International Journal on Food, Agriculture, and Natural Resources
Volume 04, Issue 02, Page 40-45
ISSN: 2722-4066
http://www.fanres.org

Original Paper

Effect of Compound (NPSB) Fertilizer Type on Yield and Nutrient use Efficiency of Maize (*Zea mays* L.) at Beko Village in Yeki District, Southwest Ethiopia

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Received: 25 October 2022; Revised: 07 June 2023; Accepted: 19 June 2023
DOI: *https://doi.org/10.46676/ij-fanres.v4i2.130*

***Abstract* – Farmer in different parts of Ethiopia uses a similar type of fertilizer and amounts that are below the crop requirements, even the low soil fertility which limits crop production in general. To solve the over-blanket fertilizer application over different agroecology Ethiopian Soil Information System (EthioSIS) mapped the soil fertility and recommended types of fertilizer for a specific location. A NPSB type of fertilizer where recommended for Beko village, but the rate of this fertilizer type was not studied so far. So, this field experiment was conducted to determine the rate of NPSB fertilizer type and nutrient use efficiency of maize during the 2018 cropping season. A total of eight treatments with four replications were laid out in a factorial randomized complete block design. Treatments were control (zero fertilizer), previously blanket recommended nitrogen and phosphorus (92 N+ 69 P2O5) kg/ha, 150 NPSB +100 urea +100 K2O kg/ha, 200 NPSB +100 urea + 100 K2O kg/ha, 250 NPSB +100 urea +100 K2O kg/ha, 150 NPSB +150 urea +100 K2O kg/ha, 200 NPSB +150 urea +100 K2O kg/ha and 250 NPSB +150 urea +100 K2O kg/ha. Data were statistically analyzed by statistical analysis system (SAS) and mean treatment differences were compared by least significant differences (LSD). An analysis of variance indicated that application of NPSB fertilizer was not influenced plant height, ear height, ear length, cob length, number of ears per plant, thousand seed weight, harvest index, and shelling percentage as compared to the previously blanket recommended Nitrogen and Phosphorus (NP) fertilizer but grain and above-ground dry biomass were influenced except the application of 150 NPSB +100 urea. Application of 250 NPSB + 100 urea gave the highest maize grain yield (8828.2 kg/ha). Application of NPSB fertilizer improved the nitrogen and phosphorus use efficiency of maize compared to the previously blanket recommended NP. The highest N use efficiency (64.75 kg/ha) was obtained from the application of 200 NPSB +100 urea, while the lowest N use efficiency (23.89 kg/ha) was from the previously blanket recommended NP fertilizer. As economic analysis indicated that the application of 150 NPSB +100 urea is recommended for the study area.**

Keywords— Above-ground dry biomass, Blanket recommended, Grain yield, Nutrient uptake

I. INTRODUCTION

Maize (Zea mays L.) is one of the most important food crop in Ethiopia as well as in Sheka zone. Its average productivity is below 3.67 t/ha [1] when compared to the national average to 4.7 t/ha [2] and lower than the world average yield which about 5.21 t/ha [3]. Low soil fertility is one of the bottlenecks for sustaining maize production and productivity in Ethiopia [4; 5). Continuous crop production without improved farming practices has resulted in several deplete nutrients and soil organic matter which affect agricultural production [6; 7]. Lower biomass production and increasing demand of local organic matter of fuel and fodder also accelerate the declining of soil fertility [8; 9]

In Ethiopia farmers use similar fertilizer types commonly known as urea and DAP in different agro-ecology as a blanket recommendation [10]. Urea and DAP fertilizer provide only nitrogen and phosphorus plant nutrients [46, 47]. Plants require a specific amount of certain nutrients in some specific form at appropriate times for their growth and development. The role of both macro and micronutrients are crucial in crop nutrient and thus important for obtaining higher yields [11; 12; 13]

In a past decade Ethiopian Soil Information System (EthioSIS) where mapping soil fertility status of the country. Accordingly, in addition to nitrogen and phosphorus plant nutrients other nutrients like, potassium (K), Sulfur (S), boron (B), copper (Cu), manganese (Mg), iron (Fe), and zinc (Zn) where deficiencies are widespread in Ethiopian soil [14;15;16].

Four types of fertilizer (NPS, NPSB, NPSBCa and NPSCa) are suggested for Yeki District. However, the map is suggested type of fertilizer but, the rate of those fertilizer in respective to crop type is not studied [45]. With this back ground, the present study was designed to evaluate the effect of NPSB fertilizer type on grain yield, nutrient use efficiency of maize and economic feasibility in Yeki district at Beko village Southwest of Ethiopia.

II. Materials and Methods

A. Description of the study area

The experiment was conducted in Sheka Zone Yeki District at Beko village during 2018 main cropping season. The Yeki located in Southwest Ethiopia in South West people of Ethiopia regional state at an elevation of 1200 m.a.s .l, latitude of 7º10'54.5'' and longitude of 35º25'04.5" East of Ethiopia and approximately 611km far from the capital city of Addis Ababa, Ethiopia. The average maximum and minimum annual temperatures is 29.7ºC and 15.5ºC respectively. The annual rainfall in the area is unimodal distribution with average of 1559mm. The area is dominated by Nitisols [17].

B. Experimental Materials

A high yield medium maturity date of hybrid maize variety (BH140) was used as a test crop. Urea fertilizer as source of nitrogen, triple super phosphate (TSP) as phosphorus source, potassium chloride as a source of potassium and NPSB fertilizer were used. Fertilizers' Triple Super Phosphate (TSP) and NPSB were applied at planting while, urea applied in twice equal split half at knee height and the remaining at flag leaf emergence as Tolessa *et al.*[4] recommendation.

C. Experimental Design

A field experiment was conducted in a factorial randomized block design with eight treatments with four replication, an experimental plot 3.5mx3.75m length and width respectively. The treatments consisted three level of NPSB (150, 200, 250) kg/ha each combined with two levels of urea (100, 150) kg/ha and two checks were added to each block (Control and previously blanket recommended 92 N + 69 P2O5) kg/ha. The details treatment combination were indicated as follow (Table 1).

TABLE I. Treatment details

Treatment code	Treatment details
T1	Control (zero fertilizer)
T2	Recommended NP (92 N+ 69 P_2O_5) kg/ha
T3	150 NPSB +100 Urea +100 KCl kg/ha
T4	200 NPSB+100 Urea +100 KCl kg/ha
T5	250 NPSB +100 Urea +100 KCl kg/ha
T6	150 NPSB +150 Urea +100 KCl kg/ha
T7	200 NPSB+150 Urea +100 kg KCl/ha
T8	250 NPSB +150 Urea +100 KCl kg/ha

D. Data collection and Analysis

Before the experimentation composite surface soil samples was collected from the plough layer (0-20 cm) depth across the experimental plot. The composite soil sample was analyzed in laboratory and used for analysis of soil physio-chemical properties; soil texture by Bouyoucos hydrometer method [18], soil reaction (pH) in a 1:2.5 soil water suspension by a glass electrode pH meter [19], total nitrogen by modified Kjeldahl method [20], available phosphorus by Olsen method [21], available potassium by ammonium acetate extracts flame photometer [22], available sulfur and boron by Mehlich-3 method [23], cation exchangeable capacity (CEC) [24], organic carbon by Walkley and Black method [25], organic matter was estimated as organic carbon multiplied by 1.74 assuming the average carbon concentration of organic matter is 58%.

Six plants from each net plot were randomly taken to measure plant height, ear height, ear length, cob length, thousand seed weight, grain yield, above-ground dry biomass, harvest index, shelling percentage of maize. Maize grain was taken to analysis nutrient content for nutrient use efficiency analysis using procedure described by [26]. A partial budget analysis were calculated follow as CIMMTY [27] procedure. The collected data were statistically analyzed as using statistical analysis system (SAS) software package [28]. The mean differences were separated using the least significant difference (LSD) to signify the treatment differences at a 5% level of probability.

III. Results and Discussion

A. Pre-plant soil properties

The pre-plant composite soil sample were collected from the experimental field at Beko village, Yeki district. The various soil physio-chemical properties of the experimental site were analyzed under laboratory and the results were presented (Table 2).

TABLE II. Pre-plant basic soil properties of the experimental site

Soil properties		Values	Rating	Reference
Physical properties	Clay (%)	60		[29]
	Silt (%)	26		
	Sand (%)	14		
	Texture class		Clay	
Chemical properties	Soil reaction (pH)	6.27	Slightly acid	[30]
	Total nitrogen (%TN)	0.24	Moderate	[31]
	Olsen av. P (mg/kg)	5	Low	[30]
	av. K (ppm)	550.80	High	[32]
	av. S (ppm)	13.14	Medium	Horneck *et al.* (2011)
	Av. B (ppm)	0.99	Moderate	[32]
	CEC cmol (+)/kg	30.89	High	[30]
	OC (%)	2.64	High	[33]

B. Effect of NPSB fertilizer application on growth, yield and yield components of maize

Application of NPSB fertilizer was none significantly ($p>0.05$) influenced plant height, ear height, ear length, cob length and number of ear per plant as compared to the previously blanket recommended NP fertilizer (Table 3).

TABLE III. Effect of NPSB fertilizer on plant height, ear height, ear length, cob length and number of ear per plants of maize in Yeki district at Beko village

Treatments (Fertilizer rates kg/ha)	Plant height cm	Ear heigh cm	Ear length cm	Cob length cm	Number of ear per plant
Control	244.45	126.7b	30d	13.55c	1
200 urea +150 kg TSP	256.55	141.7ab	32.95c	15.65b	1.05
150 NPSB + 100 Urea +100 KCl	254.9	137.55ab	33.3bc	16.8ab	1.05
200 NPSB + 100 Urea +100 KCl	263.3	138.5ab	34.4bc	17ab	1

Treatments (Fertilizer rates kg/ha)	Plant height cm	Ear heigh cm	Ear length cm	Cob length cm	Number of ear per plant
250 NPSB + 100 Urea +100 KCl	268.55	140.25a b	37.55a	17.3a	1.05
150 NPSB + 150 Urea + 100 KCl	262.3	138.75a b	35.8ab	16.45ab	1
200 NPSB +150 Urea +100 KCl	258.4	136.45a b	34.6bc	16.95ab	1
250 NPSB +150 Urea +100 KCl	266.2	144.95a	35.85ab	17ab	1
LSD	ns	15.269	2.7989	1.4492	ns
CV%	6.34857	7.5183	5.54807	6.03207	5.91484

CV%=Coefficient of variation in percent, LSD=least significant difference, ns=none significant, Mean with similar letter(s) within the column were none significantly different at alpha 5% probability level

Application of NPSB fertilizer was none significantly ($p>0.05$) influenced thousand grain weight, harvest index and shelling percentage of maize as compared to the previous blanket recommended NP fertilizer, while grain and above-ground dry biomass yield were influenced (Table 4).

TABLE IV. EFFECT OF NPSB FERTILIZER ON THOUSAND SEED WEIGHT, GRAIN YIELD, ABOVE-GROUND DRY BIOMASS YIELD, HARVEST INDEX AND SHELLING PERCENTAGE (%) OF MAIZE IN YEKI DISTRICT AT BEKO VILLAGE

Treatments (Fertilizer rates kg/ha)	Thousand seed weight (gm)	Grain yield (kg/ha)	Biomass t ha^{-1}	Harvest index	Shelling percentage %
T1= control	300.78b	2968.9f	7.67e	38.61d	73.79d
200 urea + 150 TSP	364.8a	5166.6e	11.76d	43.90b	80.55c
150 NPSB + 100 Urea +100 KCl	385.24a	7033.4d	15.51c	45.31ab	84.01b
200 NPSB + 100 Urea +100 KCl	407.5a	8291.2ab	18.30a	45.28ab	84.95b
250 NPSB + 100 Urea +100 KCl	406.46a	8828.2a	18.52a	47.65a	88.51a
150 NPSB + 150 Urea + 100 KCl	384.42a	8082.9bc	17.80ab	45.46ab	84.55b
200 NPSB +150 Urea +100 KCl	395.62a	7547.1cd	16.93b	44.53b	83.92bc
250 NPSB +150 Urea +100 KCl	387.41a	7605.3cd	16.92b	44.91b	83.98b
LSD	47.4	592.6	0.9166	2.5852	3.3857
CV%	8.5043	5.80637	4.03952	3.95416	2.77276

CV%=Coefficient of variation in percent, LSD=least significant difference, ns=none significant, Mean with similar letter(s) within the column were none significantly different at alpha 5% probability level

When compared with the control treatment with other treatments application of NPSB fertilizer influenced thousand seed weight, grain yield, above-ground dry biomass yield, harvest index and shelling percentage of maize. The heaviest thousand seed weight (407.5gm) was recorded from the application of 200 NPSB + 100 urea + 100 KCl. The highest grain yield (8828.2 kg/ha), harvest index (47.65), and shelling percentage (88.51) was recorded from the application of 250 NPSB + 100 urea + 100 KCl fertilizer. The lighter thousand seed weight (300.78gm), grain yield (2968.9 kg/ha), above-ground dry biomass (38.61 t/ha), harvest index (36.61) and shelling percentage (73.79) of maize was recorded from the control treatment followed by the previously blanket recommended NP fertilizer rate. Application of macronutrient S from NPSB and K from KCl and B fertilizer in addition to enough urea contributed for the increment of maize thousand yield, grain yield, above-ground dry biomass yield, harvest index and shelling percentage over the control treatment and split nitrogen application also improve the nutrient use efficiency of the maize.

Maize request the greatest amount of potassium fertilizer. A study by Muhammad *et al*. [34] indicate that application of 120 kg/ha fertilizer improved maize yield by 24.21% as compared to the control. As a different study showed application of balanced fertilizer improved grain yield of different cereal crops. A study by Dagne [35] and Shiferaw *et al*. [36] grain yield of maize were improved under the application of blended fertilizer as compared to the control. A study on tef indicate that blended fertilizer with a recommended amount of N and P increased yield as compared with the control treatment [37; 38]. Similarly study on wheat also showed yield increments as blended fertilizer application as compared to the control [39; 40].

C. Effect of NPSB fertilizer application on nitrogen nutrient uptake of maize

Application of 250 NPSB + 100 urea + 100 KCl fertilizer gave the maximum grain N uptake (126.83 kg/ha), straw N uptake (104.16 kg/ha) and total above-ground dry biomass N uptake (230.99 kg/ha), while the minimum N uptake of grain (12.37 kg/ha), straw (13.35 kg/ha) and above-ground dry biomass (25.72 kg/ha was from the control treatment followed by the previously recommended NP fertilizer (Table 5). This N uptake improvement of maize over the control and recommended NP could be due to the mac and micronutrient provided from NPSB, KCl and split application of nitrogen application.

The application of macronutrient improve nutrient uptake of maize both the grain and straw [35]. The N uptake and grain yield has a positive association [26]. Hence, the improved N uptake in grain yield of maize may lead to improved grain yield. A combine application of nitrogen and phosphorus increase the N uptake of maize reported [41].

TABLE V. EFFECT OF NPSB FERTILIZER ON MAIZE N AND P UPTAKE IN YEKI DISTRICT AT BEKO VILLAGE

Treatments (Fertilizer rates kg/ha)	Nutrient uptake kg/ha					
	N			P		
	Grain	Straw	above-ground dry biomass	Grain	Straw	above-ground dry biomass
Control	12.37	13.35	25.72	8.02	4.58	12.59
200 urea + 150 TSP	39.27	33.04	72.31	18.6	11.76	30.36
150 NPSB + 100 Urea +100 KCl	70.1	66.25	136.35	37.98	18.2	56.18
200 NPSB + 100 Urea +100 KCl	112.76	68.33	181.09	50.58	21.9	72.48
250 NPSB + 100 Urea +100 KCl	126.83	104.16	230.99	64.45	24.3	88.75

150 NPSB + 150 Urea + 100 KCl	85.95	88.76	174.71	43.65	21.13	64.78
200 NPSB +150 Urea +100 KCl	105.66	67.35	173.01	50.57	23	73.56
250 NPSB +150 Urea +100 KCl	94.31	78.63	172.94	57.8	26.75	84.55

Total uptake (above-ground dry biomass) =grain + straw uptake

D. Effect of NPSB fertilizer application on phosphorus nutrient uptake of maize

Application of 250 NPSB + 100 Urea + 100 KCl gave the maximum grain P uptake (64.45kg/ha) and above-ground dry biomass (88.75 kg/ha) yield, while the minimum P uptake (8.02 kg/ha) and above-ground dry biomass P uptake (12.59 kg/ha) was recorded from the control treatment. P uptake was improved as compared to the control treatment.

E. Effect of NPSB fertilizer application on agronomic N and P nutrient use efficiency of maize

Agronomic fertilizer use efficiency of maize was influenced due to the application of NPSB fertilizer type (Table 6). The highest agronomic fertilizer N use efficiency (64.75 kg/ha) was recorded under the application of 200 NPSB + 100 urea, while the lowest from recommended NP fertilizer (23.89 kg/ha) and it improved by 46.10% as compared to the previously recommended NP fertilizer.

TABLE VI. AGRONOMIC NUTRIENT USE EFFICIENCY OF MAIZE

Treatments (Fertilizer rates kg/ha)	Agronomic nutrient use efficiency kg/ha	
	N	P
Control	-	-
200 urea + 150 TSP	23.89	31.85
150 NPSB + 100 Urea +100 KCl	55.56	75.06
200 NPSB + 100 Urea +100 KCl	64.75	73.72
250 NPSB + 100 Urea +100 KCl	64.21	64.92
150 NPSB + 150 Urea + 100 KCl	53.14	94.44
200 NPSB +150 Urea +100 KCl	43.52	63.41
250 NPSB +150 Urea +100 KCl	40.58	51.37

Agronomic fertilizer use efficiency of any nutrient can be increased by increasing plant nutrient uptake and the use of nutrients by decreasing nutrient losses from the soil plant system. As Mengel *et al*. [42] stated the mean value of agronomic fertilizer use efficiency for a nutrient should not be less than 5 kg/ha and according Dobermann [43] in the range of 10 to 30 kg/ha. The agronomic use efficiency of the study area ranged from 23.89 to 57.98 kg/ha which was the optimum range according to Mengel *et al* [42; 43]. In the case of high value of agronomic use efficiency could be good field management system or at which soil N supply is low [43].

The application of NPSB fertilizer was influenced agronomic P fertilizer use efficiencies of maize when compared to the recommended NP fertilizer (Table 6). The highest agronomic P fertilizer use efficiency (94.44 kg/ha) was recorded from the application of 150 NPSB + 150 urea, while the lowest (31.85 kg/ha) from the recommended NP fertilizer.

F. Economic NPSB fertilizer application analysis

One of the boldly important in fertilizer study is its economic advantage for smallholder farmer. According to CIMMYT, (1988) the minimum rates of return by investing any cost to the acceptable return between 50 to 100%. So, farmers select the best treatment based on minimum acceptable marginal rate of return, highest net benefit with low total variable cost. In this study a partial budget average of eight (8) treatments were calculated from income and expenses based on variable cost. Net benefit (NB) calculated as subtracting the total variable cost (TVC) from the gross field benefit (GFB) for each treatment. A gross field benefit was calculated as multiplying yield obtained by fife which is a local selling price of a kilogram of maize estimated from the average of fife year. The cost of NPSB fertilizer was Ethiopian birr (ETB 13.75 kg/ha, TSP was ETB 12.75/kg, KCl was ETB14.50/kg and urea was ETB 10/kg. The cost of fertilizer transportation was considered as ETB 15 per 100 kg fertilizer and labor cost of fertilizer application ETB 18 per day for 8 hours for 100 kg fertilizer. The yield adjustment to downward by 10% is to indicate the difference between yield obtained from experimental site and the expected yield from farmers' fields [44].

The acceptable marginal rate of return (4.35%) for un-dominated treatment at the lowest total cost of variable with the highest net (13445.3 ETB/ha) was recorded from the application of 150 NPSB + 150 urea (Table 7). Dominated treatment indicate that any treatment that has net benefits are less than those of a treatment with lower costs that vary. According to this study, application of 150 NPSB + 150 urea along with 100 KCl is recommended for the experimental site.

TABLE VII. PARTIAL BUDGET ANALYSIS OF NPSB FERTILIZER APPLICATION FOR MAIZE.

Treatments	Grain yield Kg/ha	Adj. grain yield	GFB	TVC	NB	MRR
Control	2968.9	2672.01	13360.05	0	13360.05	
200 urea + 150 TSP	5166.6	4649.94	23249.7	16635	6614.7	D
150 NPSB + 100 Urea	7033.4	6330.06	31650.3	18205	13445.3	4.35
150 NPSB + 150 Urea + 100 KCl	8082.9	7274.61	36373.05	20395	15978.05	1.15
200 NPSB + 100 Urea	8291.2	7462.08	37310.4	21230	16080.4	0.12
250 NPSB + 100 Urea	8828.2	7945.38	39726.9	22780	16946.9	0.55
200 NPSB +150 Urea +100 KCl	7547.1	6792.39	33961.95	23420	10541.95	D
250 NPSB +150 Urea	7605.3	6844.77	34223.85	23510	10713.85	1.91

Ad. =Adjusted grain yield to 10%, GFB=Growth field benefit, NB=Net benefit, TVC=Total cost that varies MRR= Marginal rate of return, D=dominated treatment

IV. CONCLUSION

Application of NPSB fertilizer was significantly influenced maize grain yield and above-ground dry biomass. The highest maize grain yield (8828.2 kg/ha) was obtained from the application of 250 NPSB + 100 Urea + 100 KCl kg/ha, while the lowest grains yield (2968.90 kg/ha) was obtained from the control plot. Application of NPSB and urea improved nutrient

uptake and agronomic use efficiency of maize, as compared with the blanket recommended NP fertilizer. The maximum grain N uptake (126.83 kg/ha) was obtained from the application of 250 NPSB + 100 Urea + 100 KCl kg/ha. Economically application of 150 NPSB + 100 urea + 100 KCl kg/ha gives 13445.3 ETB net benefits. Therefore, application of 150 NPSB + 100 urea along with 100 KCl kg/ha fertilizers rate is recommended for maize production in Yeki district at Beko village.

ACKNOWLEDGEMENTS

We thanks Ethiopian Institute of Agricultural Research (EIAR) for field experiment budget fund. We express our thanks to Teppi Agricultural Research Center for field experiment impute support. Finally we thanks to Mr. Tesfaneh Ejigu for his field work support.

CONFLICT OF INTEREST

We state that for this experiment there is no any conflict of interest.

REFERENCES

[1] CSA. (2017). Agricultural Sample Survey 2016/2017 Vol-I. Report on area and production of major crops. Statistical Bulletin 269-278. Addis, Ababa Ethiopia.

[2] IFPRI. (2010). Maize value chain potential in Ethiopia; Constraints and opportunities for enhancing the system, IFPRI: Washington, DC.

[3] FAO. (2015). The State of the World's Land and Water Resources for Food and Agriculture (SOLAW) Managing Systems at Risk: Food and Agriculture Organization of the United Nations: Rome, Italy; Earth scan: London, UK, 2011.

[4] Tolessa Debele, Gemechu Gedeno and Melakeselam Leul. (1994). Response of maize to split application of nitrogen fertilizer at Bako. In6 Annual Conference of the Crop Science Society of Ethiopia. Addis Ababa, (Ethiopia). 3-4 May 1994.

[5] Abebayehu, A., Elias, E., and Diels, J. (2011). Comparative analysis of soil nutrient balance at farm level: a case study in Jimma Zone, Ethiopia. International Journal of Soil Science, 6(4): pp.259-266.

[6] Zingore, S. (2011). Maize productivity and response to fertilizer use as affected by soil fertility variability, manure application, and cropping system, Better crops, 95(1): pp.4-6.

[7] Ethiopian Agricultural Transformation Agency (ATA). (2016). Soil fertility status and fertilizer recommendation atlas for SNNPRS, Ethiopia. Ethiopian Agricultural Transformation Agency (ATA), A.A, Ethiopia.

[8] Selamyihun, K., Mamo, T and Stroosnijder, L. (2005). Biomass production of Eucalyptus boundary plantations and their effect on crop productivity on Ethiopian highland Vertisols. Agroforestry Systems, 63(3): pp.281-290.

[9] Nigussie, H., Poesen, J., Paridaens, K., Nyssen, J., Deckers, S., Mitiku, H. and Govers, G. (2007). Nutrient export and associated costs from micro-dam catchments in Tigray, pp.27-28.

[10] IFDC. (2015). Assessment of Fertilizer Consumption and Use by Crop in Ethiopia; https://africafertilizer.org/wp-content/uploads/2017/05/FUBC-Ethiopia-Final-Report- 2016.pdf.

[11] Arif, M., Ali, S., Khan, A., Jan, T., Akbar, M. (2006). Influence of farmyard manure application on various wheat cultivars. Sarhad J. Agric., 22: 27-29.

[12] Vanlauwe, B., Descheemaeker, K., Giller, K.E., Huising, J., Merckx, R., Nziguheba, G., Wendt, J. and Zingore, S. (2015). Integrated soil fertility management in sub-Saharan Africa. Unravelling local adaptation. Soil science, 1(1): pp.491-508.

[13] Lelago A.B, Mamo, T. A Haile, W.W and Shiferaw, H.D. (2016). Soil micronutrients status assessment, mapping and spatial distribution of Damboya, Kedida Gamela and Kecha Bira Districts,Kambata Tambaro zone, southern Ethiopia. African Journal of agricultural research,Vol. 11(44):pp. 4504-4516.

[14] EthioSIS. (2013). Status of soil resources in Ethiopia and priorities for sustainable management, GSP for eastern and southern Africa Mar 25-27, 2013 Nairobi, Kenya.

[15] EthioSIS. (2014). Soil fertility status and fertilizer recommendation atlas for Tigray regional state, Ethiopia. Addis Ababa, Ethiopia, July 2014.

[16] EthioSIS. (2015). Ethiopian Agricultural Transformation Agency. http://www.ata.gov. ET/highlighted deliverables/Ethiopian soil information system EthioSIS.

[17] Food and Agriculture Organization of the United Nations (FAO). (2006). Working group WRB (2007). World reference base for soil resources.

[18] Day, P.R. (1965). Particle fractionation and particle - size analysis. Methods of Soil Analysis: Part 1 Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling, 9, pp.545-567.

[19] Van Reeuwijk L.P. (1992). Procedures for Soil Analyses.3rd ed. Int. Soil Reference and Information Centre Wageningen (ISRIC), the Netherlands.

[20] Bremner, J.M. (1965). Total Nitrogen, methods of soil analysis, part 2: chemical and microbiological properties (methods of soilanb), pp.1149-1178.

[21] Olsen, S.R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate (No. 939). US Department of Agriculture.

[22] Morgan, M.F. (1941). Chemical diagnosis by the universal soil testing system; conn. agr. exp. sta. (New Haven) bull. 450.

[23] Mehlich, A. (1984). Mehlich 3 soil test extract ant, a modification of Mehlich 2 extractant. Commun. Soil Sci. Plant Anal., 15: 1409-1416.

[24] Chapman HD. (1965). Cation exchange capacity methods of soil analysis, part 2, chemical and microbiological properties, (methods of soil analysis), pp.891-901.

[25] Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science, 37(1): pp.29-38.

[26] Fageria, N.K., and V. C B. (2005a). Enhancing nitrogen use efficiency in crop plants. Adv. Agron., 88:97–185.

[27] CIMMYT. (1998). Economics Program, International Maize and Wheat Improvement Center, from agronomic data to farmer recommendations: an economics training manual (No. 27).

[28] Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for agricultural research. John wiley & sons.

[29] Food and Agriculture Organization of the United Nations (FAO). (1977). Guidelines for soil profile description. 2nd ed; Soil Dev. and Conserv. Serv., Land and Water Dev. FAO, Rome

[30] Landon J. R. (1991). Booker Tropical soil manual, a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Longman, Booker. 474p.

[31] Tekalign, M and Haque. I. (1991). Phosphorus status of some Ethiopian soils: III, Evaluation of soil test methods for available phosphorus. Tropical Agriculture (Trinidad), 68: pp.51-56.

[32] Horneck, D.A., Sullivan, D.M., Owen, J.S and Hart, J.M. (2011). Soil test interpretation guide.

[33] Hazelton, P. and Murphy, B. (2007). Interpreting soil test results: what do all the numbers mean 2nd (ed). Department of natural resources. CSIRO publishing.

[34] Muhammad.F.J, Waqas.L, Haseeb.A, Muhammad.D.A and Wazir.R. (2018). Phenology, growth, yield and yield components of maize (Zea mays L) hybrids to different levels of mineral potassium under semiarid climate. International Journal of Environmental Sciences and Natural Resources Research Article, Volume 9 Issue 5.

[35] Dagne, Chi. (2016). Blended fertilizers effects on Maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries, 5(5): pp.151-162.

[36] Shiferaw Boke, Mulugeta Habte, Atinafu Asefa and Abay Ayalew. (2018). Macro and Micronutrients for optimizing maize production at Hawassa Zuria District, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare, ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.8.

[37] Asefa, F, Mohammed, M and Debela, A. (2014). Effects of different rates of NPK and blended fertilizers on nutrient uptake and use efficiency of

Teff [Eragrostis tef (Zuccagni) Trotter] in Dedessa District, Southwestern Ethiopia. Journal of Biology, Agriculture and Healthcare, Vol.4, No.25.

[38] Ayalew, A and Habte, M. (2017). Use of balanced nutrients for better production of Teff (Eragrostis tef (zucc.) at Bensa in Southern Ethiopia. Journal of Resources Development and Management, Vol.32.

[39] Mulugeta.H and Abay.A. (2017). Blended fertilizers as sources of balanced nutrients for growth and yield of Wheat at Hulla District in Southern Ethiopia. Journal of Natural Sciences Research, www.iiste.org ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online) Vol.7, No.9.

[40] Abebaw T and Hirpa L. (2018). Effects of Fertilizer Rate (Blended) and Sowing Methods on Yield of Bread Wheat (Triticum aestivum) and its Economic Profitability in Western Ethiopia. International Journal of Comprehensive Research in Biological Sciences, Volume -5: Issue -7; Pages: 1-14ISSN: 2393-8560.

[41] Ali.J, Bakht.J, Shafi.M, Khan, S and Sha, W.A. (2002). Effect of various levels of N and P on yield and yield components of Maize. Pakistan Journal of Agronomy, 1(1): pp.12-14.

[42] Mengel, K., Hutsch, B. and Kane, Y. (2006). Nitrogen fertilizer application rates on cereal crops according to available mineral and organic soil nitrogen. European Journal of Agronomy, 24(4): pp.343-348.

[43] Dobermann, A.R. (2005). Nitrogen Use Efficiency State of the Art: Agronomy and horticulture faculty publications. Paper 316. http://digitalcommons.unl.edu/agronomy fac pub/316.

[44] Getachew, A. and Rezene, F. (2006). Response of Faba bean to phosphate fertilizer and weed control on nitisols of Ethiopian highlands. Italian Journal of Agronomy, pp.281-290.

[45] Degefa, K., Biru, G., & Abebe, G. (2022). Factors Affecting Tomato Productivity in Western Oromia, Ethiopia: Evidence from Smallholder Farmers. International Journal on Food, Agriculture and Natural Resources, 3(2), 5–10.

[46] Lyu, Y., Yang, X., Pan, H., Zhang, X., Cao, H., Ulgiati, S., Wu, J., Zhang, Y., Wang, G., & Xiao, Y. (2021). Impact of fertilization schemes with different ratios of urea to controlled release nitrogen fertilizer on environmental sustainability, nitrogen use efficiency and economic benefit of rice production: A study case from Southwest China. Journal of Cleaner Production, 293, 126198.

[47] Sabiha-Javied, N., Siddque, N., Waheed, S., Tufail, M., Nasir, R., & Aslam, A. (2022). Uptake of heavy metal in wheat from application of different phosphorus fertilizers. Journal of Food Composition and Analysis, 115, 104958.