World Journal of Agricultural Sciences 17 (4): 268-277, 2021
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2021.268.277

Effect of NPS Fertilizer Rates on Uptake and Use Efficiency of Food Barley (*Hordeum vulgare* L.) Varieties at Welmera District, Central Highlands of Ethiopia

Abdisa Mekonnen and Negessa Gadisa

Ethiopian Institute of Agricultural Research (EIAR),
Holeta Agricultural Research Center (HARC), P.O. Box: 31, Holeta, Ethiopia

Abstract: Nutrient use efficiency may be defined as yield per unit fertilizer input or in terms of recovery of fertilizer applied. It can also be defined as the nutrient recovered in the above ground part of the plant. Adequate amount and forms of blended fertilizer and crop management strategies that improve nutrient concentration, uptake and nutrient use efficiency (NUE) boosting income and ultimately increases profit as a whole, while reducing the detrimental effects on the environment associated with NPS fertilizer loss. Efficient blended NPS fertilizers management should include several critical factors that are very interrelated. The experiment was conducted at Holeta Agricultural Research Center (HARC), Welmera district, to evaluate the effects of varieties and blended NPS fertilizer rates on NPS uptake and NPS use efficiency of food barley varieties. Eighteen (18) treatments were evaluated in a factorial arrangement with Randomized complete block design (RCBD) with three replications. Results of data analyzed showed that NPS uptake was highest at 150 kg NPS ha^{-1} with HB1966 variety and nutrient use efficiency was maximum at 100 kg NPS ha^{-1} with HB 1966 variety and both agronomic NPS efficiency and apparent recovery efficiency were highest at 100 kg NPS ha^{-1} with EH1493 variety.

Key words: Food Barley · NPS Uptake · NPS Use Efficiency · Nutrient · Nitisol

INTRODUCTION

Crop management strategies that improve nutrient use efficiency obviously increase farm profits while reducing the detrimental effects on the environment associated with fertilizer loss [1]. Muhammad *et al.* [2] reported that nutrient uptake of nitrogen, phosphorus and S increased significantly with the application of P and S. Nutrient uptake efficiency refers to the ratio of Nutrient in the biomass to the nutrient in fertilizer/soil while nutrient utilization efficiency is the amount of grain yield produced per unit of nutrient recovered in the biomass [3]. It has been reported that about 90% of P is supplied by diffusion and about 10% is supplied by mass flow and root interception. Fixation of P results in low uptake of fertilizer P during year of application. Therefore, repeated use of P fertilizers results in increase in soil P content and in many instance, soils become sufficiently high in P to the extent that plants do not respond to fertilizer. Fageria *et al*. [3] reported that adequate and fertilizer form of fertilizer absolutely enhances the total nutrient uptake of N. At the time productivity of the crop that is treatment that accumulate maximum nutrient gave highest yield with linear increasing the rate of N fertilizer.

However, P fertilizer had little effect on either grain or straw P contents, while N fertilizer had positive effect on grain and straw P contents of the test crop. Taye *et al.* [4] reported linear and quadratic responses of straw yield to N rates with mean values ranging from 2324 to 4074 kg ha^{-1} during favorable growing season. Jones *et al.* [5] stated matching essential macronutrients with crop nutrient uptake could optimize nutrient use efficiency and crop yield. Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems [6]. Fertilizer use efficiency reflects the recovery of applied fertilizer by the crop, however from the crop perspective, Nitrogen (or other nutrient) use efficiency is a measure of biomass produced as a function of the N (other nutrient) available to that crop [7]. Cereals need substantial amount of N before they respond to S.

Corresponding Author: Abdisa Mekonnen, Ethiopian Institute of Agricultural Research (EIAR), Holeta Agricultural Research Center (HARC), P.O. Box: 31, Holeta, Ethiopia.

Application of S resulted in greater response to applied N, showing a positive synergy between N and S. Kiros and Singh [8] reported yield increase of 0.8-2.4 kg ha^{-1} of wheat with increased nitrogen use efficiency (NUE) of 28 % due to applied N and S in Ethiopia. Sulfur is also essential for nutrient use efficiency (NUE) and ranks equal to N for optimum crop yield and quality. It is reported to be necessary for the formation of chlorophyll, vitamins, enzymes and aromatic oils [9]. Roberts [10] revealed that nutrient use efficiency is high at a low yield level, because any small amount of nutrient applied could give a large response. Increasing levels of fertilizer NPS, agronomic efficiency and physiological efficiency decreased. Fertilizer use efficiency for different crops increased by the application of suitable micronutrients [11]. Agronomic efficiency (AE) is a measure of the dry matter assimilated in the grain in response to applied fertilizer (grain yield per supplied Nutrients). Agronomic Efficiency is a measure how grain yields are affected by nutrient applications [12]. It more closely reflects the direct production impact of an applied fertilizer and relates directly to economic return. It is calculated in units of yield increase per unit of nutrient applied. In high agronomic efficiency would be obtained if the yield increment per unit applied is high [3]. Maximum agronomic efficiency of N recorded at lower rate of Mekonnen Asirat [13].

Apparent recovery efficiency is a measure of the ability of the crop to extract Nutrient from the soil [6]. It is most commonly defined as the difference in nutrient uptake in above-ground parts of the plant between the fertilized and unfertilized crop relative to the quantity of nutrient applied. It is often the preferred nutrient use efficiency expression by scientists studying the nutrient response of the crop. Endalkachew [14] reported that the AR efficiency of P due to P fertilizer application was 45.5% when 10 kg P ha^{-1} was applied and declined to 29.93% when the P rate was increased to 30 P kg ha^{-1}.

Use of various fertilizers has made a tremendous contribution in enhancing food production. It has been estimated that nutrient inputs are responsible for crop yield. However, the issues such as low nutrient use efficiency and associated environmental pollution and global warming have raised serious concerns about the current nutrient management practices. The major reasons for low and declining crop responses to fertilizer nutrients include continuous nutrient mining from the soil due to imbalanced nutrient use (7:2.8:1 NPK) leading to depletion of some of the major, secondary and micro nutrients like N, K, S, Zn, Mn, Fe etc., decreasing use of organic nutrient sources such as Vermicomposting or compost and integration of these sources with chemical fertilizers in cropping systems leading to serious soil fertility depletion. Proper soil nutrient management is useful to increase the performance of crop, provide economically optimum nourishment to the crop and minimize nutrient losses from the field and supporting agricultural system sustainability. Cropping system, soil and water management, use of appropriate NPS fertilizer source and rate based on crop variety and soil type are among the main management options to increase NPS fertilizer use efficiency [15].

The recommendations developed tell about the amounts of different nutrients required on hectare basis and their time of application. Such blanket recommendations which largely did not take into account the variability in the inherent soil fertility and other edaphic characteristics resulted into over-application of nutrients in some pockets and under-application in others. This resulted in wastage of fertilizers and low nutrient use efficiency. Research conducted in different area has depicted the limitations of the conventional approach of fixed-rate and fixed-time (blanket) fertilizer recommendations. However, recognizing the flaws of the blanket recommendations of nutrients, the concept of SSNM of nutrients was developed. Therefore, the study was conducted to evaluate effect of NPS fertilizer rates on uptake and use efficiency of food barley (*Hordeum vulgare* L.) varieties at Welmera District.

MATERIALS AND METHODS

Description of the Study Area: The experiment was conducted at Holetta agricultural research center, Welmera district, Oromia National Regional State, special zone around Fifinne (Addis Ababa), in highland of Ethiopia (Figure 1). Holetta Agricultural Research Center (HARC) is located at 09°03' 19.4''N latitude and 38°30' 25.43''E longitudes and altitude of 2400 masl site. The study was conducted in 2019 main cropping season at Holetta agricultural research center on station. It is found in Walmera district, Oromia special Zone around Fifinne and 29 km away from Fifinne. According to Ethiopian agro-ecological classification the experimental site is grouped under *Dega,* the soil type is *Nitisols* [16]. According to the weather record from the National Meteorological Services Agency (NMSA) and Holetta Agricultural Research Center (HARC) the annual rainfall and annual mean minimum and maximum temperatures of the area based on the last 10 years (2009-2018) records were 1044 mm and 7.7 and 22.9°C, respectively and mean relative humidity of 62% [17]. The main rainy season is from June to September and accounts for 70% of the annual rainfall (Figure 1).

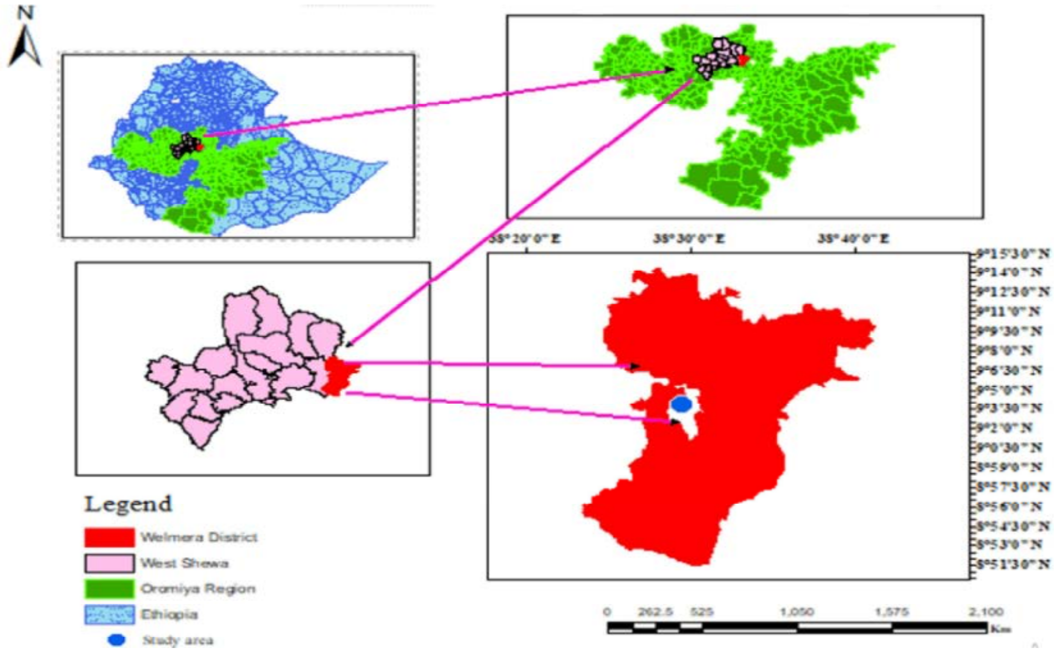

Fig. 1: Map of the Study Area

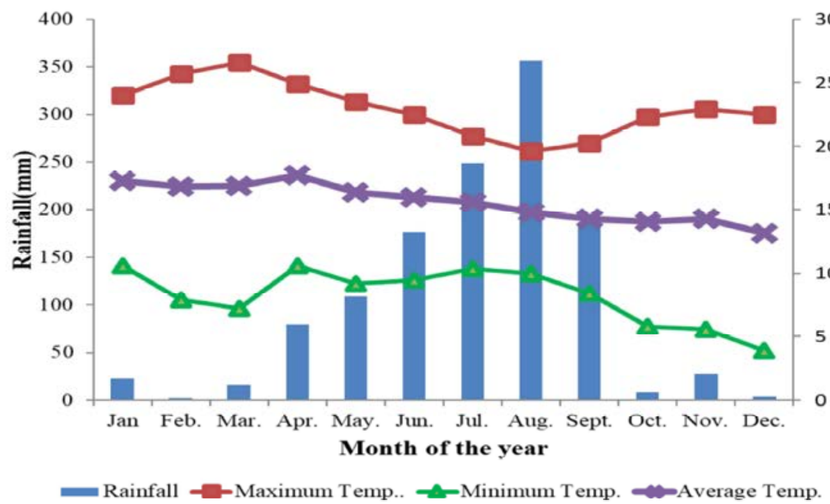

Fig. 2: Mean monthly meteorological data of the study area

Description of Experimental Materials

Plant Materials: Seeds of three food barley varieties namely HB-1966, EH-1493 and HB-1307 were used for the study material. The varieties were obtained from Holetta Agricultural Research center (HARC). They have relatively the same area of adaption and growing period.

Fertilizer Materials: Application of nitrogen fertilizer from urea at the rate of 60 kg N ha^{-1} was used for all treatments as per recommended by Getachew Agegnehu *et al.,* [18]. Recommended NP (60kgN and 69kg P_2O_5 ha^{-1}) and NPS fertilizer contents (18.9% N kg ha^{-1}, 37.7% P_2O_5 kg ha^{-1} & 6.95% S kg ha^{-1}) were used for the study.

Treatments and Experimental Design: The treatments consists of three varieties of food barley HB1966, EH1493 and HB-1307 and five levels of NPS blended fertilizer (0, 100, 150, 200 and 250 kg NPS ha^{-1}) and recommended NP (60kgN/ha and 69kg P_2O_5/ha) (Table 2). The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement with three replications. The size of each plot was 6m^2 (3m x 2m) and plots and blocks were at the distance of 0.5 and 1m apart, respectively. The spacing between rows of barley plant was 0.20m. Each plot consisted of 15 rows. Barley plants in the 11 inner most rows at central one as well as 0.40m on both end of central rows were considered border plants and not considered for data collection. The net plot area that was used for data collection consisted of 11rows (1.6 x 2.2) with a total area of 3.52m^2.

Experimental Procedures: The experimental land was prepared by ploughing with machinery. Fine seed beds were prepared and leveled manually and rows were made across each plot. After the layout, the plots were leveled manually; treatment was assigned randomly each to the experimental plots within a block. The levels of each blended fertilizer formulations (NPS) (0, 100, 150, 200 and 250 kg ha^{-1}) and recommended NP were applied with full dose of basal application based on treatments. The full dose of NPS were applied at planting time close to the seed drilling line, while to avoid N losses by leaching, N fertilizer in the form of urea was applied in split application, half at planting time and the remaining half N fertilizer was top dressed at 35 days after planting and second weeding in the form of urea. Application of nitrogen fertilizer from urea at the rate of 60 kg N ha^{-1} was used for all treatments as per recommended [18]. Three food barley varieties namely HB1966, EH1493 and HB-1307 were drilled at the rate of 125 kg ha^{-1} in rows 20cm apart, respectively in 11th July, 2019. The study area has high rainfall and this excessive rainfall removes exchangeable basic ions like Ca, Mg, Na and K from the surface of soil and acid formation takes place by reducing pH of soil. Therefore, based on the exchangeable acidity of soil, required lime was applied according to the following formulae:

$$\text{LR } CaCO_3 \text{ (Kg/ha)} = \frac{\text{EA(Cmol)/Kg of soil depth (m)} * \text{area } (m^2)\text{BD}(Mg/m^3) * 1000}{2000} \quad (1)$$

where LR = Lime requirement, EA = exchangeable acidity (2.32), BD = bulk density with value = 1.2 correction factor (CF) for cereal crops1.5.

Based on the above formula (2.5 kg plot^{-1}) lime ($CaCO_3$) were evenly broadcasted manually and mixed thoroughly in upper soils at 15cm below depth applied uniformly for all experimental units one month before sowing, cultivation and weeds were removed by hand when required. Rouging of lately emerging grasses and off-type plants was done to avoid interference with the barley cultivars. All other recommended cultural practices for the test crops were done as per the recommendation of the area.

Data Collection and Analysis

Soil Sampling and Analysis: Composite soil sample was taken before planting to determine available plant nutrients in the soil. Samples were randomly collected in a zigzag pattern before sowing from a depth of 0-20cm. Similarly, surface soil samples of the same depth were collected after harvest from each plot by taking samples from three points within each plot and composited for analysis. The soil samples were air dried, grounded using a pestle and mortar and allowed to pass through a 2mm sieve. Selected physico-chemical properties mainly texture (particle size), soil pH, cation exchangeable capacity (CEC), organic carbon, total N, available P and S was analyzed at Holeta Agricultural Research Center (HARC), soil and plant nutrient analysis laboratory.

Particle size distribution was determined using the Bouyoucos hydrometer method. Organic carbon was determined by Potassium dichromate method [19]. Total nitrogen was analyzed by Micro-kjeldahal method [19]. The pH of the soil was determined at 1:2.5 (weight/volume) soils to water dilution ratio using a glass electrode attached to digital pH meter [20]. Cation exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH_4OAC) and displacing it with 1N NaOAC. Available phosphorus was determined using the Bray method [21]. Available sulfur was determined by turbid metric method.

Plant Tissue Sampling, Preparation and Analysis: At maturity, ten non-boarder barley plant samples were randomly collected from net plots of each plot and partitioned into grain and straw. The straw samples were washed with distilled water to clean the samples from contaminants such as dust. The grain and straw samples were oven dried at 70°C to constant weight. Oven dried plant samples were ground with the help of Willy mill grinder. After grinding the sample was passed through 0.5 mm sieve. Then, the grains and straw samples were analyzed for nitrogen, phosphorus and sulphur content following wet digestion using Kjedahl method as described by, Calorimetric (Vando-Molybdate) Method [22] and Turbidimetric determination of sulfur in plant tissue [23].

NPS Uptake and Use Efficiency Indices

N, P and S Uptake and Use Efficiency: Total NPS uptake was calculated as the sum of the respective grain NPS uptake and straw NPS uptake values. Then, NPS use efficiency parameters by the crop were determined using the formulae described by Fageria and Baligar [6].

$$NUG \text{ (kg ha}^{-1}\text{)} = AV.GY * \frac{NCG}{100} \quad (2)$$

where, NUG nitrogen uptake of grain, Av.GY average grain yields (kg ha^{-1}), NCG nitrogen concentration of grain in percent.

$$\text{NUS (kg ha}^{-1}\text{)} \; AV.SY * \frac{NCS}{100} \quad (3)$$

where NUS nitrogen uptake of straw, Av.SY average grain straw, NCS nitrogen concentration of straw in percent.

$$\text{TNU (kg ha}^{-1}\text{)} = \text{NUG+NUS} \quad (4)$$

where TNU total nitrogen uptake, NUG nitrogen uptake of grain, NUS nitrogen of straw.

Nitrogen Use Efficiency (NUE) is Weight of grain per unit of total nitrogen supplied determined as follows:

$$\text{NUE (kg/kg)} = \frac{Grain\ Yield}{Total\ N\ Spplied} *100 \quad (5)$$

Agronomic Efficiency (*kg/ kg*): It expressed as units increase in economic yield per unit N fertilizer applied was calculated as:

$$\text{AE (kg/kg)} = \frac{Gyf - Gyu}{Na} \quad (6)$$

AE stands for agronomic efficiency, Gyf and Gyu for grain yield in fertilized and unfertilized plots, respectively and Na for quantity of fertilizer applied.

Apparent Fertilizer N Recovery Efficiency (%): It indicates the quantity of nutrient uptake per unit of nutrient applied and was calculated as:

$$\text{ARE (\%)} = \frac{Nf - Nu}{Na} *100 \quad (7)$$

where Nf is the total N uptake of the fertilized plot (kg), Nu is the total N uptake of unfertilized plot (kg) and Na is the quantity of N applied (kg).

Data Analysis and Interpretation: The collected data were subjected to Analysis of Variance (ANOVA) using SAS version 9.3 statistical software programs. Comparisons among treatment means with significant difference for measured and scored characters were made using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Soil Physico-Chemical Properties of the Experimental Site: Soil analysis for physical and chemical properties with specific parameters relevant to the current study was carried out at Holeta Agricultural Research Center (HARC) soil laboratory (Table 1).

Effects of NPS Fertilizer and Varieties on N-use Efficiency Parameters

Interaction of Varieties and NPS Fertilizer on N, P and S Concentration and Uptake: Nutrient uptake of nitrogen was significantly affected by the main effect of variety (($P < 0.05$) and NPS rates ($p < 0.05$). Likewise, the two-way interaction effect of NPS * varieties ($p < 0.05$)) also significantly ($p < 0.05$) influenced total nitrogen uptake (Table 2).The highest (75.62) grain nitrogen uptake was recorded from plot that received 150 kg NPS ha^{-1} and HB1966 variety, highest (15.79) grain uptake of phosphorous was recorded at 200 NPS kg ha^{-1} with EH1493 variety and highest (6.54) grain uptake of sulfur was obtained at 250 NPS kg ha^{-1} with HB1966 variety. The lowest (34.10) grain nitrogen uptake, grain phosphorus uptake (8.14) was obtained from combination of EH 1493 variety and control plot and lowest (2.65) grain sulfur uptake was recorded at control plot with HB-1307 variety; nutrient uptake from the soil was depending on barley varieties.

Total Nitrogen Uptake (TnuP): Total uptake of nitrogen was significantly affected by the main effect of variety (($P < 0.05$) and NPS rates ($p < 0.05$). Likewise, the two-way interaction effect of NPS * varieties ($p < 0.05$)) also significantly ($p < 0.05$) influenced total nitrogen uptake (Table 3). The highest (101.90) total nitrogen uptake was recorded from plot that received 150 kg NPS ha^{-1} and HB-1966 variety. The lowest (47.27) total nitrogen uptake was obtained from combination of EH 1493 variety and control or unfertilized plot and nitrogen uptake from the soil was depending on barley varieties.

The result was clearly indicates that positive effects of applied Nitrogen, phosphorous and Sulfur on food barley. This shows that as the rate of fertilizer applied increases up to optimum level, nutrient uptake of grain and straw was also increase. Fageria [3] reported that adequate and form of fertilizer absolutely enhances the total nitrogen uptake up to optimum level. According to Mensah *et al*. [24] who stated that N and P fertilization

Table 1: Selected soil physical and chemical characteristics of the study area before sowing

Soil physical properties		Value	Methodology
Sand (%)	11.5		
Silt (%)	20		
Clay (%)	68.5		
		Clay	Rowell, (1994)
Soil chemical properties	Value	Rate	
pH (1:2.5 H_2o)	4.71	Highly acidic	Potentiometric (Davis, 1943)
TN (%)	0.18	Medium	Kjeldhal (Jackson, 1970)
Organic carbon (%)	1.26	Low	Walkely and Black (Jackson, 1970)
Organic matter (%)	2.17	Low	OC * by 1.72 (Broadbent, 1953)
Available phosphorous (ppm)	13.46	Low	Bray II (1945)
Available Sulfur (ppm)	0.018	Low	Turib (EthioSIS, 2014)
CEC (cmol/kg)	16.42	Medium	Ammoni (USDA, 1989)

CEC=Cation exchange capacity, OC=Organic carbon, OM= Organic Matter, TN=Total nitrogen, Av.P= Available Phosphorus, Av.P=Available Sulfur

Table 2: Interaction of Varieties and NPS- Fertilizer Levels on Uptake of Nitrogen, Phosphorus and Sulfur

Treatments		Nutrient Uptake (kg ha^{-1})					
		N		P		S	
Variety	NPS Level	Grain	Straw	Grain	Straw	Grain	Straw
EH1493	0	34.10h	13.17hi	8.14h	0.42i	3.88de	0.41g
	100	53.51f	21.34cd	12.28ef	2.38bcd	4.61bcd	2.13e
	150	60.17e	25.94b	12.43def	2.87a	6.48a	4.74a
	200	68.96bc	26.06b	15.79a	2.57bc	5.19b	4.61a
	250	60.41e	22.88c	13.70cde	2.37cd	4.73bcd	2.42cde
	Rec.NP	50.80f	30.85a	10.96fg	2.23de	3.34efg	2.25de
HB1307	0	40.28g	12.31i	9.44gh	1.02h	2.65fg	0g
	100	44.78g	20.34cde	10.26g	2.33cd	2.51g	3.03bcd
	150	76.39a	17.66fg	14.60abc	1.92f	4.90bc	3.14bc
	200	63.58dc	15.35gh	14.75abc	2.33cd	3.48ef	3.33b
	250	66.27cd	18.76ef	15.44ab	2.23de	4.71bcd	3.35b
	Rec.NP	68.03cd	15.51gh	14.61abc	1.63g	4.65bcd	2.99bcd
HB1966	0	51.58f	13.17hi	10.99fg	0.28i	2.66fg	2.32de
	100	63.66de	11.72i	15.26abc	2.37cd	3.92de	1.28f
	150	75.62a	26.27b	14.94abc	2.62b	5.49b	3.35b
	200	73.73ab	22.84c	15.67a	2.08ef	5.06b	3.14bc
	250	58.92e	20.20def	13.99bcd	1.47g	6.54a	3.15bc
	Rec.NP	75.41a	21.78cd	13.78cde	1.66g	3.98cde	1.81ef
LCD (5%)		5.17	2.57	1.58	0.24	0.96	0.81
CV (%)		5.17	7.84	7.24	7.49	13.31	18

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P= Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

Table 3: Interaction of Varieties and NPS Fertilizer Levels on Total Nitrogen Uptake

Treatments	TnuP (kg ha^{-1})					
	NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	47.27^{g}	74.85^{e}	86.12^{c}	95.03^{b}	83.30^{cd}	81.66^{cd}
HB-1307	52.59^{g}	65.13^{f}	94.06^{b}	78.93^{de}	85.03^{c}	83.55^{cd}
HB-1966	64.75^{f}	75.39^{e}	101.90^{a}	96.58^{ab}	79.14^{de}	97.21^{ab}
LCD (5%)					5.73	
CV (%)					4.31	

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P= Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

Table 4: Interaction of Varieties and NPS Fertilizer Levels on Total Phosphorus Uptake

Treatments	TpuP ($kg\ ha^{-1}$)					
	NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	6.04^{g}	14.70^{de}	15.28^{cd}	18.40^{ab}	16.51^{abcd}	14.19^{de}
HB-1307	10.74^{f}	12.37^{ef}	16.50^{abcd}	17.55^{abc}	18.39^{ab}	16.41^{abcd}
HB-1966	15.50^{cd}	16.54^{abcd}	17.50^{abc}	18.65^{a}	15.89^{bcd}	15.48^{cd}
LCD (5%)				2.72		
CV (%)				10.5		

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P=Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

was significantly increased availability or accessibility of these nutrients in the soil depending on capability of varieties, also significant increase in straw nitrogen uptake with increased nitrogen rates up to optimum level.

Total Phosphorus Uptake (TpuP): Total uptake of phosphorus was significantly affected by the main effect of variety (($P < 0.05$) and NPS rates ($p < 0.05$). Likewise, the two-way interaction effect of NPS * varieties ($p < 0.05$)) also significantly ($p < 0.05$) influenced total phosphorus uptake (Table 4). The highest (18.65) total phosphorus uptake was recorded from plot that received 200 kg NPS ha^{-1} and HB-1966 variety. The lowest (6.04) total phosphorus uptake was obtained from combination of EH1493 variety and control or unfertilized plot.

Total Sulfur Uptake (TsuP): Total uptake of sulfur was significantly affected by the main effect of variety (($P < 0.05$) and NPS rates ($p < 0.05$). Likewise, the two-way interaction effect of NPS * varieties ($p < 0.05$)) also significantly ($p < 0.05$) influenced total sulfur uptake (Table 5). The highest (11.22) total sulfur uptake was recorded from plot that received 150 kg NPS ha^{-1} and EH1493 variety. The lowest (2.66) total sulfur uptake was obtained from combination of HB1307 variety and control or unfertilized plot.

Grain Nitrogen Use Efficiency (GnuE): Grain nitrogen use efficiency was significantly affected by the main effect of variety (($P < 0.05$) and NPS rates ($p < 0.05$). Likewise, the two-way interaction effect of NPS * varieties ($p < 0.05$)) also significantly ($p < 0.05$) influenced grain nitrogen use efficiency (Table 6). The highest (336.86) grain nitrogen use efficiency was recorded from plot that received 100 kg NPS ha^{-1} and HB1966 variety, but statistically no difference with Eh1493 variety. The lowest (84.68) grain nitrogen use efficiency was obtained from combination of EH1493 variety with recommended NP fertilizer. The differences in nitrogen use efficiency of varieties were resulted from grain yield difference between varieties, when even treated with the same level of NPS. For all varieties, the result generally indicated a decreased in efficiency of N use by grain as NPS fertilizer rate increased, because as NPS levels increased, amount of nitrogen in NPS decreased.

Agronomic Efficiency of NPS: The analysis of variance showed that there was significant ($p<0.01$) difference between the interaction effect of varieties and NPS fertilizer levels on agronomic Nitrogen use efficiency (Table 7). The maximum (78.08 $kg\ kg^{-1}$) recorded from 100kg NPS ha^{-1} application rates with EH1493 varieties, whereas the minimum (15.73 $kg\ kg^{-1}$) was obtained with the combination of 60N &69 P_2O_5 kg ha^{-1} with HB1966 varieties. The result clearly indicates as rates of both fertilizer increases, agronomic efficiency decrease, as the result increasing amount of additional yield obtained for each additional kg of nutrient applied [6].

The result in line with finding of Melkamu *et al*. [12] who reported that application of different types of fertilizer fertilizers significantly influence agronomic nutrient use efficiency of food barley. With Malakouti [11] reported that application of suitable macro and micronutrients increases use efficiency for different crop. Likewise with Nano *et al.* [25] also reported a decreasing trend in agronomic efficiency with increasing NP levels.

Apparent Recovery Efficiency of NPS: It is a measure of the ability of the crop to extract Nutrient from the soil [6]. The effect of Varieties and NPS levels on apparent recovery NPS efficiency of food barley was presented in (Table 8). The highest (160.75 &161.35%) apparent recovery of NPS use efficiency were recorded with combination of 100kg NPS and 150kg NPS ha^{-1} level with both EH1493 varieties while the lowest (40.12%) apparent recovery NPS efficiency were obtained with the combination of 250kg NPS ha^{-1} with HB1966 variety.

Table 5: Interaction of Varieties and NPS Fertilizer Levels on Total Sulfur Uptake

Treatments	TsuP (kg ha^{-1}) NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	4.3^{h}	6.75^{ef}	11.22^{a}	9.80^{b}	7.16^{de}	5.60^{fgh}
HB-1307	2.66^{i}	5.54^{fgh}	8.05^{cde}	6.82^{ef}	8.07^{cde}	7.64^{cde}
HB-1966	4.98^{gh}	5.20^{gh}	8.85^{bc}	8.21^{cd}	9.70^{b}	5.79^{fg}
LCD (5%)				1.32		
CV (%)				11.33		

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P=Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

Table 6: Interaction of Varieties and NPS Fertilizer Levels on Nitrogen Use Efficiency

Treatments	NuE (kg/ka) NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	-	283.13^{a}	212.24^{e}	182.45^{f}	127.86^{hi}	84.68^{k}
HB-1307	-	236.94^{d}	269.46^{c}	168.20^{g}	140.26^{h}	113.39^{j}
HB-1966	-	336.86^{a}	266.76^{c}	195.97^{f}	124.79^{ij}	125.70^{ij}
LCD (5%)				12.92		
CV (%)				4.89		

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P=Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

Table 7: Interaction of Varieties and NPS- Fertilizer on Agronomic NPS Efficiency

Treatments	AEN (kg/kg) NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	-	78.08^{a}	73.42^{b}	45.99^{f}	39.92^{g}	17.15^{jkl}
HB-1307	-	13.64^{m}	51.43^{d}	35.49^{h}	16.46^{kl}	18.53^{j}
HB-1966	-	62.28^{c}	49.73^{e}	26.21^{i}	17.63^{jk}	15.73^{l}
LCR (5%)				1.62		
CV (%)				3.13		

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P=Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

Table 8: Interaction of Varieties and NPS- Fertilizer on apparent recovery efficiency

Treatments	NARE (%) NPS Levels					
Variety	0	100	150	200	250	Rec.NP
EH-1493	-	160.75^{a}	161.35^{a}	104.68^{c}	66.57^{e}	65.64^{e}
HB-1307	-	63.32^{f}	144.92^{b}	83.66^{d}	55.32^{g}	55.25^{g}
HB-1966	-	85.79^{d}	144.37^{b}	42.88^{i}	40.12^{j}	48.09^{h}
LCD (5%)				1.8		
CV (%)				1.49		

Means followed by the same letter are not significantly different ($P < 0.05$) N=Nitrogen, P=Phosphorus, S= Sulfur, CV = Coefficient of variation, LCD= Least Critical Difference

This indicated that, like that of agronomic efficiency, apparent recovery efficiency of food barley was also decreased with increasing NPS level. This finding is in line with Jones *et al*., [5] matching appropriate essential macro nutrients and micro nutrients with crop, nutrient uptake could optimize nutrient use efficiency and crop yield.

CONCLUSION

Results of the study indicate that application of 100 kg ha^{-1} blended NPS fertilizer level, maximized nutrient use efficiency, agronomic efficiency and apparent recovery efficiency of food barley variety. Among tested food barley, EH1493 variety had higher grain nitrogen, agronomic and recovery efficiency than others experimental varieties. Moreover, EH1493 variety with 100 kg ha^{-1} NPS fertilizer gave the maximum grain nitrogen use efficiency (283.13), agronomic efficiency (78.08) and apparent recovery efficiency (160.75).

Recommendations: Depending on the result of this experiment the following recommendations are given to improve the production and productivity of food barley in the study area. Application of 100 kg ha^{-1} NPS fertilizer with EH1493 variety gave maximum grain nutrient use efficiency (283.13), agronomic efficiency (78.08) and apparent recovery efficiency (160.75). Hence, farmers in study area and areas with the same agro-ecology and soil type can be advised to use EH-1493 variety with 100 kg ha^{-1} NPS fertilizer to improve the nutrient use, agronomic and recovery efficiency, to boosting production and quality of food barley.

REFERENCES

1. Grant, C.A., G.A. Peterson and C.A. Campbell, 2002. Nutrient considerations for diversified cropping systems in the Northern Great Plains. Journal of Agronomy, 94: 186-198.
2. Muhammad, I., M. Saleem and Safdar, 2013. Interactive effect of sulfur and phosphorus on nodulation, nitrogen fixation and nutrient uptake by chickpea grown on calcareous soils in Pakistan, Journal of Plant Nutrition, 36: 1649-1658.
3. Fageria, N.K., 2009. The use of nutrients in crop plants. Taylor and Francis Group, LLC: CRC Press.
4. Taye Bekele, Yesuf Assen, Sahlemdhin Sertsu, Amanuel Gorfu, Mohammed Hassena, D.G. Tanner, Tesfaye Tesemma and Takele Gebre, 2002. Optimizing fertilizer use in Ethiopia: Correlation of soil analysis with fertilizer response in Hetosa Wereda, Arsi Zone. Addis Ababa: Kawakawa-Global 2000.
5. Jones, C., R. Olson and C. Dinkins, 2011. Nutrient uptake timing by crops: to assist with fertilizing decisions. Montana State University, pp: 2-8.
6. Fageria, N.K. and V.C. Baligar, 2001. Fertility management of tropical acid soils for sustainable crop production. In: Handbook of soil acidity. Eds., 359-385. New York: Marcel Dekke.
7. Dobermann, A., 2007. Nutrient use efficiency-measurement and management. In “IFA International Workshop on Fertilizer Best Management Practices”, Brussels, Belgium, pp: 1-28.
8. Kiros, H. and B.R. Singh, 2009. Response of wheat cultivars to N and S for crop yield, nitrogen use efficiency and protein quality in the semiarid region. J. Plant Nutr., 32: 1768-1787
9. Korb, N. , C. Jones and J. Jacobsen, 2005. Secondary macronutrients: cycling, testing and fertilizer recommendations. Nutrient Management Module, 5: 1-12.
10. Roberts, T.L, 2008. Improving Nutrient Use Efficiency. Turky Journal of Agriculture, 32: 177-182.
11. Malakouti, M.J., 2008. The effect of micronutrients in ensuring efficient use of macronutrients. Turk J. Agric., 32: 215-220.
12. Melkamu Hordofa, Gashaw Meteke and Wassie, Haile, 2019. Effects of Different Fertilizer Fertilizers on Yield and Yield Components of Food Barley (*Hordeum vulgare* L.). On Nitisols at Hulla District, Southern Ethiopia. Academic Research Journal Agricultural Science Research, 7: 49-56.
13. Mekonnen Asirat, 2005. Response and uptake of barley (*Hordeum irregular* L.) to different rates of Orga-P and nitrogen fertilizers on Nitisols of Gozamin district, Ethiopia, MSc. Thesis, Alemaya University.
14. Endalkachew Kissi, 2006. "Effects of rates and methods of phosphorus placement on residual soil phosphorus, yield and phosphorus uptake of wheat in Nitisols of Kulumsa area, Arsi Zone. An MSc. Thesis, Alemaya University, Ethiopia.
15. United States Department of Agriculture (USDA), 2011. National agronomy manual. 190-V-NAM, 4th Ed. pp: 59.
16. Getachew, A., 2000. Optimization of the efficiency of phosphate fertilizers in acidic-ferralitic soils of the humid tropics. Ethi. J. Natur. Resou., 2: 63-77.

17. HARC, 2019. Holeta Agricultural Research Center, metrological station, Oromia, Ethiopia.
18. Getachew Agegnehu Paul N. Nelson, Michael I. Bird and Cheristy van Beek, 2015. Phosphorous response and fertilizer recommendations for Wheat grown on Nitisols in the Central Highlands of Ethiopia, Communications Soil Science and Plant Analysis, 46: 19-24.
19. Walkley, A. and I.A. Black, 1934. Examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37(1): 29-38.
20. Davis, L.E., 1943. Measurement of soil pH with the glass electrode as affected by soil moisture. Soil Sci., 56: 405-422.
21. Bray, R.H. and L.T. Kurz, 1945. Determination of total, organic and available forms of phosphorous in soil. Soil Science Journal, 59: 39-45.
22. AOAC (Association of Official Analytical Chemists), 1970. Methods of determination of phosphorus in plant tissue. AOAC 11th edition.
23. Tabatabai, M.A., 1974. Determination of Sulfur in water samples. Sulfur Institute Journal, 10: 11-13.
24. Mensah, F. and M. Mensah, 2016. The effect of phosphorus and nitrogen fertilizers on grain yield, nutrient uptake and use efficiency of two maize (*Zea mays* L.) varieties under rain fed condition on Haplic Lixisol in the forest-savannah transition zone. Environmental System Research, 5(22). doi 10.1186/s40068-016-0073-2. (Accessed on June 9/2018.
25. Nano, A., J.J. Sharma and Firdissa, 2012. Influence of weed management practices and nitrogen levels on yield and yield attributes of bread wheat (*Triticum aestivum* L.) at Kulumsa, southeastern Ethiopia MSc. Thesis presented to the School of Graduate Studies of Haramaya University, Haramaya.