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EFFECTS OF DIFFERENT BLENDED FERTILIZERS ON YIELD AND YIELD COMPONENTS OF FOOD BARLEY (*Hordeum vulgare L.)* ON NITISOLS AT HULLA DISTRICT, SOUTHERN ETHIOPIA

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An experiment was executed to investigate effects of different blended fertilizers on yield and yield components of food barley (Hordeum vulgare L.) on Nitisols at Hulla district, Southern Ethiopia. The experiment comprised of 12 treatments viz. control, recommended Nitrogen and Phosphorous, 50 NPS, 100 NPS, 150 NPS, 200 NPS, 250 NPS, 50 NPSB, 100 NPSB, 150 NPSB, 200 NPSB and 250 NPSB kg ha^{-1} blended fertilizers; and was laid out in RCB design with three replications. The significant effect of blended fertilizers were observed on barley yield and yield components. Results revealed that the highest above ground biomass (12.63), straw yield (7.73) and grain yield (4.9 t ha^{-1}) response were obtained with application of 200 kg ha^{-1} of NPSB blended fertilizer and is superior on grain yield by 22.4 and 70.4% to recommended N and P and control respectively. Besides, marked nutrient recovery and agronomic nutrient use efficiency was obtained at 100 and 50 Kg ha^{-1} NPSB blended fertilizers respectively. The highest net return of 52,068.00 Eth-birr ha^{-1} with MRR of 2277.3% were obtained from application of 200 kg ha^{-1}of NPSB blended fertilizer. Therefore, based on the yield response and economic indicators, it is recommended to apply 200 NPSB kg ha^{-1} blended fertilization at Hulla district, Southern Ethiopia and areas with the same soil conditions and agro-ecology.

Keywords: Blended fertilizers, soil test based fertilizer recommendation, barley and nutrient use efficiency

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INTRODUCTION

Barley (*Hordeum vulgare L.*) is one of the most staple food and economically important widely used cereal crop in Ethiopia next to teff, maize, wheat, and sorghum (CSA, 2014). However, production of barley in Ethiopia fall under low fertility soils (Yihenew, 2002). Similarly, Woldeyesus *et al.* (2002) investigated that low barley productivity was obtained in the highland of Ethiopia due to low soil fertility. Low soil fertility is one of the bottlenecks to sustainable agricultural production and productivity in Ethiopia (Wakene *et al.,* 2007).

In Ethiopia, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of Di-ammonium phosphate (DAP) (18-46-0) and Urea (46-0-0) or blanket recommendation for the major food crops. Continuous application of nitrogen (N) and phosphorus (P) fertilizers without due consideration of other nutrients led to the depletion of other important nutrient elements such as potassium (K), magnesium (Mg), calcium (Ca), sulfur (S) and micro-nutrients in soils (Abiye *et al*., 2004). Balanced fertilization is the key to sustainable crop production and maintenance of soil health. It has both economic and environmental consideration. An imbalanced fertilizer use results in low fertilizer use efficiency leading to less economic returns and a greater threat to the environment (Abiye *et al*., 2004).

Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%) and zinc (53%) are widespread in Ethiopian soils and similarly in study area (Ethio-SIS, 2016). However, information on the application of rate blended fertilizer (NPS and NPSB), especially for barley, was not determined for the study area. Therefore, this particular experiment was designed to investigate the effects of different blended fertilizers on yield and yield components of food barley (*Hordeum vulgare l.)* on Nitisols at Hulla district, Southern Ethiopia having the following specific objectives:

- To investigate the effects of different blended fertilizers and their rates on yield and yield components of barley on Nitisols
- To find out the economically optimal rate of different blended fertilizers on yield and yield components of barley on Nitisols
- To determine effects of blended fertilizers on nutrient use efficiency

MATERIALS AND METHODS

Description of the Experimental Area

The experiment was conducted during the 2017 main cropping season at Hulla district, Ethiopia located at 38°30'47'' E and 06°33'30''N at 2689 *m.a.s.l.* The long-term average annual rainfall is 1000 to 1300 mm out of which 87 % of the total rainfall of the area occurs from mid-June to mid-September, with its peak in the month of July and August and average minimum and maximum monthly temperatures is 22.5 °C and 4.6 °C respectively. According to FAO, (1998) the dominant soil type of the site is Nitiosls, with textural class of clay loam.

Experimental Set-up and Procedure

The experimental sites were prepared for sowing using standard cultivation practices and was plowed using oxen-drawn implements. The experiment was randomized complete block design with five NPS (50, 100, 150, 200 and 250 kg ha^{-1}), five NPSB (50, 100, 150, 200 and 250 kg ha^{-1}) blended fertilizer levels, recommended NP and control with three replicates for each treatment. According, to (Ethio-SIS, 2016) nutrients level in 100 kg of NPS (19N - $38P_2O_5$ – $0.0K_2O$ + 7S + 0.0Zn + 0.0B) and NPSB (18.1N - 36.1 P_2O_5 – 0.0 K_2O + 6.7 S + 0.0 Zn + 0.71B). Sowing was done manually at a seed rate of 100 kg/ha using manual row maker with a spacing of 0.20 m between rows.

The blended fertilizers and TSP were basal applied once at planting. To minimize losses and increase efficiency, all the N fertilizer (urea) was applied in the row in two applications: half at planting and the other half 40 days after planting, during the maximum growth period of the crop at full tillering stage, after first weeding and during light rainfall to minimize loss of N to the atmosphere. Based on exchangeable acidity lime ($CaCO_3$) were evenly broad casted manually and mixed thoroughly in upper soils at 15 cm plow depth applied uniformly for all experimental units one month before seed sowing. Other recommended agronomic practices were applied during the crop growth.

$$LR, CaCO_3\ (kg/ha) = \frac{cmolEA/kg\ of\ soil * 0.15\ m * 10^4\ m^2 * B.D.(Mg/m^3) * 1000}{2000}$$

Soil Sampling and Analysis

Initial Representative composite surface soil samples were collected from 0-20 cm depth at each experimental unit just before sowing were analyzed for texture, pH, organic carbon %, TN%, cation exchange capacity (CEC) available phosphorus and Sulfur and Boron. After manual homogenization, the samples were ground to pass a 2-mm sieve. The method used for soil physical and chemical analysis was soil texture determined by boycouos hydrometer and soil pH was determined by water suspension in a 1:2.5 (soil: water) (Van Reeuwijk, 2002), OC% by wet oxidation method (Walkley and Black, 1934), TN% by Kjeldhal method (Black, 1965), available Phosphorus determined by Olsen method (Olsen *et al.,* 1982). Sulfur was determined by Turbidimetric method. Exchangeable cations and CEC firm by using ammonium acetate (1N NH_4OAc) at pH 7.0 (Sahlemedhin and Taye, 2000). Exchangeable acidity (Al^{3+} and H^+) was determined from a neutral 1N KCl extracted solution through titration with a standard NaOH solution (McLean, 1965). Born was determined by hotwater extraction procedure (Havlin *et al.,* 1999). Moreover, agronomic nutrient use efficiency and apparent recovery efficiency were calculated by the formula developed (Fageria and Baligar 2003).

Agronomic Nutrient Use Efficiency (ANUE): Is the economic production obtained per unit of nutrient applied. $ANUE(\text{kg/kg}) = (Gf - Gu)/Na$

Apparent Recovery Efficiency (ARE): Is the quantity of nutrient uptake per unit of nutrient applied. $ARE(\%) = (Nf - Nu/Na) * 100$

Where: Nf and Nu: Is N uptake (grain plus straw) of the fertilized and unfertilized plot (kg) Gf and Gu: Is the grain yield of the fertilized and unfertilized plots, respectively (kg) and Na: quantity of N applied (kg)

Crop Data Collection

At harvest, the following yield components were determined: plant height, spike length, number of productive tillers m^{-2}, number of grains per spike, above ground biomass, grain yield, straw yield, 1000 grain weight and harvest index. The grain yield was determined from each experimental plot and adjusted to constant moisture levels of 12%.

Economic Analysis

The cost of other production practices like, seed and weeding were assumed to remain the same or insignificant among the treatments. Analysis of marginal rate of return (MRR %) was carried out for non-dominated treatments, and the MRRs were compared to a minimum acceptable rate of return (MARR) of 100% in order to select the optimum treatment (CIMMYT, 1988). The net benefit per hectare for each treatment is the difference between the gross benefit and the total variable costs. The average yield was adjusted downward by 10% to reflect the difference between the experimental field and the expected yield at farmers' fields and with farmer's practices from the same treatments (CIMMYT, 1988).

Statistical Analysis

Analyses of variance (ANOVA) were carried out using Statistical Analysis Software (SAS) version 9.3, (SAS, 2014). Whenever treatment effects were significant, mean separations, made using the least significant difference (LSD) test at the 5% level of probability.

RESULTS AND DISCUSSION

Physicochemical Properties of the Experimental Field Soil

The analysis results indicated that the proportions of soil particle size distribution were 33, 31 and 35 % sand, silt and clay respectively with a clay loam .textural class (Table 1). The soil pH and exchangeable acidity (EA) were 5.54 (pH H_2O) and 0.33 mg/100g, respectively. The pH was moderately acidic (Tekalign, 1991) which suggests the presence of substantial quantity of exchangeable H^+ and Al^{3+} ions which is associated with acidity. Mengel and Kirkby (1996) found that the optimum soil pH values ranges from 4.1 to 7.4 were recommended for wheat and barley production.

The OC and TN% were 2.02 and 0.12 % respectively and rated moderate as per Tekalign (1991). Available P content of the site experimental is 8.51 mg kg^{-1} rated as low; and it is indicative of soil capable of significant yield responses to application of the appropriate level of the nutrient. Similarly, Olsen and Dean, (1965) stated as the P content of less than 12 P kg ha^{-1} in soil indicates a crop response to P fertilizers, between 12 and 24 kg P ha^{-1} indicates a probable response. The available S and B content of the site is 21.02 and 0.5 mg kg^{-1} respectively. According to Hazelton and Murphy, (2007) the cation exchange capacity (CEC) of the soil was 21.15 cmol (+) kg^{-1}, is low to moderate.

Effect of Blended Fertilizer on Yield and Yield Components

Data presented in Tables 2 showed that application of different blended fertilizers had significant influence ($P < 0.01$) on plant height, spike length, number of tillers per square meter and number of kernel per spike of barley with increasing blended fertilizers application rates. The maximum plant height (109.9 cm), spike length (7.1 cm), number of tillers per square meter (61.67) and number of kernel per spike (53) were obtained from application of 200 NPSB kg ha^{-1} blended fertilizer. Several authors, Dewal and Pareek (2004), Arif *et al.* (2006), Gupta *et al.* (2004), Bereket *et al.* (2014) report that maicro and micro nutrients (Nitrogen, Phousporous with Sulfur and Born) fertilizers application can increase plant height, spike length, number of tillers and number of kernel with increasing doses and combination.

Blended fertilizer supply had a marked effect on the aboveground biomass, grain yield, and straw yield (Table 3). The maximum aboveground biomass (12.63 t ha^{-1}) was obtained from 200NPSB kg ha^{-1} of blended fertilizer application. However, the lowest (4.29 t ha^{-1}) aboveground biomass was recorded from control or un-fertilized plot. This result agrees with the finding of Woubshet *et al.* (2017) who found that application of 150

Table 1. Chemical properties of experimental site soil

Particle size distribution %			Textural class	pH	TN	OC	Av. P	Av. S	B	CEC (Cmol (+) kg^{-1})
Sand	Silt	clay			%		mg kg^{-1}			
33	31	35	Clay loam	5.54	0.12	2.02	8.51	21.01	0.51	21.15

Table 2. Mean values of plant height, spike length, and number of seed per spike of barley as affected by different rates of blended fertilizers

Treatments (kg ha^{-1})	Plant Height (cm)	Spike length (cm)	Number of tillers (m^{-2})	Number kernel $spike^{-1}$
Control	66.19g	4.13f	30.67g	31.45e
Recommended NP	94.09bcde	5.73bcd	51.53fg	49.47abc
50 NPS	84.81ef	4.33ef	36.93bcd	40.27d
100 NPS	89.81cdef	5.32cde	43.33def	44.64dc
150 NPS	91.79cdef	5.33cde	49.33cde	49.30abc
200 NPS	96.59bcd	6.24abc	58.33abc	50.33abc
250 NPS	103.77abc	6.23abc	60.33ab	52.33ab
50 NPSB	82.15f	4.87def	39.47def	41.47d
100 NPSB	87.33def	5.03def	46.33def	45.53bcd
150 NPSB	96.28bcd	5.53cd	51.27bcd	49.16abc
200 NPSB	99.11abc	7.12a	61.67a	53.12a
250 NPSB	109.87a	6.63ab	61.33ab	51.01abc
LSD (0.05)	11.47	1.1	10.11	6.91
CV (%)	7.4	11.4	12.1	8.8

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; Means in a column followed by the same letters are not significantly different at 5% level of Significance

kg ha^{-1} NPSB blended fertilizer with compost increased the biomass by 11.5 t ha^{-1}. This due to Sulfur enhanced the formation of chlorophyll and encouraged vegetative growth and B helps in N absorption.

The maximum grain yield (4.91 t ha^{1}) was obtained from 200NPSB kg ha^{-1} of blended fertilizer application. Conversely, the lowest grains yield (1.45 t ha^{-1}) was perceived in control plot. The grain yield was 70.4% and 22.4% from recommended NP fertilizer and control by application of 200 NPSB kg ha^{-1} blended fertilizer. This result agrees with the previous finding of Woubshet *et al.* (2017) who reported that application of 150 kg ha^{-1} NPSB blended fertilizer with compost increase the grain yield by 4.8 t ha^{-1}. Klikocka *et al*. (2016) also found that a positive reaction of N and S fertilization on grain yield, which was the highest grain yield (5.40 t ha^{-1}) was obtained due to application of 80 N kg ha^{-1} increasing by 1.30 t ha^{-1} (13.1%) with respect to the control and S fertilization increased grain yield by 3.58%. Besides, Khan *et al.* (2006) reported 43% raise in grain yield with the addition of 90 kg P and 60 kg ha^{-1} S. Likewise, according to Malakouti (2000) repotted that the grain yield increased due to application of boron was also witnessed by the combined application of boron with micro nutrients, with the benefits 4 to 11% wheat yield.

Application blended fertilizers resulted in significant yield influence on straw yield of barley. The maximum (12.73 t ha^{-1}) and the minimum (2.48 t ha^{-1}) straw yield were attained from application 200NPSB kg ha^{-1} of blended fertilizer and control respectively. This result agrees with the finding of Woubshet *et al.* (2017) who reported that application of 150 kg ha^{-1} NPSB blended fertilizer with compost increase the straw yield by 5.9 t ha^{-1}.

The results showed that effect of blended fertilizer on harvest index was not significant (Table 3). The mean

Table 3. Mean values of aboveground biomass, grain yield Straw yield and Harvest index of barley as affected by different rates of blended fertilizers

Treatments (kg ha^{-1})	AGBM t ha^{-1}	GY t ha^{-1}	SY t ha^{-1}	HI (%)
Control	4.29e	1.45g	2.48d	34.23
Recommended NP	10.71b	3.81bc	6.93ab	35.57
50 NPS	7.19d	2.33ef	3.91cd	33.11
100 NPS	8.22c	2.96de	5.26bc	36.47
150 NPS	10.58b	3.33cd	7.24a	31.51
200 NPS	11.42ab	4.43ab	6.98a	38.83
250 NPS	11.50ab	4.33ab	7.16a	37.69
50 NPSB	6.42c	2.24f	4.22c	34.26
100 NPSB	10.14b	3.18cd	4.96c	31.92
150 NPSB	10.81b	3.59cd	7.21ab	33.84
200 NPSB	12.63a	4.91a	7.73a	38.79
250 NPSB	11.81ab	4.45ab	7.36a	38.55
LSD (0.05)	1.89	0.73	1.67	12.19
CV (%)	9.9	12.7	16.5	18.6

LSD (0.05): least significant difference at 5% level; CV: coefficient of Variation; Means in a column followed by the same letters are not significantly different at 5% level of Significance; AGBM:aboveground biomass, GY: grain yield, SY: straw yield and HI: harvest index

value of the data showed that the harvest index ranged from 31.1 to 38.8%, the maximum 38.8% harvest index was recorded from plots treated with 250 NPSB, 200 NPSB, 200 NPS, and 250 NPSkg ha^{-1} blended fertilizers. Tahir *et al.* (2009) articulated that a higher transfer of assimilates to the grain would maximize the harvest index and reduce the proportion of dry matter produced. The higher barley harvest index with increased fertilizer rate might be due to higher grain yield per plant at higher fertilizer rates.

According to the results, the maximum (43.97 gm) 1000 kernels weight were obtained from the application of 200 NPSB kg ha^{-1} blended fertilizers treatment. Whereas, the lowest (28.37 gm) 1000 kernels weight was obtained from control. This result was in line with the findings of Tilahun *et al*. (1996) who indicated that 2.2 to 10% higher grain weights were obtained with the application of 60-120 N kg ha^{-1} depending on the location and climatic condition of the growing season.

Application of different types of blended fertilizers significantly influence apparent nutrient recovery and agronomic nutrient use efficiency on barley (Table 4). Both apparent nutrient recovery and agronomic nutrient use efficiency consistently decreased with increasing blended fertilizers rates. Hence, apparent nutrient recovery and agronomic nutrient use efficiency was obtained at 100 and 50 Kg ha^{-1} NPSB blended fertilizers respectively. This is in line with the finding of Jones *et al.* (2011) who stated matching appropriate essential macro and micronutrients with crop nutrient uptake could optimize nutrient use efficiency and crop yield. Malakouti, (2008) also reported that application of suitable micronutrients increases use efficiency for different crops.

Economic Analysis

The market price of barley grain was 12.00 Eth-birr kg^{-1} and prices for blended fertilizers NPS, NPSB, TSP, and Urea were 11.55, 11.99, 10.23, and 9.1 Eth-birr kg^{-1}, respectively. While the cost of other production practices like seed and weeding were assumed to remain the same or insignificant among the treatments. The highest net return of 52068.00 Eth-birr with highest MRR value of (2277.3%) was obtained from plot treated with 200 kg ha^{-1} NPSB was economically superior and profitable than the rest of the treatments (Table 5). This recommendation is also supported by CIMMYT (1988) which stated that farmers should be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return.

Table 4. Effect of balanced fertilizers on ANUE and NRE

Treatments code	Nutrient applied (kg ha^{-1})	Yield (kg ha^{-1})	ANUE(kg ha^{-1})	ANR %
Control	0	1450		
RNP	84.1	3800	28.0	243.3
50 NPS	21.3	2330	41.3	279.0
100 NPS	42.6	2960	35.5	290.7
150 NPS	63.9	3330	29.4	338.4
200 NPS	85.2	4430	35.0	326.6
250 NPS	106.5	4330	27.1	246.1
50 NPSB	20.3	2200	37.0	377.7
100 NPSB	40.6	3180	42.7	314.6
150 NPSB	57.5	3590	37.2	376.8
200 NPSB	81.1	4900	42.5	339.6
250 NPSB	101.4	4450	29.6	271.7

Where: ANUE: agronomic nutrient use efficiency, ANR: apparent nutrient recovery and RNP: recommended nitrogen and phosphorous.

Table 5. Economic analysis of blended fertilizer and recommended NP in terms of partial budget and marginal rate of return (MRR) for food barley production

Treatments (kg ha^{-1})	Yield (kg/ha)			GB (Eth-Birr/ha)			TVC (Eth-Birr/ha)	NB (Eth-Birr/ha)	MRR (%)	D
	Av. G	Ad. G	Straw	Grain	Straw	(G+S)				
Control	1450	1305	496	15660	496	16156.00	0	16156.00	-	
RNP	3800	3420	1380	41040	1380	37460.00	2480.00	39940.00	959.0	
50 NPS	2330	2097	782	25164	782	24791.00	577.50	25368.51	-	D
100 NPS	2960	2664	1052	31968	1052	30710.00	1155.00	31865.02	609.4	
150 NPS	3330	2997	1448	35964	1448	33947.00	1732.50	35679.54	220.2	
200 NPS	4430	3987	1396	47844	1396	44620.00	2310.00	46930.01	1948.2	
250NPS	4330	3897	1432	46764	1432	42201.00	2997.50	45198.51	-	D
50 NPSB	2200	1980	844	23760	844	23405.00	599.50	24004.50	-	D
100 NPSB	3180	2862	992	34344	992	32938.00	1199.00	34137.00	1151. 5	
150 NPSB	3590	3231	1442	38772	1442	36617.00	1798.50	38415.50	713.7	
200 NPSB	4900	4410	1546	52920	1546	49670.00	2398	52068.00	2277.3	
250 NPSB	4450	4005	1472	48060	1472	43537.00	2997.5	46534.50	-	D

***Where**: net benefit Av. G: Average yield and Ad. G: Adjusted yield kg ha^{-1}; RNP: recommended Nitrogen & Phosphorous; GB: Gross benefit AV.G: average grain yield; Ad.G: adjusted grain yield; G: grain; S: straw; TVC**:** Total Variable Cost; NB: net benefit; MRR%: marginal rate of return: dominated,*

***N.B**: Prices of Urea: 9.99 birr/kg, NPS: 11.55, NPSB: 11.99, TSP: 11.15 birr/kg, Price of barley: 12 birr/kg, Price of straw: 0.20 birr/kg. Family labor cost was not assigned cost but similar labor time was used on each treatments.*

CONCLUSIONS AND RECOMMENDATIONS

In Ethiopia food, barley production and productivity have been limited mainly due to declining soil fertility, unbalanced application of plant nutrients, and application of fertilizer without soil test base and crop response and use of inappropriate fertilizer recommendations. The experiment was done to evaluate the response of different blended fertilizers on yield and yield components of food barley (*Hordeum vulgare l.)* on Nitisols at Hulla district, Southern Ethiopia.

The findings of the study revealed that the growth, yield and yield components of barley responded positively and significantly to the application of different rates of blended fertilizers. Results from the experiment shown that the application of different blended fertilizers fertilizer rates significantly Thus, the highest (4.9 t ha^{-1}) grain yield response were obtained from the application of 200 kg ha^{-1} of NPSB blended fertilizer and was superior on grain yield by 22.4 % and 70.4 % to recommended NP fertilizer and control, respectively. In terms of economic feasibility, application of 200 kg $ha^{-1}$of NPSB blended fertilizer accrued the highest net return of 52068.00 Eth-birr ha^{-1} with MRR of 2277.3% and advisable for farmers to maximize barley grain yield kg ha^{-1} and economic return. Therefore, based on the yield response and economic indicators, it is recommended to apply 200 NPSB kg ha^{-1} blended fertilization at Hulla district, Southern Ethiopia and areas with the same soil conditions and agro-ecology.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests

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REFERENCES

Abiye A., Tekalign M., D. Peden, and M. Diedhiou. (2004). Participatory on-farm conservation tillage trial in Ethiopian highland vertisols: Impact of potassium application on crop yield. Expl. Agriculture. 40:369-379.

Arif M, Ali S, Khan A, JanT and Akbar M. (2006). Influence of farmyard manure application on various wheat cultivars. Sarhad Journal of Agriculture 22(1):27-29.

Bereket H., Dawit H., Mehretab H. and Gebremedhin. G. (2014). Effects of Mineral Nitrogen and Phosphorus Fertilizers on Yield and Nutrient Utilization of Bread Wheat on the Sandy Soils of Hawzen District, Northern Ethiopia. Agriculture, Forestry, and Fisheries. 3 (3) 2014, pp 189-198.

Black, C.A. (19650. Methods of soil analysis Part 2, Am. Soc Agronomy. Madison, Wisconsin, U.S.A.

CIMMYT. (1988). From agronomic data to farmer's recommendations: economics training manual. Completely revised edition, CIMMYT, Mexico. D.F. 79 pp.

CSA (Central Statistical Agency). (2014). Agricultural sample survey. Vol. I. Report on area and production for major crops (private peasant holdings, meher season). Statistical Bulletin 532, Central Statistical Agency. Addis Ababa, Ethiopia.

Dewal, G. S. and Pareek R. G. (2004). Effect of phosphorus, Sulphur, and zinc on growth, yield and nutrient uptake of wheat (*Triticum aestivum L.).* Indian J. Agronomy. 49: 160-162.

Ethio-SIS (Ethiopia Soil Fertility Status). (2016). Fertilizer Recommendation Atlas of the Southern Nations, Nationalities and Peoples' Regional State, Ethiopia. pp 81.

Fageria NK, Baligar VC. (2003). Methodology for evaluation of lowland rice genotypes for nitrogen use efficiency. Journal of Plant Nutrition 26: 1315-1333.

FAO-WRB (Food and Agriculture Organization of the United Nation) World reference base for soil resources), (1998). World reference base for soil resources. World soil report. No. 84. Rome. pp 88.

Gupta V.K, Kumar S., and Singh A.K. (2004). Yield and quality of wheat (*Triticum aestivum L.*) as influenced by Sulphur nutrition and weed management. Indian J. Agric. Sci. 74 (5) 254-256.

Havlin J.L, J.D Beaton, S.L Tisdale, W.L Nelson. (1999). Soil fertility and fertilizers: An introduction to nutrient management. Prentice Hall, New York, 499p.

Hazelton, P., and B. Murphy, (2007). Interpreting soil test results: What do all the numbers mean 2nd Edition. CSIRO Publishing. 152p.

Malakouti, M.J. (2000). Balanced nutrition of wheat: An approach towards self-sufficiency and enhancement of national health. "A compilation of papers". Ministry of Agriculture, Karaj, Iran. 544 pp.

Jones, C., Olson, R and Dinkins, C. (2011). Nutrient uptake timing by crops: to assist with fertilizing decisions. Montana State University, pp 2-8.

Khan, M.J., M. H. Khan, and R. A. Khattak. (2006). Response of Maize to different levels of Sulfur. Soil Sci and Plant Anal, 37:41-51.

Klikocka, H.,Cybulska M., Barczak B., Narolski B., Szostak B., Kobiałka A., Nowak A., and Wojcik. E. (2016). The effect of Sulphur and nitrogen fertilization on grain yield and technological quality of spring wheat Plant Soil Environ.

Malakouti, M. J. (2008). The effect of micronutrients in ensuring efficient use of macronutrients. Turk J. Agric., 32:215-220.

McLean, E. O. (1965). Aluminum. In Methods of Soil Analysis: Part 2. Chemical Methods, 978-998 (Ed C. A. Black). Madison ASA.

Mengel, K. and E. A. Kirkby, (1996). Principles of plant nutrition, panimo publishing corporation, New Delhi, India.

Olsen S.R and Dean L.A. (1965). Phosphorus. In: Methods of soil analysis. Agronomy 9: pp 920-926. Amer. Soc. Argon., Madison, Wisconsin, USA.

Olsen S.R., and L.E. Sommers. (1982). Phosphorus. Methods of soil analysis, Part 2. (2nd eds), pp. 403-429. Amer. Soc. Agronomy, Madison, Wisconsin.

Sahlemedhin S. and Taye B. (2000). Procedures for soil

and plant analysis. National soil research center tech. Paper, 74110 p. NFIA, Addis Ababa, Ethiopia.
SAS (Statistical Analysis System Institute). (2014). SAS Version 9.4 © 2002-2012. SAS Institute, Inc., Cary, North Carolina, USA.
Tahir M., Tanveer A, Shah T, Fiaz N, and Wasaya A. (2009). Yield response of wheat (*Triticum aestivum L.)* to Boron application at different growth stages. Pak. J. Life Soc. Sci. 7:39-42.
Tekalign M. and I. Haque. (1991). Phosphorus status of some Ethiopian soils, II. Forms and distribution of inorganic phosphates and their relation to available phosphorus. Tropical Agriculture. 68: 1:2-8.
Tilahun G., Tanner D.G., Tekalign M and Getinet G. (1996). The response of rain fed bread and durum wheat to the source, level, and timing of nitrogen fertilizer at two Vertisol sites in Ethiopia. pp. 127-147.
Van Reeuwijk. (2002). Procedures for Soil Analysis (6th Eds.). FAO, International soil reference and information Center. 6700 A. J. Wageningen, Netherlands.
Wakene N., G. Fite, D. Abdena and D. Berhanu. (2007). Integrated use of organic and inorganic fertilizers for Maize production. Utilization of diversity in land use systems: Sustainable and organic approaches to meet human needs. Tropentag 2007, 2007. Witzenhausen
Walkley A, and Black C.A. (1934). An examination of different methods for determining soil organic matter and proposed modifications by the chromic acid titration method. Soil Sci. 37:29-38.
Woldeyesus S, Chilot Y. and Rezene F. (2002). On-farm fertilizer trial on food barley in Wolemera area. pp 266–279, Proceedings of a client-oriented research evaluation workshop. Holetta Agricultural Research Centre, Holetta, Ethiopia.
Woubshet D., Selamyihun K. and Cherukuri V. (2017). Effect of integrated use of lime, blended fertilizer, and compost on productivity, nutrient removal and economics of barley *(Hordeum vulgare L.)* on acid soils of high lands in West Showa Zone of Ethiopia. Int. J. of Life Sciences, 2017, Vol. 5 (3): 311-322.
Yihenew G. (2002). Selected chemical and physical characteristics of soil Adet research center and its testing sites in north-western Ethiopia.