Effect of Blended Fertilizer Application on (Eragrostis tef /Zucc./Trotter) Yield, Yield Component and Nutrient Uptake by Grain Grown on Regosols and Vertisols, North Ethiopia

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Abstract
A field experiment was conducted during cropping season to investigate the effect of blended fertilizer application on *(Eragrostis tef /Zucc./Trotter)* yield, yield component and nutrient uptake on regosols and vertisols. An improved tef variety (*Eragrostis tef* /Zucc./Trotter) was used as a test crop and 5 treatment combinations were laid out in randomized complete block design (RCBD) with three replications in each site. Ten plants from each plot were randomly picked at maturity stage, just before harvest for yield component determination. Plant height, shoot length per plant, panicle length per plant, number of tillers per plant, number of spicks per panicle, weight of seeds per panicle were measured. And grain yield, straw yield and harvest index were measured from $12m^2$ plot area. All yield components on vertisols treated with T_I was significantly ($P<0.001$) higher than T_{II}, T_{III}, T_{IV} and T_V; while in regosols T_{III} resulted significantly ($P<0.0001$) higher than the other trials. Grain yield and straw yield on vertisols treated with T_I was significantly ($P<0.001$) higher than T_{II}, T_{III}, T_{IV} and T_V; while in regosols grain yield was highly significant ($P<0.001$) in the trial treated with T_{II} than the other trials, but straw yield was highly significant ($P<0.001$) in T_I than the other trials because yield components were high in the banded trial due to low nutrient competition and placement of fertilizers. Furthermore, in vertisols treated with T_I and T_V had significant ($P<0.001$) higher in harvest index than the other trials; while in regosols T_I had significant ($P<0.001$) higher harvest index than the other trials. In both vertisols and regosols T_I significantly increases nutrient uptake than the other trials because yield is high in this treatment. Therefore, application of blended fertilizer and row seeding rate increases yield and yield components than DAP and Urea because it contains many mineral elements such as N, P, K, Mg, Zn and S. And nutrient uptake is high in plots with blended fertilizer and banded trials because, nutrient uptake is the product of nutrient concentration and grain yield.
Keywords: Eragrostis *tef, Blended fertilizer, Yield, Yield component and Uptake of nutrient.*

1. INTRODUCTION

Teff (*Eragrostis tef* /Zucc./Trotter) belonging to the grass family poaceae, is a C4, self-pollinated annual grass, 40– 80cm tall (Dejene *et al*., 2012). It is one of the most important cereal crops and indigenous to Ethiopia that covers about 2 million hectares of land annually (CSA, 2010). The teff outer seed coat can be of different colors, ranging from pearl-white, to brown; the white grain being the most widely preferred for human consumption. The grains are milled into flour which when mixed with water to form slurry and fermented for two to three days, can be used to bake a flat spongy bread-resembling crepe-like pancake, known as "Injera" (Haftamu *et al,* 2009). Its excellent nutritional value and high resilience in resisting diverse biotic and abiotic stresses make it an excellent food security crop.

However, productivity of the current cultivars in the country is very low, 12.8 quintal ha^{-1} under traditional practices (CSA, 2010). Although, research efforts in the last few decades developed important technologies to overcome production constraints and increase productivity (Seifu Ketema, 1993), it has not yet been raised to satisfactory level as compared to its yield potential.

According to Tarekegne (2010) factors that contributing to low productivity of the crop is low soil fertility and method of planting problems. Thus, the study will address the challenges of limited knowledge on soil fertility management and associated challenges for increasing crop productivity with increased current fertilizer use. It also, contribute to tailor fertilizer recommendations based on nutrient levels in the soil and crop needs; as well as to close the knowledge gap about the nutrient status and fertility limitations of Ethiopian major agricultural soils. Therefore, this research is initiated to confirm effect of blended fertilizer application on (*Eragrostis tef* /Zucc./Trotter) yield, yield component and nutrient concentrations on grain grown on two soil types (regosols and vertisols).

2. METHODOLOGY

2.1. Site Selection

The experimental area was selected based on major soil type of the study area so as to have representative results and further extending the research output through their verification to the other parts of the area. In view of the variability of the area, the experiment was carried out at soil types (regosols and vertisols) during the main crop season at farmer's field. The soil types were characterized according to World Reference Book of Soil Resources (Atlas, 1998).

2.2. Experimental Design and Treatments

The experimental field was prepared following the farmer's practice (field was ploughed with oxen three times) and finally manual digging after lay out before planting. An improved tef variety (*Eragrostis tef* /Zucc./Trotter) was used as a test crop and 5 treatment combinations were laid out in randomized complete block design (RCBD) with three replications in each site. The plot size was 5m x 4m =20 m^2 with border spaces of 0.5 m between plots and 1m between blocks (Fig 1).

In accordance with the nature of the design, each experimental unit was assigned randomly to the treatment within each block and the treatments were:

T_I. 100kg/ha of 23-10-5 (NPK) +3S+0.3 Zn + 0.02Mg + 50kg/ha Urea + 50kg/ha Potassium Sulphate + 80kg/ha TSP; both seed and fertilizers row planted/banded with seed rate=5kg/ha.

$T_{II.}$ = 100kg/ha of 23-10-5 (NPK) +3S+0.3 Zn + 0.02Mg + 50kg/ha Urea + 50kg/ha Potassium Sulphate + 80kg/ha TSP; but both seed and fertilizers broadcast sowing with seed rate =25kg/ha

$T_{III.}$ 100kg/ha DAP + 100kg/ha Urea. Both seed and fertilizers row planted/banded with seed rate=5kg/ha

T_{IV}. = 100kg/ha DAP + 100kg/ha Urea, but both seed and fertilizers broadcast sowing with seed rate =25kg/ha

$T_{V.}$ Control treatment (seed rate=25kg/ha and no fertilizer)

2.3. Data Collection

2.3.1. Soil sampling and analysis

Composite surface soil samples from 0 to 20cm depth were collected during the dry season in the middle of May before the onset of the main rainy season using auger. And a minimum of 30 soil subsamples per plot of equal volume each randomly were collected to make a composite sample.

After drying, the samples were prepared and analyzed for soil particle size using hydrometer method as described by Bouyoucos (1951), organic matter content of the soil using Walkley-Black method (1934), CEC using Sodium acetate method, pH (1:2.5 soil : water ratio) as described by Jackson (1958), EC of the saturated past extract, Soil available P (Olsen et al.1954), available Mg, available K by flam photometer, Soil test Zn by DTPA as an extractant (Lindsay and Norvell, 1978) , CaCO3 using the method described by Jackson (1970), total soil N content using kjeldahal method and available S using Turbidimeter.

Surface soil samples from 0 to 20 cm depth were taken during planting, tillering, butting, 50% flowering and maturity phonological stages to determine FC, PWP, gravimetric moisture content, volumetric moisture content and bulk density of the soils. Similarly, post fertilization soil samples from 0 to 20cm depth were collected following the same procedure as described above from each plot and these samples were collected just before the crop is harvested and removed from the land and was analyzed for residual N and P.

2.3.2. Agronomic data collection at the field experiment

Agronomic data like plant height shoot length per plant, panicle length per plant, number of tillers per plant, number of spicks per panicle, weight of seeds per panicle, grain yield, straw yield and harvest index were collected from 12m^2 areas of each plot to avoid border effect. The crop was harvested and threshed manually for seed extraction from the straw.

2.4 Yield, Yield Components and Nutrient Uptake by teff grain

Teff plants in 12m^2 quadrants were used from each plot for recording yield at physiological maturity. As the teff seeds are very small in size only seed weight per panicle was recorded. To determine plant height, shoot length per plant, panicle length per plant, number of tillers per plant and number of spicks per panicle ten randomly picked plants from each plot were used at maturity, just before harvest.

Concentration of N, P, K, Zn, Mg and S from the dry grain samples of tef were determined after the grains were separated from straw yield and oven dried at a temperature of 70 ºc for about 48 hours. From the oven dried grain samples, the dry weight of the grains were determined and ground to pass 0.5 mm sieve for further analysis. The plant sample was brought in to solution form through digestion with acids that dissolve the plant grains and bring the plant nutrient in liquid form for estimation. These digested grains were analyzed for the concentration of N, P, K, Zn, Mg and S. P in grains was determined from ashed samples of the ground tef parts using dry ashing method (Sahlemedhin and Taye, 2000) (the plant sample was heated at high temperatures to destroy OM, and the ash so obtained was dissolved in acids to bring the sample in to liquid form for estimation).

The ash residue is dissolved in dilute HCl, filtered through acid-washed filter paper in a 50/100ml volumetric flask, and the volume is made up to the mark. Total N in plant grains was determined by the microkjeldahl method of the ashed tef samples (Sahlemedhin and Taye, 2000). Mg in grains was determined by atomic absorption spectrophotometer of the wet digest tef samples. K in grains was determined by flame photometer of the digest tef samples. For the determination of Zn concentration in grains of tef part of the sample digest was done by the wet digestion method. Total S was analyzed using Turbidimeter.

2.5. Statistical Analysis

Field soil and plant data were statistically analyzed using JMP 5. Single factor analysis of variance (ANOVA) were performed to evaluate the main effect of treatments (T_I, T_{II}, T_{III}, T_{IV} and T_V) on yield, yield components and concentration of N, P, K, Zn, Mg and S on teff grains for the two soil types. Yield data on the two soil types were compared considering the soil types as main plots and treatments as sub plots by split plot. In every case treatment means were separated using Tukey HSD comparison method. Significancey unless mentioned all the statistical significance of treatments were made at $\alpha = 0.05$. The linear relationship between yield and yield components were made using Pearson correlation product moment coefficients (r) at $\alpha = 0.05$. Yield components that overwhelming determines the yields of teff were detected using stepwise regression.

3. RESULT AND DISCUSSION

3.1. Soil Moisture

The results of analysis for gravimetric moisture content, bulk density and volumetric moisture content; during planting, tillering, butting, 50% flowering and harvesting phonological stages of surface soil (20cm) at FC (38.33%) and PWP (23.6%) on vertisols and at FC (24.1%) and PWP (14.3%)on regosols respectively (Figure-2). From this result, it was possible to say that vertisols have higher moisture holding capacity and plant available water capacity compared to regosols. Because filed moisture capacity (FC) and moisture content at PWP differs widely among soils. Texture especially clay content, clay minerals, porosity and pore size distribution and soil organic matter content affect FC. In contrast to FC, the PWP is not significantly influenced by aggregation, structural porosity and soil organic matter content. PWP is primarily influenced by the amount and nature of clay content.

3.2. Soil Analysis

The result of soil physical and chemical properties analysis used for field experiment are given in table-1. Regosols are sandy clay loam in texture while vertisols are clay. Both soils are alkaline in reaction and calcareous with calcium carbonate content of 24.57% and 12.71% for regosols and vertisols respectively (Havlin et al., 2005). The soils are non saline, low organic matter content, deficient in available Sulfur (S) (<10mg/kg); (Kiros, 2010) and deficient in total N, typical for semiarid soils (Brady and Weil, 2002). The alkaline pH and high CaCO3 content of the soil indicate the fixing potential of the soil to P, Zn and other micronutrient metal ions. This could also be seen from the soil analysis concentration values for available P and Zn in which available P and Zn are deficient at (4-7ppm) and (0-0.5ppm) category respectively (Havlin et al. 2005) and vertisols are better in nutrient status than the regosols (Table-1).

3.3. Yield components

Plant height, shoot length per plant, panicle length per plant, number of tillers per plant, number of spicks per panicle and weight of seeds per panicle at maturity stage on vertisols treated with T_I was significantly ($P<0.001$) higher than T_{II}, T_{III}, T_{IV} and T_V (Table-2) due to planting method and seeding rate which influences yield components. Therefore, low seeding rate/banded planting method and blended fertilizer application significantly increases yield components; while in regosols T_I was significantly ($P<0.001$) increases plant height, number of tillers per plant and weight of seeds per panicle at maturity stage than the other trials (Table- 3). Furthermore, T_{III} was significantly ($P<0.001$) increases in plant height, panicle length per plant, number of tillers per plant and weight of seeds per panicle at maturity stage than T_{IV} and T_V in vertisols (Table- 2); while in regosols T_{III} resulted significant ($P<0.0001$) increase in plant height, number of tillers per plant and weight of seeds per panicle at maturity stage than T_{IV} and T_V (Table- 3). Therefore, low seeding rate/banded planting method and blended fertilizer application leads to significantly increase yield components (Puckridge and Donald, 1967; Harper, 1977).

3.4. Yield

Data regarding grain yield, straw yield and harvest index at maturity stage for the various treatments are present in table-4 below for vertisols and regosols respectively. Grain yield and straw yield at maturity stage on vertisols treated with T_I was significantly ($P<0.001$) higher than T_{II}, T_{III}, T_{IV} and T_V. Grain yield at maturity stage on vertisols treated with T_I (76.3%), T_{II} (34.5%), T_{III} (53.4%) and T_{IV} (28.2%) increases compared to control; while in regosols, T_I (111.5%), T_{II} (118.1%), T_{III} (63.7%), and T_{IV} (106.8%) increases compared to control.

Similarly, straw yield at maturity stage on vertisols treated with T_I (68.2%), T_{II} (45.9%), T_{III} (56.7%),

T_{IV} (41.3%) increases compared to control; while in the regosols, T_I (54.6%), T_{II} (40.1%), T_{III} (25.9%) and T_{IV} (39.2%) increases compared to control. Therefore, application of blended fertilizer increases yield than DAP and Urea because it contains many mineral elements such as N, P, K, Mg, Zn and S. Due to this; N may be attributed to spicklets initation, improvement of spicklets fertility, increasing grains per fertile spicklets and for biomass formation (Damene, 2003). Furthermore, grain-straw yield response of teff to increasing rates of N was highly significant on vertisols (DZARC, 1988/89) and P promotes root formation and growth; affects quality of seed, fruit and flower production (Fageria and Gheyi, 1999). Similarly, application of K increases diseases resistance of crops. Application of Zn increases number of tillers per plant, weight of seeds per panicle and grain yield. This may be due to Zn is important in fruiting, growth and metabolism of crop plants (Fageria, 2009; Marschner, 1993; Brown et al., 1993).

These results are in agreement with the recent findings of (Tareke et al., 2008) that blended fertilizer application increases tef yield; While in regosols grain yield was highly significant (P<0.001) in the trial treated with T_{II} than the other trials, but straw yield was highly significant (P<0.001) in T_I than the other trials because yield components were high in the banded trial due to low nutrient competition and placement of fertilizers. Furthermore, T_{III} resulted significantly (P<0.001) higher grain yield and straw yield at maturity stage than T_{IV} and T_V in vertisols. This indicates that row planting method increases teff yield. These results are also in agreement with the recent findings of row planting plots was three times than broadcasted plots (Tareke et al., 2008); While in regosols grain yield was highly significant (P<0.001) in the trial treated with T_{IV} than T_{III} and T_V due to the nature of the soil: gravelly sand dominantly with low moisture holding capacity. It is possible to suggest that vertisols have higher moisture holding capacity than regosols as a result, yield and yield components of teff was also higher on vertisols than regosols because water plays a very significant role in soil plant growth relationship (Gupta, 2000). Furthermore, in trials treated with T_I and T_V had significant (P<0.001) higher harvest index than the other trials; while in regosols T_I had significant (P<0.001) higher harvest index than the other trials.

3.5. Post-harvest available P and total N residuals after fertilization of blended fertilizer, DAP and Urea

Available P-residual on vertisols treated with T_I was significantly (P<0.001) higher than T_{II}, T_{III}, T_{IV} and T_V; while in regosols T_I was only significantly (P<0.01) increases available P-residual than T_V. Similarly, T_{III} significantly (P<0.001) increases available P-residual than T_{II}, T_{IV} and T_V; while in regosols T_{III} was only significantly (P<0.01) increases available P-residual than T_V (Table- 5). According to Tanner et al. (1992), phosphorous application increased the soil organic matter content. Therefore, application of P fertilizer increases available P-residual. Furthermore, total N-residual on both regosols and vertisols had not significant effect for the various treatments because N is subject to leaching or de-nitrification soon after application (very volatile in nature).

3.6. Concentration of N, P, K, Zn, Mg and S by teff grains from blended fertilizer and DAP and Urea application

The effect of blended fertilizer, DAP and Urea fertilization on the grain contents of N, P, K, Zn, Mg and S are shown in table-6 and table-8 for vertisols and regosols respectively. The analysis in table-6 and table 8 shows that the main effect of blended fertilizer, DAP and Urea fertilization significantly (P<0.001) increases the nitrogen, phosphorous, potassium, zinc, magnesium and sulfur concentration of Eragrostis teff grains in both regosols and vertisols. Nutrient concentration on vertisols treated with T_I significantly increases N (53.2%), P (52.3%), Zn (38.3%), Mg (137.2%) and S (79.44%) compared to control. Similarly, T_{II} significantly increases N (33.4%), P (39.6%), Zn (37.2%), Mg (129.8%) and S (70.09%) compared to control.

Moreover, T_{III} significantly increases N (26.7%), P (39.8%), Zn (36.4%), Mg (57.1%) and S (33.96%) compared to control. And T_{IV} significantly increases N (20.05%), P (36.8%), Zn (10.8%), Mg (15.03%) and S (15.58%) compared to control in vertisols. While in regosols, T_I significantly increases N (131.7%), P (47.3%), Zn (21.8%), Mg (165.7%) and S (62.68%) compared to control. Similarly, T_{II} significantly increases N (86.8%), P (14.4%), Zn (19.1%), Mg (128.5%) and S (8.55%) compared to control. In addition, T_{III} significantly increases N (76.2%), P (17.6%), Zn (8.9%), Mg (15.2%) and S (8.55%) compared to control. And T_{IV} significantly increases N (5.7%), P (10.4%), Zn (7.25%), Mg (13.9%) and S (7.124%) compared to control. Therefore, blended fertilizer application and low seeding rate/banded planting method significantly (P<0.001) increases the nitrogen, phosphorous, zinc magnesium and Sulfur concentration of *Eragrostis tef* (Zucc. /Trotter) grains in both regosols and vertisols.

Similarly, The effect of blended fertilizer, DAP and Urea fertilization on the grain uptake of N, P, K, Zn, Mg and S were assessed at maturity stage and the result for the main effects of various treatments are shown in table-7 and table-9 for vertisols and regosols respectively. The analysis shows that the main effect of blended fertilizer, DAP and Urea fertilization significantly (P<0.001) increases the nitrogen, phosphorous, potassium, zinc, magnesium and Sulfur uptake of Eragrostis tef grains in both regosols and vertisols (Table-7 and Table 9).

On both vertisols and regosols T_I significantly increases nutrient uptake than the other trials because yield is high in this treatment. These results are in agreement with the recent findings of Tareke et al., (2008) which states row planting plots was three times than broadcasted plots. Nutrient uptake is high in plots with blended fertilizer and banded trials because, nutrient uptake is the product of nutrient concentration and grain yield.

3.7. Comparison of grain yield on regosols and vertisols

Yield data on the two soil types were compared considering the soil types as main plots and treatments as sub plots by split plot. Yield on vertisols (1681kg/ha) were highly significant (P<0.001) than regosols (595kg/ha) due to vertisols are better in nutrient status and moisture holding capacity than the regosols.

3.8. Stepwise regression of major yield components

Yield components that overwhelming determines the yields of tef were detected using stepwise regression at 0.1 significant probability value for both Prob-to-Enter and Prob-to-Leave for model building. Grain yield on vertisols was highly affected by weight of seeds per panicle (g), number of tillers per panicle and plant height (cm) at $R^2 = 0.9552$; while grain yield on regosols was highly affected by weight of seeds per panicle (g), number of tillers per panicle, panicle length per plant (cm) and plant height (cm) at $R^2 = 0.9553$.

Y1 (kg) = 578.43 + 6.52X1 + 7.09X3 + 405.64X5

Y2 (kg) = -191.83 + 10.03X1 + 13.75X2 – 9.33X3 – 806.99X5

Where

Y1 = Grain yield on vertisols (kg), Y2 = Grain yield on Regosols (kg), X1 = Plant height (cm), X2 = Panicle length per plant (cm), X3 = Number of tillers per panicle and X5 = Weight of seeds per panicle (g)

4. CONCLUSION

From this study it was possible to conclude that T_I resulted significant higher plant height, shoot length per plant, panicle length per plant, number of tillers per plant, number of spicks per panicle and weight of seeds per panicle at maturity stage than T_{II}, T_{III}, T_{IV} and T_V. Generally, both T_I and T_{III} showed significantly high grain yield, plant height, and panicle length per plant, number of tillers per plant and weight of seeds per panicle than T_{II}, T_{IV} and T_V.

Therefore, application of blended fertilizer and row planting method has brought a significant effect in the Eragrostis tef yield and yield components grown on vertisols. Similarly, on regosols T_I resulted significant higher plant height, shoot length per plant, panicle length per plant, number of tillers per plant, number of spicks per panicle, weight of seeds per panicle and straw yield at maturity stage than T_{II}, T_{III}, T_{IV} and T_V. Even if, grain yield is higher in T_{II}; yield components (plant height, shoot length per plant, number of tillers per plant, number of spicks per panicle and weight of seeds per panicle) is higher in T_I and T_{III}. Generally, grain yield is higher in broadcasted trials (T_{II} and T_{IV}) due to low tillering number; because, regosols has low moisture holding capacity (sandy clay loam in texture) and low annual rain fall during the growing period (427.9mm).

There is a positive correlation between straw yield and plant height, shoot length per plant and number of tillers per plant; and between grain yield and plant height, shoot length per plant, number of tillers per plant, number of spicks per panicle and weight of seeds per panicle on both regosols and vertisols. Yield on vertisols were highly significant than regosols due to vertisols are better in nutrient status and moisture holding capacity than the regosols.

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List of Tables

Table 1. Some selected physical and chemical properties of two soil types

Parameters	Regosols	Vertisols
pH H2O (1:2.5)	8.1	8.0
EC (ds/m)	0.182	0.247
CEC (Cmol(+) /Kg)	22.13	45.65
CaCO3 (%)	24.57	12.71
OC (%)	0.74	1.50
Exc. Mg (Cmol(+) /Kg)	1.11	4.56
Exc. K (Cmol(+) /Kg)	0.59	1.15
Exc. Ca (Cmol(+) /Kg)	55.01	73.85
Available K (ppm)	230.69	449.65
Available Mg (ppm)	134.31	551.76
Available Zn (ppm)	0.232	0.432
Available P (ppm)	4.78	2.94
Available S (mg/kg)	9	1
T.N (%)	0.08	0.12
Sand (%)	52	18
Silt (%)	22	26
Clay (%)	26	56
Textural Class	Sandy Clay Loam	Clay

Table -2. Main effect of blended fertilizer, DAP and Urea fertilization on plant height (ph), shoot length (shl), panicle length (pl), number of tillers per plant (ntpp), number of spicks per panicle (nspp)and weight of seeds per panicle (Wspp) at maturity stage grow on Vertisols

Treatments	Ph	Shl	Pl	Ntpp	Nspp	Wspp
T_I	107a	54.6a	52.4a	30a	33.333a	1.876a
T_{II}	97.267b	52.567b	44.7b	17c	30.333a	0.917c
T_{III}	99.7b	51.8c	47.9b	25b	32.333a	1.318b
T_{IV}	92.6c	51.68c	40.92c	13c	29.667a	0.916c
T_V	56.8d	29.17d	27.63d	5d	16.0b	0.713d
SE	0.904	0.151	0.767	1.0	0.978	0.002
P-value	***	***	***	***	***	****
R2	0.994728	0.999488	0.983722	0.974874	0.954158	0.999971

Table -3. Main effect of blended fertilizer, DAP and Urea fertilization on plant height (ph), shoot length (shl), panicle length (pl), number of tillers per plant (ntpp), number of spicks per panicle (nspp)and weight of seeds per panicle (Wspp) at maturity stage grow on Regosols

Treatments	Ph	Shl	Pl	Ntpp	Nspp	Wspp
T_I	94.4a	53.7a	40.7a	14.0a	21.0a	0.603a
T_{II}	83.6c	46.2b	37.4ab	5.667c	17.333ab	0.509c
T_{III}	85.3b	51.5a	35.567bc	10.333b	20.667a	0.593b
T_{IV}	76.9d	44.8b	32.1c	3.333cd	16.667b	0.321d
T_V	47.9e	30.0c	17.9d	2.0d	10.0c	0.224e
SE	0.292	0.530	0.907	0.632	0.856	0.0007
P-value	***	***	***	***	***	***
R2	0.999323	0.99191	0.974459	0.961653	0.91464	0.999954

Where:

Those not connected by same latter are significantly different at $\alpha = 0.05$, *=P<0.05, **=P<0.01, ***=P<0.001 and Ns = non significant

Table -4. *Main effect of blended fertilizer, DAP and Urea fertilization on grain yield (kg/ha), straw yield (kg/ha) and harvest index (Hi) at maturity stage grow on Vertisols and Regosols*

Treatments	GyV	SyV	HiV	GyR	SyR	HiR
T_I	2245a	4760a	0.32a	722.667b	847.0a	0.46c
T_{II}	1712c	4130bc	0.29b	745.333a	768.0b	0.49a
T_{III}	1952.667b	4433.333ab	0.307ab	559.333c	690.0c	0.4467d
T_{IV}	1633d	4000c	0.29b	706.667b	763.0b	0.48b
T_V	1273.333e	2830d	0.31a	341.667d	548.0d	0.383e
SE	11.395	76.848	0.0039	4.063	1.372	0.0021
P-value	***	***	***	***	***	***
R2	0.997545	0.973224	0.815789	0.998564	0.999629	0.993723

Where:
Those not connected by same latter are significantly different at α = 0.05, *=P<0.05, **=P<0.01, ***=P<0.001 and Ns = nonsignificant
GyV = Grain yield on Vertisols, SyV = Straw yield on Vertisols, HiV = Harvest index on Vertisols, GyR = Grain yield on Regosols, SyR = Straw yield on Regosols and HiR = Harvest index on Regosols

Table-5. Post harvest available P and total N residuals for the various treatments on Regosols and Vertisols

Treatments	Available PR	Available PV	Total NR	Total NV
T_I	6.48333a	10.9667a	0.07333a	0.11333a
T_{II}	7.63667a	5.1267c	0.07333a	0.11333a
T_{III}	4.960ab	7.410b	0.09333a	0.10667a
T_{IV}	7.28667a	5.370c	0.08667a	0.110a
T_V	2.920b	2.6567d	0.080a	0.11667a
SE	0.66984	0.43161	0.00471	0.00394
P-value	**	***	Ns	Ns
R2	0.770153	0.953876	0.576271	0.270833

Where:
Those not connected by same latter are significantly different at α = 0.05, *=P<0.05, **=P<0.01, ***=P<0.001 and Ns = non significant

Table -6. Main effect of blended fertilizer, DAP and Urea fertilization on tef grain contents of N, P, K, Zn, Mg and S on vertisols

Treatments	N-content (%)	P-content (ppm)	K-content (ppm)	Zn-content (ppm)	Mg-content (ppm)	S-content (ppm)
T_I	1.9867a	2316.3a	4916.67a	0.5473a	1631a	2.88a
T_{II}	1.73b	2123.3b	4876.67a	0.543ab	1580b	2.73b
T_{III}	1.643c	2126.3b	3983.33b	0.53967b	1080.3c	2.156c
T_{IV}	1.5567d	2080.67c	4750a	0.4383c	791d	1.855d
T_V	1.2967e	1520.67d	4583.33a	0.39567d	687.67e	1.605e
SE	0.01758	1.0220	73.318	0.00092	1.9607	0.00733
P-value	***	***	***	***	***	***
R2	0.987942	0.999971	0.914838	0.99581	0.99995	0.999555

Table -7. Main effect of blended fertilize, DAP and Urea fertilization on N, P, K, Zn, Mg and S uptake by tef grain contents of on vertisols

Treatments	N-uptake (kg)	P- uptake (kg)	K- uptake (kg)	Zn- uptake (kg)	Mg- uptake (kg)	S- uptake (kg)
T_I	44.61a	5.20a	11.04a	0.0012a	3.66a	0.0065a
T_{II}	29.62c	3.64c	8.35b	0.0009c	2.70b	0.0047b
T_{III}	32.09b	4.15b	7.78b	0.0011b	2.11c	0.0042c
T_{IV}	25.42d	3.397d	7.76b	0.0007d	1.29d	0.0030d
T_V	16.51e	1.94e	5.84c	0.0005e	0.88e	0.0020e
SE	0.52267	0.024840	0.165202	0.0000056580	0.014877	0.000028672
P-value	***	***	***	***	***	***
R2	0.993542	0.99891	0.980932	0.999009	0.999553	0.999274

Table -8. Main effect of blended fertilizer, DAP and Urea fertilization on tef grain contents of N, P, K, Zn, Mg and S on regosols

Treatments	N-content (%)	P-content (ppm)	K-content (ppm)	Zn-content (ppm)	Mg-content (ppm)	S-content (ppm)
T_{I}	4.750a	1956.3a	3966.6667a	0.4483a	1643a	2.855a
T_{II}	3.83b	1519.67c	3716.6667b	0.4383b	1413b	1.905b
T_{III}	3.613b	1562.3b	3950a	0.40067c	712c	1.905b
T_{IV}	2.16c	1467d	3633.3333bc	0.39467d	704d	1.88c
T_{V}	2.05c	1328.3e	3500c	0.368e	618.3e	1.755d
SE	0.07783	2.5734	40.825	0.00087	1.5348	0.00528
P-value	***	***	***	***	***	***
R2	0.988794	0.9997	0.907806	0.998269	0.999974	0.999654

Table -9. Main effect of blended fertilize, DAP and Urea fertilization on N, P, K, Zn, Mg and S uptake by tef grain contents of on regosols

Treatments	N-uptake (kg)	P- uptake (kg)	K- uptake (kg)	Zn- uptake (kg)	Mg- uptake (kg)	S- uptake (kg)
T_{I}	32.86a	1.35a	2.74a	0.00030a	1.136a	0.001975a
T_{II}	27.41b	1.09b	2.66ab	0.00029b	1.010b	0.001362b
T_{III}	19.15c	1.03c	2.09c	0.00024c	0.377d	0.001009c
T_{IV}	15.12d	0.83d	2.54b	0.00028b	0.493c	0.001316b
T_{V}	6.97e	0.45e	1.19d	0.00013d	0.210e	0.000597d
SE	0.63829	0.0090836	0.036281	0.0000024266	0.0060669	0.000010682
P-value	***	***	***	***	***	***
R2	0.99026	0.998171	0.992055	0.997136	0.999442	0.99889

Where:

Those not connected by same latter are significantly different at α = 0.05, *=P<0.05, **=P<0.01, ***=P<0.001 and Ns = non significant

List of Figures

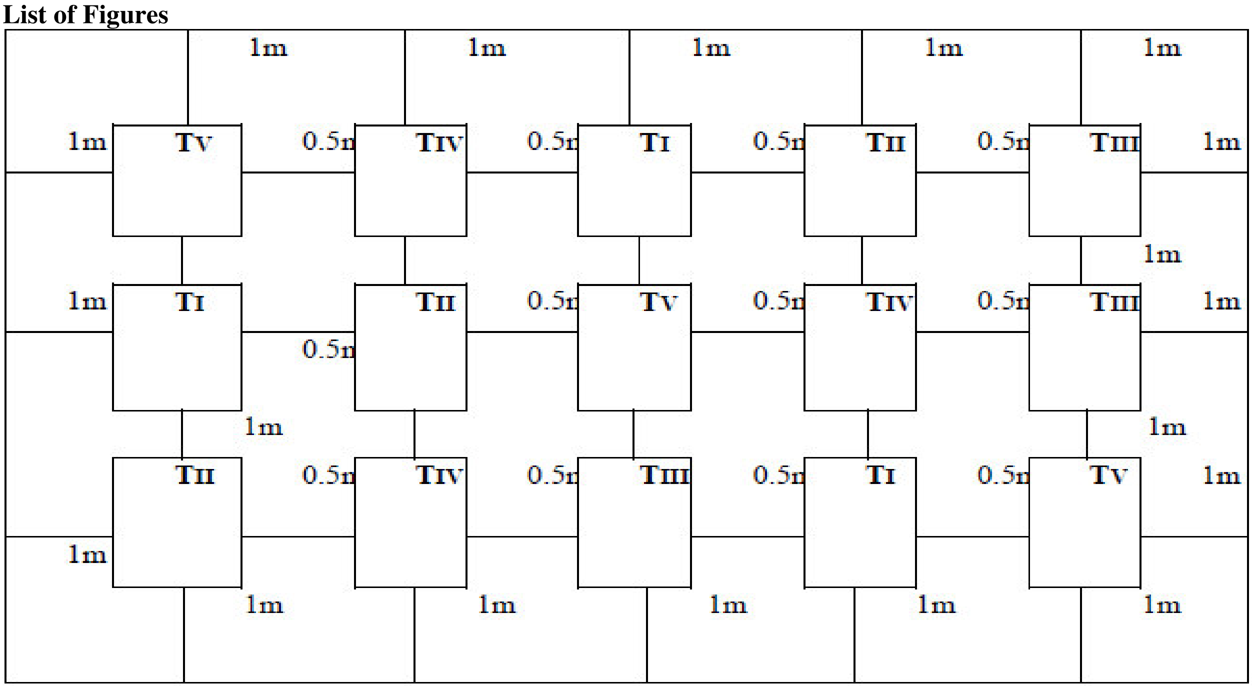

Figure.1 experimental field layout of the trials

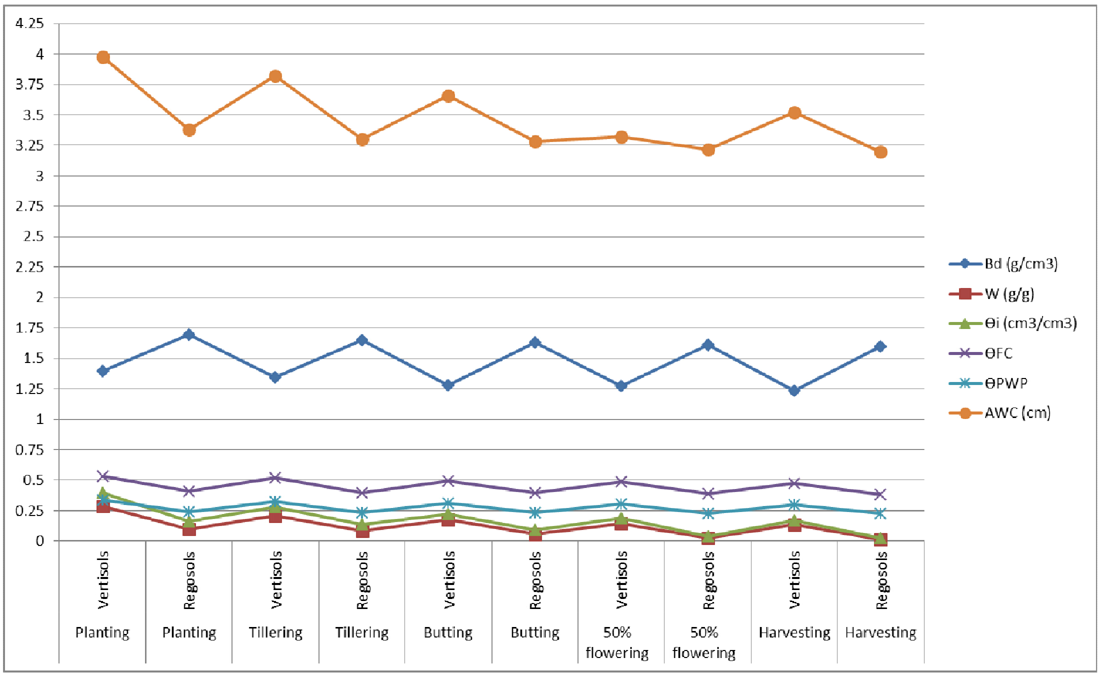

Figure 2. Soil moisture and soil moisture constants during planting, tillering, butting, 50% flowering and harvesting stages at 20cm depth of Regosols and Vertisols