Nadu states in southern India [5], it appears to have been a major staple crop in the late pre-history of the wider region of the Deccan [6]. They tend to be smaller than *Setaria italica* and squatter in cross section. The surface of well-preserved grains can be used for identification as these have a distinctive undulating pattern, although this again has similarities to *S. italica* [6]. The husk has a fine beaded and rugose pattern, which again has some resemblance to that of *Setaria spp.,* but it is somewhat coarser than *S. italica* and finer than *S. verticillata* (https://www.researchgate.net/publication/2863 1352). The productivity of browntop millet can be increased by applying of fertilizers. The presence of organic manure along with inorganic fertilizers helps in better availability of nutrients and moisture. By understanding the soil nutrient status and corrective fertilizer management practices to support high yields of high-quality crops require a balanced fertilizer application. Balanced and adequate fertilization is essential for increasing crop yields and ensuring sustainable agriculture. Browntop millet being low nutrient demanding crop, but response well for the addition of NPK. Depleted soil NPK status due to higher crop removal as equal as or higher than nitrogen, phosphorus and potassium fertilizers. The present investigation study was carried out in the agricultural research station for that reason this research was undertaken to find out an optimum level of chemical fertilizer like urea, single super phasphate (SSP) and muriate of potash (MOP) that can maximize growth characters, grain and straw yield production of browntop millet under climatic and soil conditions of Eastern Zone of Karnataka, India.

2. MATERIALS AND METHODS

In order to study the effect of different levels of NPK on brown top millet in *Alfisols* of Chikkaballapura district, which comes under Eastern dry zone of Karnataka (Fig. 1). The experimental field was located at 77.7^{o} East longitude and 13.4^{o} North latitude from the mean sea level. To initiate the experiment, the soil samples were collected at random from the selected locations of ARS, Baljigapade, Chikkaballapura district and taluk of Karnataka and analyzed for the nitrogen, phosphorus, potassium content and the soil low in available N, P_2O_5 and K_2O selected for the field experiment. The initial properties of the experimental soil are presented in the Table 1. The soil was sandy clay loam in texture, low in organic carbon (0.48%), available nitrogen (125.20 kg ha^{-1}), phosphorus (11.47 kg ha^{-1}) and potassium (138.85 kg ha^{-1}) with acidic reaction (5.62) .The soil was low in DTPA extractable zinc (0.47 mg kg^{-1}) and boron (0.39 mg kg^{-1}). Olsen's method [7], Neutral normal ammonium acetate extract using flame photometer [8] and Walkely and Black method [9] for the determination of available nitrogen (N), phosphorus (P_2O_5) potassium (K_2O) and organic carbon, respectively. The pH of experimental site was determined through 1:2.5 soil and water suspension method [9]. There is no recommendation of NPK and micronutrients for brown top millet according to package of practices (UAS-B). In recent years, research is being conducted, to work out the recommendation of major and micro nutrients for the millets. Hence, the present work was focused to study the effect of different levels of NPK on browntop millet.

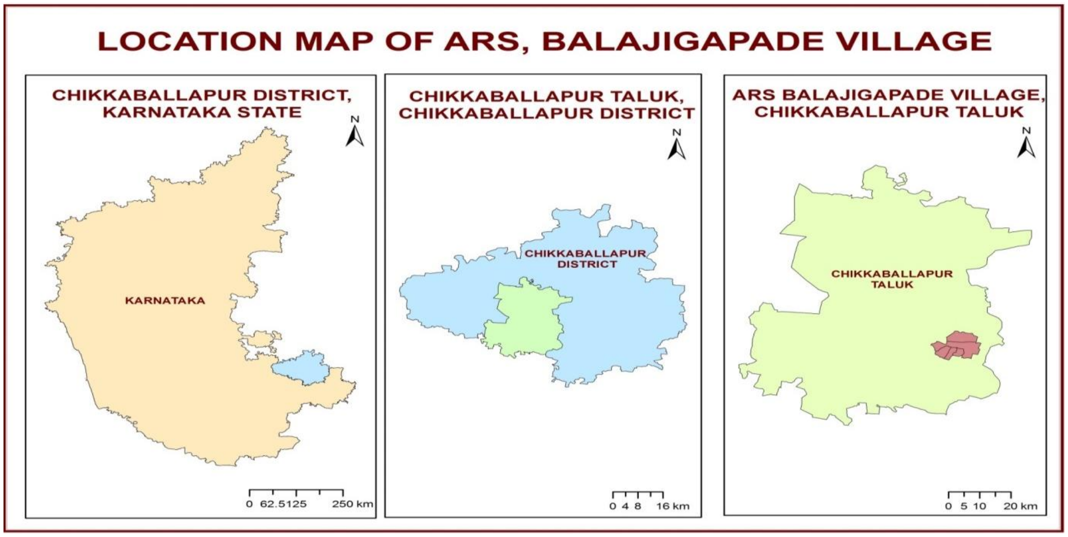

Fig. 1. Location of the experimental study area at ARS, Baljigapade village, Chikkaballapur taluk and district of Karnataka

The experiment was laid out in the randomized complete block design with fourteen treatments and three replications with a plot size of 4.2 m length and 4.0 m width. Test crop taken was brown top millet at a seed rate of 7 kg ha^{-1} sown with 30 cm inter-row and 10 cm intra row spacing under protective irrigation condition. There are fourteen treatments, which included T_1: Absolute control, T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}, T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}, T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}, T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}, T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}, T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}, T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}, T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}, T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}, T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}, T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}, T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}, T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}. Farmyard manure (FYM) was applied at the rate of 6.25 t ha^{-1} to all treatments except absolute control. Treatment wise recommended dose of N, P_2O_5 and K_2O were given in the form of urea, single super phosphate and muriate of potash, respectively as basal dose at the time of sowing and recommended dose of FYM was applied before 15 days of sowing of the crop. Gap filling was done after one week of sowing in places where seeds failed to germinate and where excess seeds were sown thinning was done 15 DAS to maintain intra row spacing (10 cm). Inter cultivation was done using blade hoe at 35 DAS with bullock pair and one hand weeding was done at 40 DAS. The growth parameters include plant height and number of tillers were recorded at 30, 60 DAS and at harvest, whereas yield and yield parameters include panicle length, panicle weight, grain weight per ear head, grain yield, straw yield and test weight were recorded at harvest. The whole crop of browntop millet in the net plot was harvested separately from each treatment and was dried separately. Then ear heads of each plot were threshed by beating, winnowed and cleaned separately. The straw in each net plot was harvested separately and sun-dried. The grain and strawweight were recorded.

2.1 Soil Sampling, Processing, and Analysis

The composite soil sample for individual replication was prepared by mixing five soil cores (5 cm inner diameter and 15 cm height) collected with the help of soil core sampler randomly after the harvest of brown top millet crop during 2018. Soil cores were collected to depth increments of 0–15 cm. Immediately after collection, the soil samples were brought to the laboratory in a cooler. Soil potentially available N of soil was distilled with 25 mL of 0.32% potassium permanganate ($KMnO_4$) and 25 mL of 2.5% Na OH. The ammonia released was trapped in 4% boric acid containing mixed indicator and titrated against standard sulfuric acid [10]. Available P2O5 in soil samples were extracted with Bray's-1 reagent (NH_4F+HCl). Phosphorus content in the extract was determined by ascorbic acid–molybdate complex method and the blue color intensity was recorded at 660 nm using a spectrophotometer (Jackson 1973). Available potassium in soil was estimated by extracting the soil with neutral normal ammonium acetate (pH 7.0) and measuring potassium in the extract using a flame photometer as outlined by Jackson (1973).

2.2 Plant Analysis

Grain and straw samples were harvested from each plot and grins were hand-threshed to separate. The collected grain and straw samples of the crop were cleaned, oven-dried at 65°C for 10 hrs, powdered, and analyzed for macro and micro nutrient content, and uptake was calculated using the formula.

Major nutrients uptake (kg ha^{-1}) = (Nutrient concentration (%) x Biomass (kg ha^{-1})) / 100

2.3 Digestion of Plant Samples for Nutrients Estimation

One gram of the powdered plant samples (grain and straw) was pre-digested with 10 mL HNO_3 (62%) for 24 h, later digested in a digestion chamber at 85°C with following steps: The pre-digested samples were treated with 10 mL di-acid mixture reagent (HNO_3 + $HOCl_4$ at 9:4 ratio) and kept in digestion chamber until white precipitate was left at the bottom of the flask. The digested samples were diluted with distilled water to known volume after filtration. This extract was used in the estimation of P and K by using standard procedures.

2.4 Nitrogen, Phosphorus, and Potassium

Nitrogen content in the grain and straw samples were estimated by micro Kjeldhal digestion and distillation method as outlined by Piper [11]. Phosphorus was estimated using a suitable aliquot of the above extract by vanodomolybdophosphoric yellow color method. Potassium content in plant samples was estimated by feeding the digested extract after suitable dilution to flame photometer [11].

2.5 Statistical Analysis

The experimental data collected on various growth, yield components, nutrient content and uptake of plant were subjected to Fisher's method of "Analysis of variance" (ANOVA). Whenever F-test was significant for comparison amongst the treatments means an appropriate value of critical differences (CD) was worked out. Otherwise against CD values abbreviation NS (Non- Significant) was indicated. All the data were analyzed and the results are presented and discussed at a probability level of 0.05 per cent and correlation study was done as given by Gomez and Gomez [12].

Table 1. Initial physico-chemical properties of the experimental soil

Sl. No	Parameter	Value
	Physical properties	
1	Sand (%)	64.49
2	Silt (%)	08.95
3	Clay (%)	25.14
4	Textural class	Sandy clay loam
5	Maximum Water Holding Capacity (%)	32.09
6	Bulk density (g cm^{-3})	1.39
	Chemical properties	
1	$pH_{1:2.5}$	5.62
2	$EC_{1:2.5}$ (dS m^{-1})	0.34
3	Organic carbon (%)	0.48
4	Available N (kg ha^{-1})	125.20
5	Available P_2O_5 (kg ha^{-1})	11.47
6	Available K_2O (kg ha^{-1})	138.85
7	Exchangeable Ca (c mol kg^{-1})	4.17
8	Exchangeable Mg (c mol kg^{-1})	1.88
9	Available S (mg kg^{-1})	20.33
10	DTPA Fe (mg kg^{-1})	14.98
11	DTPA Zn (mg kg^{-1})	0.47
12	DTPA Mn (mg kg^{-1})	4.08
13	DTPA Cu (mg kg^{-1})	0.34
14	Hot water soluble Boron (mg kg^{-1})	0.39

3. RESULTS AND DISCUSSION

3.1 Effect of Different Levels of NPK on Macronutrient Nutrient Status of Soil

The trend of available macronutrients like nitrogen, phosphorous, potassium in the soil increased after the harvest of brown top millet (Table 2).

3.2 Available Nitrogen

There was significant difference among treatments with respect to available N content of soil. In present study, use of FYM in combination with NPK was found to significantly increase the available N content of soil when compared to the without application of fertilizer and FYM. Among the treatments with graded doses of fertilizers, combination of FYM @ 6.25 t ha^{-1}+30 kg N + 30 kg P_2O_5+30 kg K_2O ha^{-1} recorded highest available N of 150.29 kg ha^{-1} and which is on par with T_{13} with the application of FYM @ 6.25 t ha^{-1}+30 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1} 148.85 kg ha^{-1} and T_{12} with the application of FYM @ 6.25 t ha^{-1}+30 kg N+30 kg P_2O_5 +10 kg K_2O ha^{-1} 146.98 kg ha^{-1}. Whereas, lower value of 123.54 kg ha^{-1} was obtained for absolute control.

The available N content of soil recorded significant differences among the different treatments. Application of inorganic and organic fertilizers recoded a direct relationship between available N and organic matter content of the soil [13]. The increase in available N content of soil in higher dose of fertilizers i.e. 30 kg N:30 kg P_2O_5:30 kg K_2O ha^{-1} along with FYM could be attributed to the increased organic matter and total N contents of the soil [14,15]. The addition of FYM favoured the soil conditions and might have helped in the mineralization of soil N leading to build up of available N. This can be attributed to higher levels of N and organic carbon present in FYM, which may have accelerated the mineralization process during the growing season [16]. The higher available nitrogen with the application of FYM applied treatment might be due to better biological activities and its effect on mineralization of nitrogen (Lokesh et al. 2015; Prakash et al. 2003).

3.3 Available Phosphorus

There was significant difference among treatments with respect to available P2O5 content of soil. In present study, use of FYM in combination with NPK was found to increase available P2O5 content significantly in soil when compared to the without application of fertilizer and FYM. Among the treatments with graded doses of fertilizers, FYM @ 6.25 t ha^{-1}+30 kg N:30 kg P_2O_5:30 kg K_2O ha^{-1} recorded highest available P_2O_5 content of 17.60 kg ha^{-1} and which is on par with T_{13} with the application of FYM @ 6.25 t ha^{-1}+30 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1} 17.54 kg ha^{-1} and T_{12} with the application of FYM @ 6.25 t ha^{-1}+30 kg N + 30 kg P_2O_5+10 kg K_2O ha^{-1} 17.20 kg ha^{-1}. Whereas lower value of 10.08 kg ha^{-1} was obtained for absolute control.

Table 2. Effect of different levels of NPK on available primary nutrients content of soil

Treatments	Nitrogen	Phosphorus	Potassium
		(kg ha^{-1})	
T_1: Absolute control	123.54	10.08	136.50
T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}	126.38	12.74	142.91
T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}	128.16	13.18	146.25
T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	129.65	13.80	151.48
T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	131.41	14.57	153.04
T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	133.12	14.92	147.83
T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	138.06	15.23	152.99
T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	138.16	15.97	156.29
T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}	140.89	16.43	148.27
T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	141.97	16.85	155.19
T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	143.24	16.90	158.44
T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	146.98	17.20	150.99
T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	148.85	17.54	158.81
T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	150.29	17.60	160.84
S.Em. ±	2.03	0.19	2.16
CD @ 5 %	5.88	0.56	6.26

FYM itself could contribute considerably to the available P pool of soil upon mineralization [17,18]. The application of FYM increased P because of its P content and possibly by increasing retention of P in soil. A positive effect of FYM on P availability was also observed by Roy, Sharma, and Trehan [19]. The increase in the availability of phosphorus in soil could be attributed to the use of FYM along with a high inorganic dose, which leads to an accumulation of more phosphorus in soil pools and contributes to an increase in available phosphorus [20].

Further in control the available phosphorus content declined when compared to the initial value after harvest. Removal of labile P by the crops in a soil not nourished by the addition of P from external sources might be the reason for significant reduction in available P content of the soil in control plots [21,22].

3.4 Available Potassium

There was considerably significant difference among treatments with respect to available K_2O content of soil. In present study, use of FYM in combination with higher levels of NPK was found to increase significantly the available K_2O content of soil when compared to the without application of fertilizer and FYM. Among the treatments with graded doses of fertilizers, FYM @ 6.25 t ha^{-1}+30 kg N+30 kg P_2O_5+30 kg K_2O ha^{-1} recorded highest available K_2O content of 160.84 kg ha^{-1} and which is on par with T_{13} with the application of FYM @ 6.25 t ha^{-1}+30 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1}158.81 kg ha^{-1}, T_{11} with the application of FYM @ 6.25 t ha^{-1}+ 30 kg N+20 kg P_2O_5+30 kg K_2O ha^{-1} 158.44 kg ha^{-1} and T_{10} with the application of FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} 155.19 kg ha^{-1}. Whereas, lower value 136.50 kg ha^{-1} was observed in absolute control.

The plots incorporated with FYM also had relatively higher amounts of available K. Farmyard manure is not only a direct and ready source of K [23] but also aids in minimizing the leaching loss of K by retaining K ions on exchange sites of its decomposed products. The available potassium status of the soil significantly increased at harvest of brown top millet in T_{14} (30 kg N+30 kg P_2O_5+30 kg K_2O ha^{-1}) may be attributed to the application of high dose of inorganic fertilizers and FYM which minimizes the leaching loss of K by retaining K ions on exchange sites of its decomposed products and thus contributes to accumulation of more K in soil pool [16]. Higher available potassium status in the soil might be due to balanced supply of NPK through inorganics and FYM. The results are in good agreement with the findings of Singh et al. [24] and Dindayal Dangi [25] that found that the available K in soil also increased significantly. It also might be due to release of nonexchangeable K could have resulted in the increased available K [26].

3.5 Effect of Different Levels of NPK on Growth of Brown Top Millet

Plant height of brown top millet as influenced by different levels of NPK at 30, 60 DAS and at harvest are furnished in Table 3.

At 30 and 60 DAS and at harvest, plant height differed significantly due to different levels of NPK. Significantly higher plant height of 40.87, 99.50 and 103.27 cm was obtained with 30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} (T_{10}) and was on par with T_9 (39.73, 98.07 and 100.90 cm, respectively) compared to other treatments (Table 3). In addition to FYM, soil physical properties should have changed, providing optimal conditions for crop growth in addition to growing nutrient availability. The taller plants observed in nitrogen, phosphorus and potassium applied treatments, might be due to increased activity of meristematic cells and cell elongation thus increasing the plant height. Several studies have highlighted the value of fertilization of nitrogen, phosphorus and potassium on the brown top millet crop, highlighting its impact on growth, nutrition and production [27]. These results agree with the findings of Chittapur et al. [28], Muthukrishnan and Subramanian [29] and Hanumantha Rao et al. [30].

The data pertaining to the number of tillers $hill^{-1}$ as influenced by the application of different levels of NPK is presented in Table 4. Significantly higher number of tillers of 7.33, 8.16 and 9.12 at 30, 60 DAS and at harvest respectively, was recorded in the T_{10} treatment which received 30 kg N: 20 kg P_2O_5: 20 kg K_2O ha^{-1} and which is on par withT_9 (30 kg N: 20 kg P_2O_5: 10 kg K_2O ha^{-1}) with 7.09, 7.94 and 9.10 tillers $hill^{-1}$ at 30, 60 DAS and at harvest, respectively and found superior to the rest of all treatments. However, significantly minimum number of tillers $hill^{-1}$ (30 DAS: 4.13, 60 DAS: 5.37 and at harvest: 6.70) was noticed in treatment T_1 i.e. absolute control with no fertilizers and FYM. It was largely attributed to better photosynthetic and net performance assimilation which helped to improve overall plant production. All the

Table 3. Effect of different levels of NPK on plant height of brown top millet

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
T_1: Absolute control	29.53	88.53	90.53
T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}	30.47	88.13	90.91
T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}	31.10	88.97	91.72
T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	32.63	89.50	91.53
T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	32.73	90.10	92.86
T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	32.97	91.27	93.93
T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	34.00	92.40	95.16
T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	34.90	92.93	95.69
T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}	39.73	98.62	100.90
T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	40.87	99.50	101.27
T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	37.10	94.93	97.69
T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	38.27	97.10	99.90
T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	37.53	95.70	98.48
T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	35.93	93.80	96.60
S.Em. ±	0.41	0.30	0.41
CD @ 5 %	1.20	0.88	1.19

Note: 6.25 tonnes of FYM ha^{-1} was applied to all treatments except T_1: Absolute control

Table 4. Effect of different levels of NPK on number of tillers per hill of brown top millet

Treatments	Number of tillers per hill		
	30 DAS	60 DAS	At harvest
T_1: Absolute control	4.13	5.37	6.70
T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}	4.21	5.56	6.90
T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}	4.40	6.01	6.97
T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	4.95	6.11	7.16
T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	4.98	6.30	7.39
T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	5.08	6.38	7.60
T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	5.32	6.55	7.76
T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	5.59	6.82	8.07
T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}	7.09	7.94	9.10
T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	7.33	8.16	9.12
T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	6.17	7.20	8.53
T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	6.80	7.63	8.74
T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	6.47	7.62	8.70
T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	5.83	7.04	8.30
S.Em. ±	0.14	0.18	0.12
CD @ 5 %	0.40	0.52	0.34

Note: 6.25 tonnes of FYM ha^{-1} was applied to all treatments except T_1: Absolute control

treatments excluding control reported a higher number of successful tillers that may be attributed to better and more controlled nutritional supply for the plants.

3.6 Effect of Different Levels of NPK on Yield and Yield Components of Brown Top Millet

The data pertaining to panicle length (cm), panicle weight (g), grain weight $panicle^{-1}$, grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), harvest index (HI) and test weight (g) as influenced by different levels of NPK are presented in Table 5. Distinct positive effect of NPK levels along with FYM were noticed on these yield attributes.

Significantly higher panicle length (15.31 cm), panicle weight (1.38 g), grain weight $panicle^{-1}$ (0.77 g), grain yield (1014.99 kg ha^{-1}) and straw yield (1902.67 kg ha^{-1}) were recorded with the application 30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} (T_{10}) and which is followed by T_9 as compared to other treatments and the lowest panicle length (11.66 cm), panicle weight (0.92 g), grain weight $panicle^{-1}$ (0.41 g), grain yield (628.10 kg ha^{-1}), straw yield (1540.81 kg ha^{-1}). The increasing nutrient rates with FYM dramatically improved brown top millet grain and straw production, This can be attributed to the combined influence of NPK and FYM on the production and absorption of NPK and brown top millet grain and straw yield.

The inorganic and organic manure given increased the quality of brown top millet grain and grass. The application of FYM may affect the availability of N, P and K by maintaining good physical soil condition and plant growth, yield. Rahman et al. [31]; Gupta et al. [32]; Bajpai et al. [33]; Tzudir and Ghosh [34] and Yadav et al. [35] reported by increase in straw production of hybrid rice with combined fertilizer application and manure use.

There was no significant difference in harvest index and test weight (1000 seed weight) among the different levels of NPK applied in the present study (Table 5). However, the lower harvest index and test weight was recorded in T_1 (0.33 and 2.93 g, respectively). From the results it is evident that the harvest index and weight of 1000-grain increased to a considerable extent when FYM applied with chemical fertilizers. Gangadhar Nanda [36] also reported that the combined performance of organic and inorganic fertilizers was good in increasing the 1000-grain weight.

3.7 Effect of Different Levels of NPK on Macronutrients Content and Uptake by Grain and Straw of Brown Top Millet

The data pertaining to macronutrient content and uptake by brown top millet crop as influenced by application of different levels of NPK fertilizers are presented in Tables 6 and 7.

3.8 Nitrogen

Nitrogen content in grain and straw differed significantly with different levels of fertilizer applied, significantly higher N content in grain (1.25%) and straw (1.00%) was recorded in plot which received FYM @ 6.25t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} (T_{10}) and it was on par with T_9 (30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1}), T_{12} (30 kg N+30 kg P_2O_5+10 kg K_2O ha^{-1}) and T_{13} (30 kg N+30 kg P_2O_5+20 kg K_2O ha^{-1}) by 1.39, 1.37, 1.32% and 1.04, 1.03, 1.02% in grain and straw, respectively. The lower N concentration of grain (1.07%) and straw (0.86%) was observed in absolute control.

Nitrogen uptake by grain and straw differed significantly with varied levels of NPK fertilizers applied, significantly higher N uptake in grain (14.34 kg $ha^{-1)}$, straw (19.90 kg ha^{-1}) was observed in plot which received FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} and it was on par with T_9 (30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1}), T_{12} (30 kg N+30 kg P_2O_5+10 kg K_2O ha^{-1}) by 13.85, 13.58 and 19.68, 19.15 kg ha^{-1} in grain and straw, respectively. The lower N uptake of grain (6.75 kg ha^{-1}) and straw (13.25 kg ha^{-1}) was observed in absolute control.

3.9 Phosphorus

Phosphorus content in grain and straw differed significantly with varied levels of NPK fertilizers applied, significantly higher P content in grain (0.47%) and straw (0.31%) was recorded in plot receiving FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} and it was on par with T_9 (30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1}), T_{12} (30 kg N+30 kg P_2O_5+10 kg K_2O ha^{-1}) by 0.46, 0.45% and 0.29, 0.29% in grain and straw, respectively. The lower N concentration of grain (0.29%) and straw (0.19%) was observed in absolute control.

Phosphorus uptake in grain and straw differed significantly with different levels of NPK fertilizers applied, significantly higher P uptake by grain (5.87 kg ha^{-1}), straw (4.60 kg ha^{-1}) was recorded in plot which received FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} and it was on par with T_9 (30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1}), T_{12} (30 kg N+30 kg P_2O_5+10 kg K_2O ha^{-1}) by 4.63, 4.36 kg ha^{-1} and 5.46, 5.34 kg ha^{-1} in grain and straw, respectively. The lower P uptake of grain (1.84 kg ha^{-1}) and straw (2.93 kg ha^{-1}) was observed in absolute control.

3.10 Potassium

Potassium content in grain and straw differed significantly with different levels of NPK fertilizer applied, significantly higher K content in grain (0.51%), straw (1.35%) was recorded in plot which received FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} and it was on par with T_9 (0.88%), T_{12} (0.86%) in grain, where as in straw it is on par with T_9 (1.76%), T_{12} (1.74%), T_{13} (1.73%) and T_{14} (1.69%). The lower K content of grain (0.51 %) and straw (1.35%) was observed in absolute control.

Potassium uptake by grain and straw differed significantly with different levels of fertilizer nutrients applied, Significantly higher K uptake in grain (9.99 kg ha ha^{-1}), straw (33.67 kg ha ha^{-1})

Table 5. Effect of different levels of NPK on yield and yield components of brown top millet

Treatments	Panicle length	Panicle weight	Grain weight panicle^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	Test Weight (g)
T_1	11.66	0.92	0.41	628.10	1540.81	0.33	2.93
T_2	11.65	0.88	0.34	696.06	1563.70	0.35	3.09
T_3	11.74	0.88	0.35	704.41	1594.47	0.34	3.21
T_4	11.97	0.89	0.36	737.52	1631.80	0.35	3.24
T_5	12.23	0.90	0.37	768.59	1659.53	0.35	3.25
T_6	12.26	0.93	0.40	823.79	1668.47	0.37	3.28
T_7	12.41	0.96	0.43	838.68	1701.13	0.36	3.29
T_8	12.54	1.06	0.46	892.63	1742.70	0.37	3.30
T_9	14.76	1.34	0.74	999.35	1893.22	0.37	3.47
T_{10}	15.31	1.38	0.77	1014.99	1902.67	0.38	3.62
T_{11}	13.80	1.31	0.73	946.68	1804.70	0.37	3.44
T_{12}	13.75	1.31	0.54	972.10	1860.36	0.37	3.39
T_{13}	13.27	1.16	0.49	953.88	1819.25	0.37	3.35
T_{14}	12.99	1.13	0.46	921.88	1764.81	0.34	3.34
S.Em. ±	0.13	0.04	0.03	7.89	12.45	0.005	0.08
CD @ 5 %	0.37	0.11	0.08	22.85	36.07	NS	NS

Note: 6.25 tonnes of FYM ha^{-1} was applied to all treatments except T_1: Absolute control

Table 6. Effect of different levels of NPK on nitrogen, phosphorus and potassium content in grain and straw of brown top millet

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Absolute control	1.07	0.86	0.29	0.19	0.51	1.35
T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}	1.08	0.88	0.33	0.21	0.56	1.39
T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}	1.10	0.90	0.33	0.22	0.56	1.47
T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	1.15	0.93	0.34	0.23	0.57	1.53
T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	1.16	0.95	0.34	0.24	0.58	1.57
T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	1.19	0.95	0.35	0.24	0.59	1.64
T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	1.23	0.96	0.36	0.24	0.65	1.66
T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	1.24	0.97	0.36	0.25	0.68	1.67
T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}	1.39	1.04	0.46	0.29	0.88	1.76
T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	1.41	1.05	0.47	0.31	0.90	1.77
T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	1.31	1.01	0.38	0.26	0.80	1.70
T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	1.37	1.03	0.45	0.29	0.86	1.74
T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	1.32	1.02	0.40	0.26	0.84	1.73
T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	1.25	1.00	0.37	0.26	0.74	1.69
S.Em. ±	0.03	0.01	0.01	0.01	0.01	0.03
CD @ 5 %	0.09	0.04	0.04	0.04	0.04	0.10

Note: 6.25 tonnes of FYM ha^{-1} was applied to all treatments except T_1: Absolute control

was recorded in plot which received FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} and it was on par with T_9 (33.35 kg ha^{-1}), T_{12} (32.45 kg ha^{-1}) in straw. The lower K uptake of grain (2.92 kg ha^{-1}) and straw (20.85 kg ha^{-1}) was observed in absolute control.

Mariaselvam et al. [37] recorded the beneficial role of potassium and nitrogen in chlorophyll production, regulating the concentration of auxin and its stimulating influence on most of the plant's physiological and metabolic processes that helped the plants consume more nutrients from the soil. The phosphorus also tended to reinforce and elongate the root surface for further nutrient absorption. Thus, the beneficial impact of nitrogen and potassium added along with phosphorus on photosynthesis and metabolic processes increased photosynthesis output and translocation from source to sink, which eventually increased nutrient concentration in plants. Uddin et al. [38] and Sandhyakanthi et al.

[39] published related results. Better crop growth is always accomplished with higher uptake and retentivity of various nutrients by the crops. Hence, yield maximization on the other hand includes all the processes associated with uptake of nutrients, translocation, partitioning, assimilation and mobilization of nutrients at different growth stages of crop. As a part of the inorganic constituent in plant system, nutrients accomplish the growth enhancement. Hence, biomass and nutrient content are synergistic in bringing the crop for healthy production. Relevant NPK treatments have mainly influenced the nitrogen, phosphorus and potassium quality of grain and brown top millet straw root biomass per unit soil volume as higher concentrations of nitrogen, phosphorus and potassium was applied along with farmyard compost, and N, P_2O_5, K_2O and other nutrients were also supplied by FYM. Similar conclusions were drawn documented by Singh et al. [40], Sidhram Patil (2014), Punitha [41], Kumari et al. [42], Setty and Murali (2001), and Sunitha et al. [43].

The higher level of nitrogen, phosphorus and potassium made it conducive for extensive root proliferation, which explored a greater volume of soil and absorbs larger quantities of nutrients, which correlated positively with dry matter production, and concentration of nutrients in the plant under a higher level of nutrient supply [44]. Higher availability of nutrients and their supply to the roots might have helped in nutrient absorption and mobilization.

This increased uptake of nitrogen which might be due to higher grain and straw yield. This may be due to improved utilization of applied nitrogen in the presence of sufficient potassium and FYM and also the higher uptake of nitrogen was due to the favorable influence of nitrogen on higher degree of vegetative growth which in turn absorb higher amount of nutrients from the rhizosphere and supply to the crop resulting in higher dry matter production. This may be due to increase in the availability of nutrients to the crop from added green manure. Similar positive interaction between N and K was reported by Thippeswamy [45], who reported that the uptake of N and K was found to increase significantly with the levels and split application of K in finger millet. Similarly, FYM enhanced available N through mineralization process and increased efficiency of applied N. Application of phosphorus increased root proliferation might be due to higher levels of P resulted in the better utilization of nitrogen by the finger millet. Significantly higher nutrient content and uptake (N, P, and K) was observed in plot received FYM @ 6.25t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1}. Lower nutrient content and uptake was observed in treatment *i.e.* absolute control, which may be due to low availability of nutrients in soil because of no fertilizer and no FYM were applied. This showed the beneficial effect of the balanced application of organic and inorganics.

Table 7. Effect of different levels of NPK on nitrogen, phosphorus and potassium uptake in grain and straw of browntop millet

Treatments	Nitrogen		Phosphorus (kg ha^{-1})		Potassium	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Absolute control	6.75	13.25	1.84	2.93	2.92	20.85
T_2: 20 kg N: 20 kg P_2O_5 ha^{-1}	7.49	13.70	2.28	3.27	4.40	21.69
T_3: 20 kg N:20 kg P_2O_5:10 kg K_2O ha^{-1}	7.73	14.31	2.32	3.56	4.52	23.46
T_4: 20 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	8.49	15.12	2.51	3.81	4.70	24.92
T_5: 20 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	8.93	15.71	2.63	3.95	5.16	26.09
T_6: 20 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	9.81	15.90	2.92	3.99	5.57	27.44
T_7: 20 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	10.36	16.27	3.00	4.07	6.17	28.22
T_8: 20 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	11.04	16.96	3.20	4.32	6.86	29.03
T_9: 30 kg N: 20 kg P_2O_5:10 kg K_2O ha^{-1}	13.85	19.68	4.63	5.46	9.72	33.35
T_{10}: 30 kg N: 20 kg P_2O_5:20 kg K_2O ha^{-1}	14.34	19.90	4.73	5.96	9.99	33.67
T_{11}: 30 kg N: 20 kg P_2O_5:30 kg K_2O ha^{-1}	12.37	18.28	3.57	4.78	8.49	30.64
T_{12}: 30 kg N: 30 kg P_2O_5:10 kg K_2O ha^{-1}	13.62	19.15	4.36	5.34	9.32	32.45
T_{13}: 30 kg N: 30 kg P_2O_5:20 kg K_2O ha^{-1}	12.56	18.61	3.81	4.75	8.99	31.47
T_{14}: 30 kg N: 30 kg P_2O_5:30 kg K_2O ha^{-1}	11.55	17.58	3.46	4.65	7.73	29.85
S.Em. ±	0.25	0.28	0.13	0.27	0.09	0.60
CD @ 5 %	0.72	0.82	0.37	0.77	0.25	1.74

4. CONCLUSIONS

Understanding plant nutrients is the most important task for sustaining a healthy crop cycle. An integrated organic and inorganic fertilizer enhances the macronutrient contents in the plant and soil which will be suitable for crop cultivation (Chong et al. 2017). Application of FYM @ 6.25 t ha^{-1}+30 kg N+20 kg P_2O_5+20 kg K_2O ha^{-1} significantly increased the macronutrient content in soil and uptake by browntop millet (grain and straw) as against absolute control. For sustaining soil quality and crop productivity, supplementing the inorganics with organics is the best strategy. This clearly indicated the complete supply of all the essential nutrients in sufficient amounts in balanced ratio during the crop growth period.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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