International Journal of Applied Agricultural Sciences
2021; 7(6): 311-316
http://www.sciencepublishinggroup.com/j/ijaas
doi: 10.11648/j.ijaas.20210706.18
ISSN: 2469-7877 (Print); ISSN: 2469-7885 (Online)

Determination of NPS Fertilizer Rate Based on Calibrated Phosphorus for Yield of Tef in Girar Jarso District, North Shewa Zone, Oromia, Ethiopia

Dereje Girma*, Tadele Geremu

Oromia Agricultural Research Institute, Fitche Agricultural Research Center, Soil Fertility Improvement and Problematic Soil Research, Fitche, Ethiopia

Email address:
dergrima@gmail.com (D. Girma)
*Corresponding author

To cite this article:
Dereje Girma, Tadele Geremu. Determination of NPS Fertilizer Rate Based on Calibrated Phosphorus for Yield of Tef in Girar Jarso District, North Shewa Zone, Oromia, Ethiopia. *International Journal of Applied Agricultural Sciences*. Vol. 7, No. 6, 2021, pp. 311-316.
doi: 10.11648/j.ijaas.20210706.18

Received: November 19, 2021; **Accepted**: December 20, 2021; **Published**: December 31, 2021

Abstract: Appropriate soil fertility management practices based on the actual limiting nutrients and crop nutrient requirement for a given crop is economic and judicious use of fertilizers for sustainable crop production. Moreover, application of balanced fertilizers and nutrient requirements of the crop is the basis to produce more crop yield from the land under cultivation. Accordingly, field experiment was conducted in 2019 & 2020 main cropping season to determine NPS fertilizer rate in relative to determined P-critical and P-requirement factor for tef and to estimate the economically feasible NPS fertilizer rate for higher yield of tef in Girar Jarso district. The indicate that, plant height, spike length, straw and grain yield was highly significantly (P<0.01) affected by NPS fertilizer rate. The highest plant height (86.32cm), spike length (32.51cm), straw yield (7004 kg ha^{-1}) and grain yield (1622 kg ha^{-1}) of tef was recorded from the application of 100% P-critical from NPS fertilizer rate supplemented with recommended Nitrogen whereas, the lowest value was recorded from the field without fertilizer which was significantly inferior to all other treatments. Furthermore, the economic analysis depicted that, application of NPS fertilizer at the rate of 100% P-critical in NPS fertilizer with recommended Nitrogen fertilizer (92 kg N ha^{-1}) for the production of tef was more economically beneficial for the district. In conclusion, farmers could be advised to use 100% PC from NPS fertilizer rate with recommended nitrogen for tef production in the district.

Keywords: NPS Fertilizer Rate, Recommended Nitrogen, Yield

1. Introduction

Tef (Eragrostistef), a cereal crop that belongs to the grass family Poaceae, is endemic to Ethiopia and has been widely cultivated in the country for centuries [22]. Tef is adaptable to a wide range of ecological conditions in altitudes ranging from near sea level to 3000 msl and even it can be grown in an environment unfavorable for most cereal, while the best performance occurs between 1100 and 2950 m.a.s.l in Ethiopia [19].

Almost two thirds of the Ethiopian population use teff as their daily staple food. It is estimated that per capita consumption grew by 4 percent over the last 5 years [1]. Tef is considered an economically superior good, relatively more consumed by urban and richer consumers [17, 9].

Growth in average incomes and faster urbanization in Ethiopia are likely to increase the demand for teff over time [17]. Even though, Ethiopia is a center of origin and diversity of tef and has the above-mentioned importance and coverage of large area, its productivity is very low to feed the demand of its people and market. These is due to low soil fertility and suboptimal use of mineral fertilizers in addition to weeds, lack of high yielding cultivars, erratic rainfall distribution in lower altitudes, lodging, water logging, low moisture, and low soil fertility conditions [18]. On the other hand, under conditions where most growth requirements are available and in organic matter rich soils, application of fertilizers without knowing its fertility status causes yield and fertilizer losses [12]. There are different blanket fertilizer recommendations for various soil types of Ethiopia for tef cultivation. This is due to its cultivation in different agro ecological zones and soil types, having different fertility status and nutrient content. Accordingly, N/P recommendation rates by the Ministry of Agriculture were set at 55/30, 30/40, and 40/35 N/P kg ha-1 for tef crop on Vertisols, Nitosols, and Cambisols, respectively across the country [10]. However, 100 kg DAP ha-1 and 100 kg urea ha-1 were set by the Ministry of Agriculture and Rural Development later [8].

Those blanket recommendations brought generally, an increase in yield of improved cultivars ranging from 1700 to 2200 kg/ha [11]. Accordingly, the average national yield in the year 2010 reached 1200 kg/ha [5]. However, the recommendations do not work for all Production aspects of various soil types of different regions. Tef responds to fertilizers especially to N highly in all its yield components. N is essential for carbohydrate use within plants and stimulates root growth and development as well as uptake of other nutrients [14, 2].

Soil test based application of plant nutrient helps to realize higher response ratio and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization. Location specific fertilizer recommendations are possible for soils of varying fertility, resource conditions of farmers and level of target yield conditions of similar soil classes and environment [16].

Since, Ethiopia is moving from blanket recommendations to soil test based fertilizer recommendations, Fitche Agricultural Research Center was conduct a research to determine critical phosphorus concentration and phosphorus requirement factors for tef in Girar Jarso district, North Shewa Zone. However, the effect of NPS fertilizer rate was not determined for tef in the study area. Thus, based on the determined Pc (18 ppm) and Pf (3.03), optimum NPS fertilizer rate determination was carried out in the study area with the objectives; to determine NPS fertilizer rate in relative to determined P-critical and P-requirement factor for tef and to estimate the economically feasible NPS fertilizer rate for higher yield of tef in Girar Jarso district.

2. Material and Methods

2.1. Description of the Study Area

The experiment was conducted in Girar Jarso district on farmer's field during 2019 and 2020 cropping season. The district is located at 112km distance from the capital city of the country, Addis Ababa. The geographical location of the district is lies between 09°38'52.8"N to 10°00'10.8"N latitude and 38°34'22.8"E to 38°50'20.4"E longitude. The elevation ranged from 1300 and 3419 meters above sea level. The mean annual rain fall is 1200mm According to Fitche Station Meteorological data (Haile Mariam, 2014). The maximum and minimum mean temperature of the area is 35°C and 11.5°C respectively.

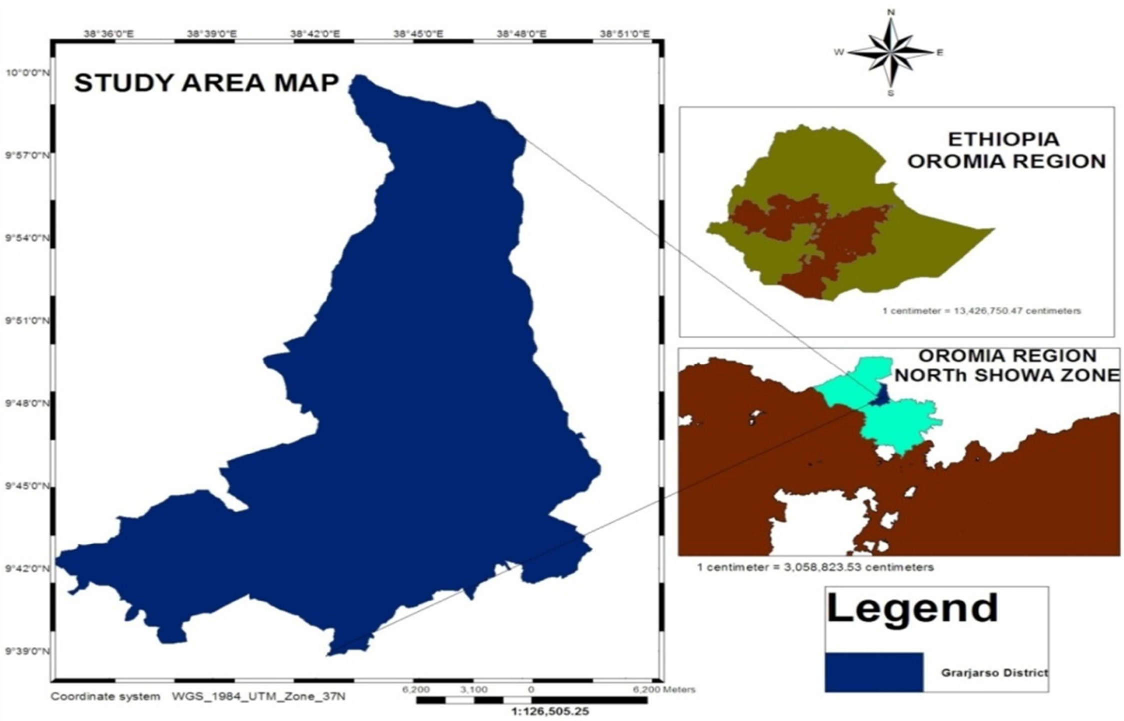

Figure 1. *Location map of Girar Jarso district.*

2.2. Site Selection, Soil Sampling and Analysis Methods

Tef production potential kebeles (small Administrative unit) were selected from the district. Accordingly, the 11 farmer's fields were selected based on their willingness to handle the experimental fields. Before planting, 45 surface composite soil samples were collected in duration of two years from the field for analysis at a depth of 0-20 cm in a zig zag methods. Soil samples were collected using Auger. The collected surface soil samples from the experimental field were air dried, grinded and allowed to pass through 2 mm sieve for further analysis in the laboratory [21]. The collected soil samples were analyzed for the parameters of pH (H_2O) in the suspension of a 1: 2.5 soil to water ratio using a pH meter [20] and Available P was determined by the Olsen's method using a spectrophotometer (Olsen *et al.*, 1954). Then the farmer's field was selected based on the analyzed soil sample results in which the soil pH above 5.5 and available soil phosphorus below critical phosphorus (Pc) was selected for the experiments.

2.3. Experimental Design and Treatments

The experimental field study was arranged with a total of 6 treatments in a randomized complete block design (RCBD) in three replications. The recommended Nitrogen (92 kg ha^{-1}) for the district was used. The gross plot size was 3m * 4m and the space between block and plot was 70cm and 30cm respectively. The net plot size was 2 * 2m. The required amount of seeds was weighed per plot by considering the recommended rate of tef seed per hectare. Urea, NPS, and DAP (Di ammonium Phosphate) was used as source of Nitrogen and Phosphorus containing fertilizers. Uniform field management practices for all plots were conducted. A tef variety (kora) was used as test crop.

The treatments were;

T1=Control (without fertilizers).

T2=25% P-critical from NPS fertilizer +Recommended Nitrogen

T3=50% P-critical from NPS fertilizer + Recommended Nitrogen

T4=75% P-critical from NPS fertilizer + Recommended Nitrogen

T5=100% P-critical from NPS fertilizer + Recommended Nitrogen

T6=100% P-critical from DAP fertilizer + Recommended Nitrogen

The determined P-critical value (18 ppm) and phosphorous requirement factor (3.03) was used to calculate the rate of phosphorus fertilizer to be applied. Thus, Phosphorus fertilizer rate was calculated by using the formula given below;

$$\text{Rate of P-applied} = (pc - pi) * pf$$

Where

Pc: Critical phosphorus concentration

P: Initial available P

Pf: Phosphorus requirement factor which was derived from the calibration study

2.4. Data Collection

Tef grain yield was harvested at the ground level from the net plot area. Then plant height and spike length was measured at harvest. After threshing, grain yield were cleaned and weighed. The straw yield was determined by subtracting the grain yield from the total above ground biomass yield for each respective treatment. Economic data such as production cost (input cost), gross income and net income based on the current market price of the yield and input was recorded.

2.5. Data Analysis

All data recorded and collected were subjected to the procedure of analysis of variance (ANOVA) using GenStat 18th edition software program. The comparisons among treatment means were employed by using of Least Significance Difference (LSD) at 5% significant level.

2.6. Economic Analysis

Partial budget analysis was done to identify economical feasibility among. The average open market price (Birr kg^{-1}) of tef, price of fertilizers was used for analysis. For a treatment to be considered a worthwhile option to farmer, the minimum acceptable rate of return (MRR) should be 100% [3], which is suggested to be realistic. This enables to make recommendations from marginal analysis. Marginal rate of return (MRR) were calculated by using the formula given blow;

$$MRR = \frac{\text{Net Income From Fertilized Field} - \text{Net Income From Unfertilized Field}}{\text{Total Variable Cost From Fertilizer Application}}$$

3. Result and Discussions

3.1. Soil Reaction (pH) and Available Phosphorus of Experimental Field

The soil pH (H_2O) of the study area was moderately to slightly acidic with the value ranged from 5.56 to 5.9 according to the ratings suggested by Tekalign [13] (Table 1). Thus, the pH of the experimental soil was within the range for productive soils. The available phosphorus content of soils was low to medium with the value ranged from 7.24 to 10.39 ppm according to the rating given by Cottenie [4]. Therefore, the soil of the study areas needs application of phosphorus containing fertilizers for crop production.

Table 1. *Soil pH and Available Phosphorus of experimental field.*

Site	Soil pH	Available phosphorus (ppm)
1	6.33	8.2
2	6.77	7.1
3	6.21	3.17
4	6.86	9.23
5	6.03	8.65
6	7.16	5.86
7	6.4	8.13
8	6.84	5.92
9	6.79	5.28
10	6.44	14.77
11	6.73	4.74
Mean	6.60	7.37
SD		

Where: SD=Standard Deviation.

3.2. Response of Yield and Yield Component of Tef to NPS Fertilizer Rate

3.2.1. Plant Height and Spike Length

The analysis of variance depicted that, plant height and spike length was highly significantly ($P<0.01$) influenced by NPS fertilizer rate. The highest plant height (86.32cm) and spike length (32.51cm) of tef was recorded from the application of 100% P-critical from NPS fertilizer rate supplemented with recommended Nitrogen. The lowest plant height (55.6 cm) and spike length (20.61 cm) was recorded from the field without fertilizer which was significantly inferior to all other treatments (Table 2). The increase in plant height with increasing NPS fertilizer could be attributed due to sufficient supply of nutrient which in turn contributed to increased vegetative growth since nitrogen plays crucial role in the structure of chlorophyll and P involved in the energy transfer for cellular metabolism. This result was in agreement with the findings of Giday et al., Feyera et al., Wakjira, and Desta et al. [7, 6, 15] reported that, application of blended fertilizers was on par with blanket recommendation of fertilizers and gave significantly higher plant height and spike length on tef. Furthermore, According to Feyera et al. [6] balanced fertilization application and efficient utilization of nutrient leads to high photosynthetic productivity and accretion of dry matter, eventually increases spike length.

3.2.2. Straw Yield

The analysis of variance indicated that the straw yield was significantly affected by NPS fertilizer rate (Table 2). The highest straw yield (7004 kg ha^{-1}) was obtained from the application of 100% P-critical from NPS fertilizer rate supplemented with recommended Nitrogen and the lowest straw yield (2886 kg ha^{-1}) obtained from unfertilized plot (Table 2). The significant increase in straw yield could be attributed due to the availability of macronutrients and some secondary nutrients formulated with the NPS fertilizer, which could increase the vegetative consequently the straw yield. Similar significant increase in biomass yield was also observed for different application rate of NPS fertilizers which states that the increased in straw yield attributed due to the proportional vegetative growth especially plant height [7, 6, 15].

3.2.3. Grain Yield

The statistical analysis showed that, the grain yield of tef was highly significantly ($P<0.01$) influenced by NPS fertilizer rate. The highest (1622 kg ha^{-1}) and the lowest (617 kg ha^{-1}) grain yield was obtained from the application of 100% P-critical from NPS fertilizer rate supplemented with recommended Nitrogen and unfertilized plot respectively (Table 2). Grain yield increased consistently and significantly in response to increasing the rate of NPS fertilizer from nil up to the highest. The increased in grain yield from NPS fertilizer might be facilitated the uptake of other essential nutrients which helps to boost plant growth and yield. This result is in line with Giday et al., Wakjira, and Desta et al. [7, 15] who reported that, the maximum of grain yield of tef was recorded at the highest application of blended fertilizer rate.

Table 2. *Effects of NPS Fertilizer rate and recommended Nitrogen on yield and yield components of tef.*

Treatment	pH (cm)	SL (cm)	Straw yield kg ha^{-1}	Grain yield kg ha^{-1}
100% P-critical from DAP fertilizer +Recommended Nitrogen	78.23^{bc}	29.08^{c}	5961^{b}	1322^{bc}
100% P-critical from NPS fertilizer +Recommended Nitrogen	86.32^{a}	32.51^{a}	7004^{a}	1622^{a}
75% P-critical from NPS fertilizer +Recommended Nitrogen	81.68^{b}	30.4^{b}	6480^{ab}	1498^{ab}
50% P-critical from NPS fertilizer +Recommended Nitrogen	74.67^{c}	27.17^{d}	5117^{c}	1225^{c}
25% P-critical from NPS fertilizer +Recommended Nitrogen	69.37^{d}	25.4^{e}	4566^{c}	1076^{c}
without fertilizer	55.6^{e}	20.61^{f}	2886^{d}	617^{d}
$LSD_{0.05}$	3.937	1.313	570.432	186.3
CV (%)	7.3	6.6	14.7	29.8

Means with the same letter in columns are not significantly different at 5% level of significance's, PH=plant height, SL=Spike length, CV=Coefficient of variation, LSD=Least Significance Difference.

3.3. Partial Budget Analysis

The partial budget analysis showed that the highest net benefit (64722.06 ETB ha^{-1}) and the highest marginal rate of return (MRR) (760.18%) was obtained from the fertilizer application of 100% P-critical from NPS fertilizer with recommended Nitrogen fertilizer (92 kg N ha^{-1}). The lowest net benefit (26531.00 ETB ha^{-1}) was obtained from unfertilized plots (Table 3). The MRR was indicated that tef producers can get an extra of 7.61 ETB for 1.00 ETB investments in the NPS and N fertilizers application on the rates of 100% P-critical in NPS fertilizer with recommended Nitrogen fertilizer (92 kg N ha^{-1}). Therefore, application of NPS fertilizer at the rate of

100% P-critical in NPS fertilizer with recommended Nitrogen fertilizer (92 kg N ha^{-1}) for the production of tef was more economically beneficial and recommended for Gira Jarso district.

Table 3. *Marginal Analysis of Bread Wheat Yield as influenced by NPS Fertilizer Supplemented by Nitrogen Rate.*

Treatment	Variable Input (Kg ha^{-1})		Unit price (ETB)		TVC	Output (Kg ha^{-1})	Unit price (ETB)	Gross Income (ETB ha^{-1})	Net Income (ETB ha^{-1})	MRR (%)
	DAP/NPS	Urea	DAP/NPS	Urea						
without fertilizer	0	0	0	0	0	617	43	26531	26531.00	
25% Pc from NPS + Rec. N	51.36	178.78	16.04	15.01	3506.78	1076	43	46268	42761.22	462.82
50% Pc from NPS + Rec. N	102.73	157.57	16.04	15.01	4012.66	1225	43	52675	48662.34	551.54
75% Pc from NPS + Rec. N	154.09	136.35	16.04	15.01	4518.22	1498	43	64414	59895.78	738.45
100% Pc from NPS + Rec. N	205.45	115.14	16.04	15.01	5023.94	1622	43	69746	64722.06	760.18
100% Pc from DAP + Rec. N	169.72	133.59	16.35	15.01	4188.74	1322	43	56846	52657.26	623.73

Where: ETB=Ethiopian Birr, TVC=Total Variable Cost, MRR=Marginal Rate of Return, PC=Critical phosphorus, Rec. N=Recommended Nitrogen.

4. Conclusion and Recommendations

Appropriate soil fertility management practices based on the actual limiting nutrients and crop nutrient requirement for a given crop is economic and judicious use of fertilizers for sustainable crop production. According to this study NPS fertilizer rate based on calibrated phosphorus significantly influences yield and yield component of tef which indicated that, it would be promising to improve the soil fertility problems. Therefore, the study was conducted to determine the effect of NPS fertilizer rate in relative to determined critical phosphorus for tef in Girar Jarso district.

The analysis of variance depicted that, plant height, spike length, straw and grain yield was highly significantly ($P<0.01$) affected by NPS fertilizer rate. The highest plant height (86.32cm), spike length (32.51cm), straw yield (7004 kg ha^{-1}) and grain yield (1622 kg ha^{-1}) of tef was recorded from the application of 100% P-critical from NPS fertilizer rate supplemented with recommended Nitrogen whereas, the lowest value was recorded from the field without fertilizer which was significantly inferior to all other treatments. Furthermore, the economic analysis depicted that, application of NPS fertilizer at the rate of 100% P-critical in NPS fertilizer with recommended Nitrogen fertilizer (92 kg N ha^{-1}) for the production of tef was more economically beneficial for the district.

Therefore, farmers could be advised to use 100% PC from NPS fertilizer rate with recommended nitrogen for tef production in the district. Demonstration and further scale up should be pre requisite.

References

[1] ATA (Agricultural Transformation Agency). 2013b. “Working Strategy for Strengthening Ethiopian’s Tef Value Chain Vision, Systemic Challenges, and Prioritized Interventions”. Addis Ababa, Ethiopia.

[2] Brady NC and RR Weil. 2002. The Nature and Properties of Soils (13th ed). Pearson education Ltd., USA. pp. 156-198.

[3] CIMMYT (International Maize and Wheat Improvement Center) (1988) An Eco-nomic Training Manual: From Agronomic Data Recordation. International Maize and Wheat Improvement Center, El Batán, 79 p.

[4] Cottenie, A. 1980. Soil and plant testing as a basis of fertilizer recommendations. FAO Soil Bulletin 38/2. Food and Agriculture Organization of the United Nations, Rome, Italy.

[5] CSA (Central Statistical Authority) (2010) Agricultural Sample Survey. 2010. Report on the Area, Production and Yield of Major Crops by Sector and Season. Central Statistical Authority, Addis Ababa.

[6] Feyera Asefa, Adugna Debela and Muktar Mohammed. 2014. Evaluation of teff [Eragrostis tef (Zuccagni) Trotter] responses to different rates of NPK along with Zn and B in Didessa district, southwestern Ehiopia. World Applied Sciences Journal 32: 2245-2249.

[7] Giday O, Gibrekidan H, Berhe T, (2014). Response of Teff (Eragrostis tef) to Different Rates of Slow Release and Conventional Urea Fertilizers in Vertisols of Southern Tigray, Ethiopia. Adv Plants Agric Res 1 (5): 00030. DOI: 10.15406/apar.2014.01.00030.

[8] Kenea, Y., A. Getachew and N. Workneh. 2001. Farming Research on Tef: Small Holders Production Practices. In: Hailu T, Getachew B, Sorrels M, editors. Narrowing the Rift: Tef Research and Development. Ethiopian Agricultural Research Organization (EARO). Addis Ababa, Ethiopia.

[9] Minten B, Seneshaw T, Ermias E, Tadesse K. Ethiopia’s value chains on the move: The case of Tef. Ethiopian Strategic Support Program, Working Paper 52. Addis Ababa, Ethiopia; 2013.

[10] Seifu Ketema. 1993. “Breeding, Genetic resources, Agronomy, Utilization and role of tef in Ethiopian Agriculture”, Ethiopian Institute of Geological Surveys, Ministry of Minesand Energy, Addis Ababa, Ethiopia.

[11] Seyfu Ketema. 1997. Tef [Eragrostis tef (Zucc.) Trotter]. Promoting the conservation and use of underutilized and neglected crops. Biodiversity institute Addis Ababa, Ethiopia.

[12] Tekalign Mamo, Teklu Erkossa and Balesh Tulema. 2001. Soil Fertility and Plant Nutrition Research on Tef in Ethiopia. pp. 199-200. In: Hailu Tefera, Getachew Belay and Mark Sorrels (eds.) Narrowing the Rift Tef Research and Development, Proceedings of the International Workshop on Tef Genetics and Improvement, 16-19 October, 2000. Addis Ababa, Ethiopia.

[13] Tekalign Tadese. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa, Ethiopia. and Subtropics. Longman Scientific and Technical, Essex, New York. 474p.

[14] Tisdale, S. L., W. L. Nelson, J. D. Beaton and J. L. Havlin, 1993. Soil fertility and Fertilizers.

[15] Wakjira Tesfahun, Tef Yield Response to NPS Fertilizer and Methods ofSowing in East Shewa, Ethiopia, Journal of Natural Sciences Research ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online) Vol. 8, No. 1, 2018.

[16] Ahmed S, Riazuddin M, Krishna Reddy PV. Opti- mizing fertilizer doses for rice in alluvial soils through chemical fertilizers, farm yard manure and green manure using soil test values. Agropedology. 2002; 12: 133-140.

[17] Berhane G, Paulos Z, Tafere K, Tamru S. Foodgrain consumption and calorie intake patterns in Ethiopia. IFPRI Ethiopia Strategy Support Program II (ESSP II) Working Paper; 2011.

[18] Fufa Hundera. 1998. Variations of morphoagronomic characters and grain chemical composition of released varieties of tef (Eragrostistef (Zucc) Trotter). Journal of Genetics.& Breeding. 52: 307-311.

[19] Hailu T, Seyfu K. 2000. Production and importance of tef in Ethiopia Agriculture. In: Tefera H, Belay G, Sorrels M (eds.), Narrowing the Rift: Tef research and developmentProceedings of the international Tef Genetics and improvement, 16-19 October 2000, Addis Ababa, Ethiopia.

[20] Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soil byextraction with sodium bicarbonate. USDA circular 939: pp 1-19.

[21] Food and Agriculture Organization of the United Nations (FAO). 2008. FAO fertilizer and plant nutrition bulletin: Guide to laboratory establishment for plant nutrient analysis, FAO, Rome, Italy. 203p.

[22] Teklu, H, Tefera 'Genetic improvement in Grain yield potential Associated Agronomic Traits of Tef (Erogrostic Tef 'Euphytical 2005. Vol 141 (3) PP. 247-254. International Livestock Research Center for Africa, Addis Ababa.