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Effect of Macro and Micronutrients on Nutrient Uptake, Yield and Economics in Transplanted Teff (*Eragrostis tef* (Zucc.) Trotter)

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ABSTRACT: A field experiment was conducted at College of Agriculture Farm, Raichur on medium deep black soil during *kharif*, 2021 to study the effect of macro and micronutrients on nutrient uptake, yield and economics of teff (*Eragrostis tef* (Zucc.) Trotter). The results revealed that, application of 25:10:10 kg NPK ha^{-1} recorded significantly higher uptake of nitrogen (70.53 kg ha^{-1}), phosphorus (19.97 kg ha^{-1}), potassium (28.03 kg ha^{-1}), grain yield (419 kg ha^{-1}), straw yield (736 kg ha^{-1}), net returns (Rs. 1,07,804 ha^{-1}) and B:C (3.89). Among the micronutrients, combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} recorded significantly higher uptake of nitrogen (59.39 kg ha^{-1}), phosphorus (15.31 kg ha^{-1}), potassium (23.45 kg ha^{-1}), grain yield (361 kg ha^{-1}), straw yield (602 kg ha^{-1}) and net returns (Rs. 85,975 ha^{-1}). The interaction effect of macro and micronutrients were non significant.

Keywords: Micronutrients, Significant, Teff, Uptake.

INTRODUCTION

Teff is an annual grass which is cultivated for its edible seeds and it is a staple food in Ethiopia and Eritea. It is believed to been originated in Ethiopia between 4000 and 1000 BC (Vavilov, 1951). It is a fine stemmed, turfed grass with large crowns and many tillers. Its roots are shallow, but develop a massive fibrous rooting system and teff is self pollinated C_4 plant which allows it to fix carbon more efficiently in drought and high temperature. Teff is highly rich in minerals, protein, carbohydrates (the newly discovered teff dietary fibre is good for blood sugar management, weight control and colon health) and also it is low in sodium, bad fat and cholesterol and it is also a gluten- free grain and it helps to fight the celiac disease, diabetics and obesity and its consumption has many beneficial effects which includes building of strong bones and teeth, controls blood sugar levels provides long lasting energy and helps to reduce weight. Teff reduces about 20-30 per cent risk of developing type 2 diabetes by consuming it (Secorun, 2016).

Teff is highly valued crop but its productivity is low due to soil fertility depletion. Synchronizing the nutrient supply with crop demand is essential to maximize yield and fertilizer use efficiency. So, the field experiment was conducted to study the effect of macro and micronutrients on yield and economics of teff.

MATERIALS AND METHODS

A field experiment was conducted during *kharif*, 2021 at Agricultural College farm, Raichur. The centre is located in Agro-Climatic Zone II (North Eastern Dry Zone) of Karnataka and is situated between 16º12′N latitude and 77º20′E longitude at an altitude of 389 metres above the mean sea level. The experiment was laid out in split plot design with four macronutrient levels *i.e.*, F_0 (Control), F_1 (15:06:06), F_2 (20:08:08) and F_3 (25:10:10) kg NPK ha^{-1} as main plots and four micronutrient levels *i.e.*, M_0 (Control), M_1 ($ZnSO_4$ @ 5 kg ha^{-1}), M_2 ($FeSO_4$ @ 7.5 kg ha^{-1}) and M_3 ($ZnSO_4$ and $FeSO_4$ @ 5 and 7.5 kg ha^{-1}, respectively) as sub plot treatments and each replicated thrice. Macro and

micronutrients were applied according to the treatments in the form of urea (nitrogen), DAP (phosphorus), MOP (potassium), zinc sulphate ($ZnSO_4$) and ferrous sulphate EDTA form ($FeSO_4$) as basal dose at the time of sowing. The soil of the experiment was medium deep black clayey in texture with alkaline reaction and medium in soil organic carbon, low in available nitrogen and zinc, medium in available phosphorus, potassium and iron.

RESULTS AND DISCUSSION

Effect of macro and micronutrients on nutrient uptake. Uptake of nutrients by teff was significantly different with the different levels of macro and micronutrients. Application of 25:10:10 kg NPK ha^{-1} recorded significantly higher uptake of nitrogen (70.53 kg ha^{-1}), phosphorus (19.97 kg ha^{-1}) and potassium uptake (28.03 kg ha^{-1}) by teff over other treatments. The lowest nitrogen, phosphorus and potassium uptake (41.75, 7.81 and 15.92 kg ha^{-1}, respectively) was recorded from control. Among sub plots, combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} significantly recorded higher nitrogen, phosphorus and potassium uptake (59.39, 15.31 and 23.45 kg ha^{-1}) whereas, control recorded the lowest nitrogen (53.69 kg ha^{-1}), phosphorus (12.09 kg ha^{-1}) and potassium (20.44 kg ha^{-1}) uptake by teff. Nutrient uptake by crop is the product of total biomass production and nutrient concentration in plant tissue. If the nutrients are more in soil then it results into higher nutrient uptake. The increase in the yield levels along with higher levels of NPK led to higher NPK uptake. Mainly nitrogen, had significant effect on P uptake by the rhizosphere acidification which resulted in the conversation of insoluble phosphates to soluble phosphates. Similar findings were reported by Ishwar (2018) in ragi. The beneficial role of micronutrients (zinc and iron) in enhancing the cation exchange capacity of root and absorption of nutrients increased the uptake of NPK. Further, the synergistic role of zinc and iron in chlorophyll formation and regulating auxin concentration might have helped in uptake of more nutrients especially nitrogen.

Effect of macronutrients on yield. With regard to macronutrients levels, application of 25:10:10 kg NPK ha^{-1} (F_3) recorded significantly higher grain yield (419 kg ha^{-1}), and lower grain yield was recorded from control (255 kg ha^{-1}). The increase in yield with increasing macronutrients application might be due to better availability and uptake of nutrients which leads to efficient metabolism, high chlorophyll synthesis, higher biomass accumulation and effective translocation of photosynthates from source to sink. Moreover nitrogen aids in improving growth and leaf area consequently resulting in higher light interception that aids in increased total photosynthesis, enhanced sink capacity and ultimately grain yield of teff. Similar results were obtained by Mubeena *et al*. (2019) in foxtail millet.

Significantly higher straw yield was recorded with application of 25:10:10 kg NPK ha^{-1} (736 kg ha^{-1}), while significantly lower straw yield was recorded with control (427 kg ha^{-1}). The synthesis and transport of photosynthates is determined by nutrient supply and higher doses of fertilizer results into more production of photosynthates and their accumulation which ultimately led to higher straw yield. Shankar (2017) in little millet and Ambresha (2017) in foxtail millet reported the similar results.

The highest harvest index was recorded with the application of 25:10:10 kg NPK ha^{-1} (40.91 %), control recorded the lowest harvest index (36.83 %). Similar results were reported by Ashoka *et al*. (2020) in teff.

Effect of micronutrients on yield. Significantly higher grain yield was recorded with combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} (361 kg ha^{-1}), while significantly lower grain yield was recorded with control (318 kg ha^{-1}). This was mainly because of the involvement of zinc and iron in starch formation and protein synthesis as well as it's maintenance. These results are in confirmation to the earlier reported by Meena *et al*. (2018) in pearl millet and mustard and Kumar *et al*. (2020) in finger millet.

In sub plots M_3 (combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1}) significantly recorded the highest straw yield *i.e*., 602 kg ha^{-1}. Whereas, control recorded the lowest straw yield (550 kg ha^{-1}). This might be due to application of zinc and iron fertilizer which enhanced the starch formation and protein synthesis as well as maintenance. Similar results was reported by Sandhya Rani *et al*. (2017) in finger millet

Among the micronutrients application, treatment receiving both $ZnSO_4$ @ 5.0 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} recorded the highest harvest index (39.47 %), which was statistically on par with M_1 ($ZnSO_4$ @ 5.0 kg ha^{-1}) and M_2 ($FeSO_4$ @ 7.5 kg ha^{-1}). And the lowest harvest index was recorded from control (38.82%).

Economics. Application of 25:10:10 kg NPK ha^{-1} recorded significantly higher gross returns (Rs. 1,45,468 ha^{-1}) and the lowest was recorded in control (Rs. 87,831 ha^{-1}). Among the micronutrients, application of $ZnSO_4$ @ 5 kg ha^{-1} along with $FeSO_4$ @ 7.5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} alone recorded the highest gross returns (Rs. 1,26,781 ha^{-1}). However, the lowest gross returns were recorded from control treatment (Rs. 1,14,387 ha^{-1}).

The higher net returns was significant with the application of 25:10:10 kg NPK ha^{-1} *i.e*., Rs. 1,07,804 ha^{-1}, control recorded the lowest net returns (Rs. 51,624 ha^{-1}). Among the micronutrients, application of both $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} recorded the highest net returns (Rs. 85,975 ha^{-1}), it was statistically on par with application of $ZnSO_4$ @ 5 kg ha^{-1} alone. Control treatment recorded the lowest net returns (Rs. 81,051 ha^{-1}).

The B:C was significantly higher with application of 25:10:10 kg NPK ha^{-1} (3.89), and the lowest was recorded from control (2.44). However, application of $ZnSO_4$ @ 5 kg ha^{-1} alone recorded the highest B:C (3.51). Application of $FeSO_4$ @ 7.5 kg ha^{-1} alone recorded the lowest B:C (3.00).

In teff crop, different macronutrients levels played a significant role in gross returns and net returns. Application of 25:10:10 kg NPK ha^{-1} recorded the highest gross, net returns and B:C (Rs. 1,45,468 ha^{-1}, Rs. 1,07,804 ha^{-1} and 3.89 respectively), which was mainly because of higher grain and straw yield of teff. These results were in close conformity with reports of Divyashree *et al*. (2018) in little millet and Weerede *et al*. (2018) in teff.

Among the sub plots, combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ,ha^{-1} recorded the highest gross and net returns (Rs. 1,26,781 ha^{-1} and Rs. 85,975 ha^{-1} respectively) this is mainly because of higher absorption of nutrients which resulted into higher grain and straw yield of teff (Shekhawat and Kumawat, 2017 in pearl millet). But, application of $ZnSO_4$ @ 5 kg ha^{-1} alone recorded the highest B:C (3.51) compared to other treatment. This is because of high cost of $FeSO_4$ fertilizer which led to higher cost of cultivation and lower B:C.

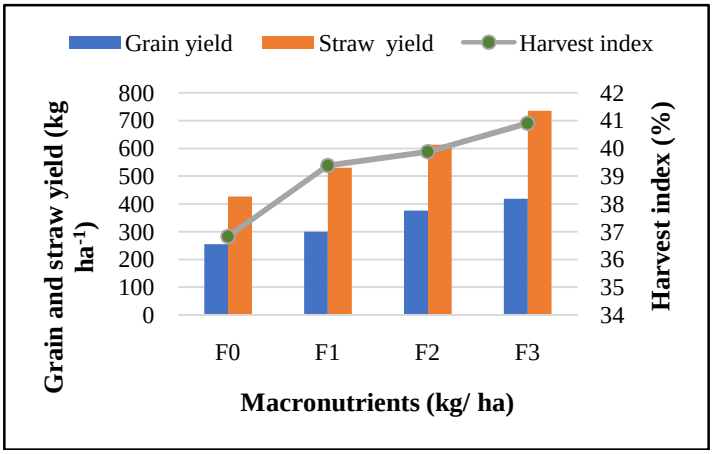
Interaction effect. The interaction effect of macro and micronutrients were non significant with respect to yield and economics of teff.

Table 1: Effect of different levels of macro and micronutrients on the uptake of nitrogen, phosphorus and potassium by teff.

Treatment	Nutrient uptake (kg ha^{-1})		
	Nitrogen	**Phosphorus**	**Potassium**
Main plot: Macronutrients			
F_0	41.75	7.81	15.92
F_1	52.03	11.33	19.97
F_2	62.76	15.92	24.04
F_3	70.53	19.97	28.03
S. Em. ±	**0.76**	**0.29**	**0.30**
C. D. at 5 %	**2.63**	**1.00**	**1.04**
Sub plot: Micronutrients			
M_0	53.69	12.09	20.44
M_1	55.69	13.34	21.71
M_2	58.07	14.28	22.37
M_3	59.39	15.31	23.45
S. Em. ±	**0.25**	**0.13**	**0.13**
C. D. at 5 %	**0.74**	**0.37**	**0.37**
Interaction (F × M)			
S. Em. ±	**0.51**	**0.25**	**0.26**
C. D. at 5 %	**NS**	**NS**	**NS**

Main plot: **Macronutrients (kg NPK ha^{-1})**
F_0- Control
F_1- 15:06:06 (75 per cent RDF)
F_2- 20:08:08 (100 per cent RDF)
F_3- 25:10:10 (125 per cent RDF)

Sub plot: **Micronutrients (kg ha^{-1})**
F_0 - Control
F_1 - Soil application of $ZnSO_4$ @ 5 kg ha^{-1}
F_2 - Soil application of $FeSO_4$ @ 7.5 kg ha^{-1}
F_3 - Soil application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1}



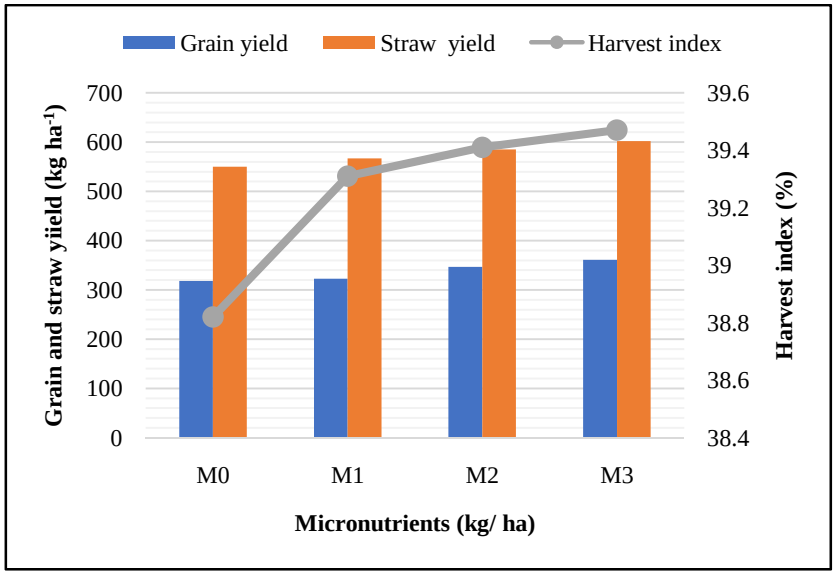


Fig. 1. Effect of different levels of macro and micronutrients on grain, straw yield and harvest index of teff.

Table 2: Effect of different levels of macro and micronutrients on economics of teff.

Treatment	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
Main plot: Macronutrients			
F_0	87831	51624	2.44
F_1	116582	79519	3.17
F_2	131632	94282	3.55
F_3	145468	107804	3.89
S. Em. ±	**222**	**222**	**0.01**
C. D. at 5 %	**768**	**768**	**0.02**
Sub plot: Micronutrients			
M_0	114387	81051	3.42
M_1	118270	84694	3.51
M_2	122075	81509	3.00
M_3	126781	85975	3.10
S. Em. ±	**722**	**722**	**0.02**
C. D. at 5 %	**2107**	**2107**	**0.06**
Interaction (F × M)			
S. Em. ±	**1444**	**1444**	**0.04**
C. D. at 5 %	**NS**	**NS**	**NS**

Main plot: **Macronutrients (kg NPK ha^{-1})**
F_0- Control
F_1- 15:06:06 (75 per cent RDF)
F_2- 20:08:08 (100 per cent RDF)
F_3- 25:10:10 (125 per cent RDF)

Sub plot: **Micronutrients (kg ha^{-1})**
F_0 - Control
F_1 - Soil application of $ZnSO_4$ @ 5 kg ha^{-1}
F_2 - Soil application of $FeSO_4$ @ 7.5 kg ha^{-1}
F_3 - Soil application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1}

CONCLUSION

Application of 125 per cent RDF (25:10:10 kg NPK ha^{-1}) along with combined application of $ZnSO_4$ @ 5 kg ha^{-1} and $FeSO_4$ @ 7.5 kg ha^{-1} recorded significantly higher nutrient uptake, grain yield, straw yield, harvest index, gross returns, net returns and benefit cost ratio. However, interaction effect of macro and micronutrients was found to be non significant with respect to yield and economics of teff.

FUTURE SCOPE

There is need to evaluate the different levels of macro and micronutrients as well as there is need to standardize the agronomic practices for teff cultivation in India.

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Conflict of Interest. None.

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