Int.J.Curr.Res.Aca.Rev.2018; 6(12): 48-58

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 6 Number 12 (December-2018)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2018.612.006

Effect of Nutrient Supply on Nutrient Use Efficiency and Yield of Barley (*Hordeum vulgare L.)* in Wolaita, Southern Ethiopia

Mesfin Kassa[1], Fassil Kebede[2] and Wassie Haile[3*]

[1]Department of Plant Science, Wolaita Sodo University, P. O. Box 138, Sodo, Ethiopia
[2]Ethiopian Agricultural Transformation Agency, Addis Ababa, Ethiopia
[3]Department of Plant and Horticultural Science, Hawassa University, P. O. Box 05, Hawassa, Ethiopia

**Corresponding author*

Abstract

The present research was intended to study the effect of different levels of NPK fertilizer on the yield and yield attributes nutrients contents, uptakes and use efficiency of barley in Wolaita zone, southern Ethiopia. The experiment was laid out in randomized complete block design with replicated three times of three nutrients three rates for N (0, 23, 46 kg ha^{-1}) and K (0, 25, 50 kg ha^{-1}) and four rates for P (0, 10, 20 and 30 $kgha^{-1}$), the total treatment combinations and the rates of P are basis of common practices of fertilizer application on barely production, Soil samples were collected before sowing from the depth 0–20 cm soil layer from each sites. The results showed that different rates of NPK had significantly ($p<0.05$) affected plant height, spike length, grains $spike^{-1}$, grain and straw yield, nutrients content, total nutrient uptakes and use efficiencies. Maximum grain yields were obtained from $N_{46}P_{30}K_{50}$ kg ha^{-1}, nutrients content and total uptakes were increased with increasing rates but decreased in use efficiencies in both sites, OC, TN and available P were low in all locations. Conclusion: Based on these results, nutrient supply and use efficiency and yield from fertilizer application will be required to sustain the productive capacity of the soils in other part of Wolaita zone and reveals to what extent changes in input parameterization of nutrient requirements of barley.

Article Info

Accepted: 18 November 2018
Available Online: 20 December 2018

Keywords

Fertilizer, Growth, Nutrient use efficiency, Uptake and Yield.

Introduction

Barley is one of the most important, economically valuable and widely used cereal crops; the crop is used for preparing traditional food and beverage consumptions (Araya, 2011). Barley yield is declining in many parts of the highlands of Ethiopia (ICARDA, 2003), which could be the result of a decline in the natural supply of one or more crop nutrients. Low barley yields can be attributed mainly to low soil pH, poor agronomic practices and deficiency of nutrients, especially N and P, due to continuous cropping and low levels of fertilizer application (Agegnehu *et al.*, 2011). Plants grown on acidic soils may be limited by deficiencies of N, P, K, Ca, Mg, Mo, toxicity of Al or Mn; reduced nutrient cycling; and reduced uptake of nutrients by plant roots and inhibition of root growth (Marschner, 2011). Soil acidity adversely affects morphological, physiological and biochemical processes in plants and thus N uptake and use efficiency (Fageria and Baligar, 2005; Marschner, 2011; Tarekegne *et al.*, 997; Ayele and Mamo, 1995). Among the plant nutrients, N plays a very important role in crop productivity (Worku *et al.,* 2007).The barely removal of nutrient per unit area of cultivated land is increased considerably, there are uncertainties about N, P, and K requirements of barey because the nutrient use efficiencies (NUE) vary greatly depending on nutrient supply, crop management practices, and climatic conditions. In this context, the nutrient use efficiency of crops has acquired great relevance (Fageria *et al.,* 2008; Steingrobe and Claassen, 2000). Fageria *et al.,* (2008) nutrient efficient plant as one that produces high economic yield with a given quantity of applied or absorbed nutrient. In Ethiopia, where as soil pH, SOC and TN content of most soils are low, and this are currently under Wolaita soils also low, the N fertilizer rates applied for barley production range from 23 to 46 kg N ha^{-1}, soils with low SOC contents have low crop yield and low use efficiency of added nutrients in the experimental sites. The application of N, P and K alone to barley has not been shown any significant effect on yield, but had a significant interaction effects, their combined application of NPK could lead to improved plant growth and yield, uptake and use efficiency. The significant test of the main effects of NPK showed that application of $N_{46}P_{30}K_{50}$ kg ha^{-1} gave grain and straw yields which were significantly different compared to the yields of other levels. Similarly, increase in K levels also increased total biomass biological yield of barely and, N. P and K alone did not affect the yield in experimental sites. So far, there has not been any scientific effort to test the effect of NPK on yield and yield components, nutrient use efficiency of barley grown in the Wolaita area. Therefore, the objectives of this study were to determine the optimum application rates of NPK fertilizer and their effects on yield and yield components of barley and use efficiencies of nutrients.

Materials and Methods

Description of experiment sites

The experiments were conducted in Sodo Zuria (Kokate), Damot Sore (Doga Mashido) and Boloso Sore (Gurimo Koyisha) distracts, Wolaita zone, Southern Ethiopia during main cropping season of 2015. The sites are situated between 6°53'.03''N and 37°48'50.60''E, 6°53'20.3''N and 37°37'40.8''E, 6°57'15.3''N and 37°44'49.9''E, Kokate, Doga Mashido, Gurimo Koysha, respectively, with altitude range of 1900-2132 meters above sea level. The data was collected from the nearest Meteorological station of Sodo. The long-term weather information at Wolaita zone shows average annual rainfall of 1000-1400 mm with bimodal distribution pattern giving rise to two distinct seasons. The short rains (Belg season) is between March and May, whereas the heavy summer rains (Meher season) is between June and October, with a peak in August. The mean annual temperature is 22 ºC

Treatments and experimental design

The experiments were laid out in randomized complete block design (RCBD) with replicated three times of three nutrients three rates for N (0, 23, 46 kg ha^{-1}) and K (0, 25, 50 kg ha^{-1}) and four rates for P (0, 10, 20 and 30 kgha^{-1}). The total treatment combinations and the rates of P are basis of common practices of fertilizer application on barley production in the wolaita. The size of each plot will be 3 m x 3 m (9 m^2) and the space between plots and blocks were 1m and 1.5 m, respectively. All doses of P (triple superphosphate) and K (potassium chloride) were applied as basal dressing at sowing, while the N (urea) was applied split form, one-half applied at sowing and the other half at early booting. In all plots, the barley variety HB1307 was sowing at a rate of 100 kg ha^{-1} on July 30 and harvested on November 17. The harvesting plants was air-dried and weighed to determine aboveground dry matter. Grain as separated from straw manually and weighing to determine grain yield

Soil analysis

Soil samples collected from three sites of every plot before sowing (0 to 20cm) and composite samples were air-dried and ground to pass through 2mm sieve. For the determinations of total N and organic carbon (OC), 0.5 mm sieve was used. Analyses of the physicochemical properties were carried out following standard laboratory procedures. Particle size distribution was determined by hydrometer method (Day, 1965). Soil pH was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture by using a pH meter (Page, 1982). Available P was determined using Bray II method (Bray and Kurtz, 1945), whereas OC by the wet digestion method as described by Walkley and Black (1954). Total N was determined by Kjeldahl wet digestion and distillation method (Jackson, 1973).The exchangeable basic cations and cation exchange capacity (CEC) were extracted by using 1MNH_4OAc (pH.7) method (Chapman, 1965).In the extract, exchangeable Ca and Mg were determined by atomic absorption spectrophotometer (AAS), while exchangeable K and Na by a flame photometer, Calcium carbonate was determined by the acid neutralization method. Available micronutrients (Fe, Mn, Zn, and Cu) of the soil were extracted by diethylene tramline penta acetic acid (DTPA) method (Tan,1996) and determined using AAS and exchangeable acidity was determined by titration with NaOH after extraction with 1N KCl in the ratio 1:20 and Exchangeable ($Al^{3+}$and H^{+}) was determined.

Plant analysis

Ten non-boarders barley plant rows per plots were randomly selected from each plot for grain and straw analysis. Grain yield per hectare was calculated on 12% moisture content. Before grinding, the straw samples were washed with distilled water to clean the samples from contaminants. After washing with distilled water, the samples were dried in oven at $70^{0}C$ for 24 hours. After drying, the plant tissue samples were grounded and passed through 0.5 mm sieve for laboratory analysis. The grain and straw of N, P and K contents were determined by wet acid digestion procedure as suggested by FAO (2008). The method used for N analysis was the usual Kjeldahl procedure, whereas the determination of P was carried out on the digest aliquot that was obtained through wet digestion. The P in the solution was determined calorimetrically by using molybdate and metavanadate for color development and the reading was made with spectrophotometer at 460 nm wavelengths and potassium by flame photo metrically. The nutrients uptake by straw and grain were calculated by multiplying nutrients contents by straw and grain yield (kg ha^{-1}). Total nutrients uptake, by whole biomass was calculated by summing up the nutrients uptake of grain and straw. Nutrients use efficiency were calculated using procedures described by (Fageria and Filho, 2007)

Physiological efficiency (PE)(kg kg^{-1}) =

$$BY_f – BY_u/N_f – N_{u-} \text{--------------} 1$$

Where, BY_f is the biological yield (grain plus straw) of the fertilized pot (kg), BYu is the biological yield of the unfertilized plot (kg), N_f is the nutrient uptake (grain plus straw) of the fertilized plot, and Nu is the N uptake (grain plus straw) of the unfertilized plot (kg).

Recovery fraction (RE) = (TU(xf) – TU(x0))/ Fr(x)------2

Where, TU(xf): average total nutrient uptake (kg ha-1) from treatments receiving a dose Fr(x)

TU(x0): average total nutrient uptake (kg ha^{-1}) from the control (zero fertilizer) treatments

Fr(x): Rate of fertilizer application (kg ha^{-1}), (x): nutrient under consideration (N, P or K)

Agronomic use efficiency (AE) (kg kg^{-1}) =

$$Gf – Gu/ Na \text{-------------------} 3$$

Where, Gf is the grain yield of the fertilized plot (kg), Gu is the grain yield of the unfertilized plot (kg) and Na is the quantity of P or N fertilizer applied

Agronomic data collections

Data were collected on yield and yield components consisting of plant height (cm), spike length, number of grains per spike, number of tillers per plant, yield (kg ha^{-1}), and total above-ground biomass (kg ha^{-1}). Harvest index (%) was calculated as the ratio of grain yield to the above ground biomass yield, expressed as a percentage. The yield and yield components data were obtained randomly from ten plants in the middle three rows.

Statistical analysis

The data were analyzed using SAS software (SAS, 2009). Analysis of variance (ANOVA) was conducted and least significant difference (LSD) test at probability 5% was employed to compare the means.

Results and Discussions

Soil physicochemical properties

The results of physical and chemical properties of the soils studied are presented in (Table 1). The textural class determinations revealed that the soils were dominated by clay, except Gurimo Koiysha site. The soil pH KCl; H_2O; $CaCl_2$ were varied from 4.54 to 4.76, 5.30 to 5.60, 4.48 to 5.06, respectively, which are slightly acidic and very acidic (Hazelton and Murphy, 2007).The soil reactions of the experimental sites were very acidic (Doga Mashido and Kokate) and was moderately in Gurimo Koiysha site. The cation exchange capacity of the soils ranged from 20.16 to 23.00 $cmolkg^{-1}$ (Table 1) and showed variation with sites, while the values of the soils was medium (Landon, 1991), the $CaCO_3$ contents of the soil was medium rated as according to Landon (1991). Karltun *et al.,* (2013) classification organic carbon, total nitrogen and available P were low in both locations. In agreement with the ratings of FAO (2006), the exchangeable Ca was in soils values ranged from medium to high in Gurimo Koyisha, Doga Mashido and

Kokate respectively (Table 1). The exchangeable Mg was high in the all sites. The exchangeable K and Na in soils of Doga Mashido, Kokate and Gruimo Koyisha in ranged from medium to low, respectively. According to Betnon (2003), the available (Zn, Fe, Mn) in the soils were high in the all locations, whereas, available Cu was low in soils of all study sites.

Yield and yield components of barley

Results in Table 2 depicted that, plant height, spike length, number of tillers per plant, number of grains per spike, yield (kg ha^{-1}), and total above-ground biomass (kg ha^{-1}) were significantly ($P \leq 0.05$) effects, however, interaction between the locations were non-significant (Table 2). Maximum plant height (72.2cm) and minimum (60.8cm) were obtained from the combination of $N_{46}P_{30}K_{50}$ kg ha^{-1} and $N_0K_0P_0$ kg ha^{-1} respectively. Likewise, there was an increasing trend in spike length with increasing NPK application rates even though it was statistically similar except with the control treatment. The lowest number of grain per spike (11.3) was produced with control; while the highest number of grains per spike (30.3) was produced with $N_{46}P_{30}K_{50}$ kg ha^{-1} increase in levels also increased the number of grains per spikes. The combine application had significant ($P < 0.05$) effect on number of tillers per plant (Table 2). Maximum number of tillers was found at the rate of $N_{23}P_{20}K_{25}$kg ha^{-1}, which was significantly higher than control. Similarly, increase in NPK levels also increased total biomass biological, grain, straw yield of barely and, N. P and K alone did not affect the yield in experimental sites but their combined application significant affect barley yield. Harvest index ranged from 24 to 67% (Table 2) was showed that harvest index tended to decrease with increasing levels of N and increased with increasing K application rates. However, there was no consistent trend of increase or decrease in harvest index applied P in related to source of fertilizers. The lowest harvest index (24%) was produced with 20 kg P ha^{-1} while the highest harvest index (67%) was produced with $N_{46}P_{30}K_{50}$. The harvest index was not significantly affected ($P < 0.05$) by the NPK rates and locations

Nutrient use efficiencies of barley

The results presented in (Appendix Table 1) indicated that variation in N uptake by grain and straw due to different treatment combinations. The range of N uptake by grain was 4.75 to 38.31 kg ha^{-1}. The highest N uptake (38.31kg ha^{-1}) by grain was obtained at Gurimo Koyisha in treatment $N_{46}P_{30}K_{50}$. The lowest N uptake (4.75kg ha^{-1}) by grain was found in treatment T1 (control). Similarly, the range of N uptake by straw was 8.14 to 39.60 kg ha^{-1}, which was obtained at Gurimo Koyisha site. The lowest N uptake by straw was found in treatment T1. The range of total N uptake both by grain and straw of $N_{46}P_0K_{50}$ was 18.19 to 66.15 kg ha^{-1} (Appendix Table 1). The highest total N uptake (66.15 kg ha^{-1}) and the lowest total N uptake 18.19 kg ha^{-1} were found in treatment1 control. The P uptake ranged from1.08 to 18.23 and 0.36 to 8.34, respectively at grain and straw at Gurimo Koyisha site was showed in the highest P uptake of 18.23 kg ha^{-1} and 8.34 kg ha^{-1} straw at Doga Mashido site. The results showed that P uptake of grain and straw differed significantly due to different treatment combinations. The range of P uptake by grain varied from 1.08 to 18.23 kg ha^{-1}. The highest P uptake (18.23 kg ha^{-1}) by grain and 8.34 kg ha^{-1} by straw were in treatment $N_{46}P_{30}K_{50}$ and $N_0P_{30}K_0$, respectively. The lowest P uptake grain and straw were recorded in treatment T1 (control). The highest total P uptake at Gurimo Koyisha (23.58 kg ha^{-1}) was obtained from $N_{46}P_{30}K_0$ and the lowest total K uptake at Doga Mahido was observed from treatment 1 (control). The results indicate that the K uptake by grain and straw of $N_{46}P_{30}K_{50}$ were significantly affected by the different treatments. Potassium uptake by grain varied from 0.78 to 30.58kg ha^{-1}. The highest K uptake (30.58 kg ha^{-1}) of grain and straw were 30.58, 49.18 kgha-1 at Kokate and Gurimo Koyisha, in treatments $N_{46}P_{30}K_{50}$ and $N_{23}P_0K_{50}$, respectively. The lowest K uptake (0.78 kg ha^{-1}) of grain was recorded in treatment T1 (control) and 10.46 kg ha^{-1} K uptake by straw in treatment $N_{23}P_{20}K_0$. The total K uptake by grain and straw ranged from 18.66 to 78.13 kg ha^{-1}. The highest total K uptake (78.13 kg ha^{-1}) was obtained in treatment $N_0P_{30}K_{50}$ at Kokate and the lowest total K uptake was observed in treatment T1 (control) at Gurimo Koyisha site. The nutrients use efficiency were increasing levels of fertilizer N, P, and K agronomic efficiency, recover fraction and physiological efficiency decreased with increasing fertilizer rates. The nutrients use efficiency significantly ($P \leq 0.05$) effect on N, P and K rates by barley compared to the control (Table 4). Agronomic use efficiency (AE) was ranged from 10 to 26.63, 10.31 to 23.86, 10.28 to 28.76 kg kg^{-1}, respectively at Doga Mashido, Kokate and Gurimo Koyisha and from treatments $N_{23}P_0K_{50}$, $N4_6P_{20}K_{50}$, $N_{23}P_{20}K_{50}$ and $N_0P_{10}K_O$, $N_0P_0K_{25}$, $N_{23}P_0K_0$, respectively. Maximum agronomic efficiency recorded at lower rates of P, N and K. The maximum agronomic efficiency of N, P and K at application rates of 23 kg N ha^{-1}, 10 kg P ha^{-1}, 25 kg K ha^{-1}, respectively, meanwhile the minimum values were recorded at rates of $N_{23}P_{20}K_{50}$ and $N_{46}P_{20}K_{50}$

kg ha^{-1}. The highest agronomic use efficiency was recorded at Gurimo Koyisha and Kokate with treatment of $N_{23}P_0K_0$ and $N_0P_0K_{25}$ respectively. The recovery fraction (RF) of N, P and K were calculated based on total uptake of nutrient by the aboveground total biomass from applied rate of N, P and K fertilizer for given areas. The mean apparent fertilizer recoveries range from 37.39 to 71.59, 40.54 to 78.97, and 38.78 to 70. 76 % at Doga Mashido, Kokate and Gurimo Koyisha respectively, in treatments $N_0P_0K_{25}$ and $N_{23}P_0K_{0,}$ respectively. The recovery fraction decreased with increasing rates NPK application (Table 3). The maximum (78.97%) and minimum (37.39%) recoveries fraction were obtained at $N_0P_0K_{25}$ and $N_{46}P_0K_{50}$, respectively. Tisdale *et al.*, (2002) mentioned that recovered by grain can vary between 40 and 75 %. Physiological efficiency (PE) of the highest (59.47) and lowest (14.10) values were recorded at application rate of $N_{46}P_{20}K_0$ and $N_{23}P_0K_{25}$, respectively. The highest (59.47) physiological efficiency of nutrients at a rates of $N_{46}P_{20}K_0$, meanwhile the lowest value of 14.10 kg kg^{-1} was obtained at $N_{23}P_0K_{25}$ (Table 3), hence it was respond positive to rate of application NPK.

Table.1 Selected physicochemical properties of experiment field's soils

Site and soil properties	Value		
Experimental Site (Location)	Kokata	Doga Mashido	Gurimo Koyisha
Sand (%)	39.00	28.00	24.00
Clay (%)	44.00	44.00	30.00
Silt (%)	17.00	28.00	46.00
Textural class	clay	clay	Clay loam
pH (H_2O)	5.51	5.30	5.60
pH (KCl)	4.67	4.76	4.54
pH ($CaCl_2$)	5.01	4.48	5.06
OC (%)	1.60	1.52	1.70
Available P (mg kg^{-1})	10.20	9.60	10.40
TN %	0.14	0.12	0.12
Exch. K (cmol kg^{-1})	0.45	0.34	0.32
Exch.Ca (cmol kg^{-1})	11.25	12.74	10.78
Exch. Mg (cmol kg^{-1})	7.21	6.94	7.58
Exch.Na (cmol kg^{-1})	0.17	0.12	0.12
CEC (cmol kg^{-1})	20.16	23.00	20.71
$CaCO_3$ (%)	23.51	23.80	22.13
DTPA Zn (mg kg^{-1})	11.4	12.6	8.40
DTPA Fe (mg kg^{-1})	165.00	146.00	102.00
DTPA Cu (mg kg^{-1})	0.89	0.78	0.90
DTPA Mn (mg kg^{-1})	44.00	38.01	48.10

Table 2.Site and yield and yield components of barley

Site	Doga	Kok	Gu	Doga	Kok	Gu	Doga	Kok	Gu	Doga	Kok	Gu
Treatment	Plant height (cm)			Spike length (cm)			Number of grains per spike			Number of tillers per plant		
1.N0P0K0	60.8	67.8	63.5	3.6	3.3	4.6	11.4	11.3	12.3	2.0	1.6	2.0
2.N0PK25	68.1	68.1	63.9	3.6	4.9	5.2	17.5	17.8	26.5	2.3	3.0	3.0
3.N0PK50	68.4	71.4	63.9	4.5	3.6	5.2	13.9	15.3	27.1	2.3	3.0	3.0
4.N0P10K0	67.9	67.9	59.1	3.8	3.7	3.8	14.4	14.6	24.1	2.2	2.3	3.0
5.N0P10K25	67.2	67.2	59.3	3.6	3.6	4.1	14.8	14.8	24.1	2.3	2.3	3.6
6.N0P10K50	61.5	70.9	61.7	4.6	4.1	4.4	17.3	16.9	26.3	2.0	1.6	4.0
7.N0P20K0	68.8	67.4	62.4	3.9	4.3	4.3	15.4	15.6	27.1	2.3	2.3	3.0
8.N0P20K25	68.2	66.2	63.6	3.3	3.3	4.4	15.1	14.6	27.8	2.1	2.0	3.0
9.N0P20K50	69.4	68.8	64.7	3.4	3.4	4.6	16.2	15.2	28.3	2.3	2.3	3.0
10.N0P30K0	62.2	68.3	65.2	3.3	3.1	4.3	15	15.1	27.6	2.3	2.3	3.3
11.N0P30K25	68.7	63.7	62.1	3.8	3.7	6.1	15.6	15.0	26.4	2.3	2.0	4.3
12.N0P30K50	68.6	60.6	63.5	3.8	3.8	6.2	15.9	15.7	27.2	2.4	1.6	4.3
13.N23P0K0	61.8	62.1	65.6	3.5	3.6	4.0	15.5	14.4	26.7	2.0	2.0	2.3
14.N23P0K25	62.9	61.8	63.8	3.5	3.5	5.1	15.5	15.4	27.1	2.0	2.3	3.0
15.N23P0K50	67.1	65.3	64.5	3.6	3.6	4.5	16.3	16.4	24.3	2.3	2.3	3.0
16.N23P10K0	63.0	63	67.4	3.2	3.4	5.1	14.6	14.6	25.4	2.3	2.0	3.0
17.N23P10K25	63.3	62.4	68.8	3.2	3.2	5.1	14.6	14.5	26.9	2.3	1.6	3.6
18.N23P10K50	65.9	65.8	69.0	3.7	3.7	5.4	15.1	16.4	30.0	2.3	2.3	3.6
19.N23P20K0	64.5	64.5	64.2	3.4	3.7	4.3	16.0	16.0	27.7	2.0	2.0	3.6
20.N23P20K25	66.6	56.4	64.8	3.5	3.8	5.0	16.3	16.3	27.7	2.3	2.0	4.3
21.N23P20K50	66.8	61.6	64.9	4.1	3.8	5.1	16.5	16.3	28.2	2.3	2.3	4.6
22.N23P30K0	64.5	62.6	64.7	3.5	3.3	5.0	16.1	15.7	26.4	2.1	2.0	3.0
23.N23P30K25	65.1	63.1	66.4	3.8	3.7	5.2	16.3	15.8	27.8	2.3	2.3	3.0
24.N23P30K50	66.8	63.6	66.6	3.7	4.4	5.3	16.3	15.8	28.5	2.3	2.3	3.3
25.N46P0K0	63.4	63.6	55.5	3.5	3.7	4.9	15.3	15.9	25.4	2.3	2.0	3.3
26.N46P0K25	63.4	63.1	59.4	4.3	4.2	5.4	16.6	16.6	26.4	2.3	2.3	4.0
27.N46P0K50	64.6	64.6	61.8	4.8	4.4	4.6	17.0	17.1	24.5	2.3	2.3	4.0
28.N46P10K0	65.4	64.5	57.8	4.4	3.4	5.6	16.8	13.2	28.3	2.6	2.3	3.6
29.N46P10K25	64.6	64.6	61.2	4.8	3.8	5.5	16.2	14.7	28.2	2.6	2.3	3.0
30.N46P10K50	70.4	69.5	66.2	4.8	3.9	5.8	16.4	15.7	27.7	3.3	2.3	3.0
31.N46P20K0	68.8	68.9	58.6	4.8	4.5	5.1	16.2	15.2	24.4	2.3	2.3	3.0
32.N46P20K25	70.1	70.1	59.2	5.2	3.2	5.1	16.6	15.6	27.3	2.7	2.3	3.0
33.N46P20K50	70.1	72.5	61.8	5.4	3.7	5.6	17.2	16.5	28.1	3.3	2.3	3.3
34.N46P30K0	69.4	68.7	68.7	5.8	3.8	5.7	17.8	14.5	27.0	3.3	2.3	3.0
35.N46P30K25	70.8	69.6	69.8	6.2	4.2	5.8	17.8	15.8	28.4	3.4	3.0	3.6
36.N46P30K50	72.2	72.7	70.1	6.5	5.6	6.0	17.9	17.1	30.3	3.4	3.0	3.6
Means	66.4	65.7	63.7	4.1	3.8	5.0	16.2	15.8	27.0	2.4	2.2	3.34
CV $_{(\%)}$	3.7	3.8	3.7	11.4	12.1	8.0	5.5	5.3	5.0	22.0	27.8	19.4
$LSD_{(0.05)}$	3.9	4.1	3.7	0.7	0.7	0.6	1.4	1.3	2.1	0.8	0.01	0.01

Table 2.Contiuned

Treatments	Doga.	Kok	Gu	Doga	Kok	Gu	Doga	Kok	Gu	Doga	Kok	Gu
	Total above ground biomass(Kgha^{-1})			Straw yield (Kgha^{-1})			Grains yield (Kgha^{-1})			Harvest index (%)		
1.N0P0K0	3452	4821	2761	2466	3618	1945	986	1203	815	0.29	0.25	0.30
2.N0PK25	3893	5320	5035	2728	3529	3764	1265	1791	1271	0.32	0.34	0.25
3.N0PK50	4690	5237	4698	3419	3381	3301	1490	1856	1397	0.32	0.35	0.30
4.N0P10K0	4757	3940	4104	3504	2611	3204	1252	1428	1101	0.26	0.36	0.27
5.N0P10K25	3425	4224	4850	2067	2423	2387	1357	1801	1563	0.40	0.43	0.32
6.N0P10K50	3981	4640	4262	2373	2684	2831	1608	1956	1631	0.40	0.42	0.38
7.N0P20K0	5334	4264	5465	3977	2623	4114	1357	1640	1324	0.25	0.38	0.24
8.N0P20K25	4326	4486	3954	2829	2704	2189	1497	1781	1765	0.35	0.40	0.45
9.N0P20K50	5348	5215	4261	3436	3045	2400	1692	2170	1862	0.32	0.42	0.44
10.N0P30K0	4315	4587	4878	3091	2542	3415	1524	1645	1464	0.35	0.36	0.30
11.N0P30K25	4472	4284	4136	2633	2336	2374	1739	1948	1762	0.39	0.45	0.43
12.N0P30K50	4705	5256	4478	2656	2986	2545	1849	2270	1933	0.39	0.43	0.43
13.N23P0K0	3858	4008	4529	3612	2256	3052	1346	1752	1477	0.35	0.44	0.33
14.N23P0K25	4101	4611	3909	2512	2834	2262	1589	1777	1647	0.39	0.39	0.42
15.N23P0K50	4702	4371	4353	2986	2320	2558	1716	2051	1796	0.36	0.47	0.41
16.N23P10K0	5324	4063	4885	3680	2390	3297	1644	1672	1588	0.31	0.41	0.33
17.N23P10K25	3817	4195	4015	2097	2246	2207	1720	1949	1608	0.45	0.46	0.40
18.N23P10K50	3867	5294	3409	2009	3129	1725	1858	2165	1684	0.48	0.41	0.49
19.N23P20K0	4757	5685	2824	3067	3479	1079	1690	2206	1745	0.36	0.39	0.62
20.N23P20K25	4704	5860	4346	2067	3495	2594	1742	2365	1752	0.37	0.40	0.40
21.N23P20K50	5344	6710	3825	2071	4273	2053	1983	2437	1772	0.37	0.36	0.46
22.N23P30K0	5151	4604	2906	3334	2248	1018	1817	2356	1888	0.35	0.51	0.65
23.N23P30K25	5070	5803	4004	2093	3363	2027	1977	2440	1978	0.39	0.42	0.49
24.N23P30K50	4407	5814	4149	2292	3243	2083	2115	2571	2066	0.48	0.44	0.50
25.N46P0K0	5446	4644	6013	3948	2744	4400	1498	1900	1613	0.28	0.41	0.27
26.N46P0K25	4175	5345	4429	2404	3241	2709	1771	2104	1720	0.42	0.39	0.39
27.N46P0K50	4660	5754	4540	2674	3371	2530	1986	2383	2010	0.43	0.41	0.44
28.N46P10K0	5665	4945	4609	3668	2872	1993	1996	2073	2616	0.35	0.42	0.57
29.N46P10K25	4224	5259	5817	2109	3069	1284	2115	2190	2685	0.5p	0.42	0.46
30.N46P10K50	5295	5379	4315	2142	3053	1384	2252	2326	2731	0.43	0.43	0.63
31.N46P20K0	4258	4528	3643	2260	2394	3309	1998	2134	2734	0.47	0.47	0.75
32.N46P20K25	4431	5233	4588	2621	3027	1695	2310	2206	2793	0.52	0.42	0.61
33.N46P20K50	5372	5891	4267	2954	3492	1315	2418	2399	2800	0.45	0.41	0.66
34.N46P30K0	4845	5773	6509	2103	3120	3754	2742	2603	2755	0.57	0.45	0.42
35.N46P30K25	5002	5832	4288	2249	3217	1451	2753	2615	2836	0.55	0.45	0.66
36.N46P30K50	5201	6036	4630	2343	3236	1540	2858	2800	3090	0.55	0.46	0.67
Means	4619	5426	4380	2734	3130	2439	1819	2224	1924	0.39	0.41	0.45
CV $_{(\%)}$	10.3	11.3	24.8	14.4	12.5	20.8	14.3	13.9	11.7	2.25	1.36	1.25
$LSD_{(0.05)}$	904.5	1003	1720	889	652.7	789	365.2	506.2	335	0.01	0.01	0.01

Doga=Doga Mashido, Kok,=Kokate, Gu= Gurimi Koyisha

Table.3 Effect of NPK fertilizer on nutrient use efficiency of barley

Experimental site and treatment	Nutrients use efficiency								
Site name	Doga Mashido			Kokata			Gurimo Koysha		
	AE	RE	PE	AE	RE	PE	AE	RE	PE
	(kgkg-1)	(%)	(kgkg-1)	(kgkg-1)	(%)	(kgkg-1)	(kgkg-1)	(%)	(kgkg-1)
1.N0P0K0	0	0	0	0	0	0	0	0	0
2.N0P0K25	11.17	38.00	29.40	23.53	61.75	38.12	18.22	69.09	26.37
3.N0P0K50	10.08	37.39	26.95	13.06	45.86	28.48	11.62	49.56	23.44
4.N0P10K0	26.63	60.22	44.23	22.53	57.24	39.38	28.53	53.45	53.37
5.N0P10K25	10.60	46.74	22.67	17.09	48.26	35.27	21.34	52.31	40.79
6.N0P10K50	10.36	46.68	22.19	12.55	54.77	22.86	13.58	42.98	31.59
7.N0P20K0	18.55	43.18	42.95	21.86	56.08	38.98	25.43	50.06	50.79
8.N0P20K25	11.35	67.58	16.79	12.85	43.53	29.52	21.10	49.13	42.94
9.N0P20K50	10.08	62.01	16.25	13.81	72.87	18.95	14.94	41.01	36.43
10.N0P30K0	17.93	38.44	40.20	14.73	40.54	36.34	21.60	43.30	49.88
11.N0P30K25	13.69	70.64	19.38	13.55	55.85	24.26	17.21	42.18	40.80
12.N0P30K50	10.79	56.59	19.06	13.33	72.36	18.42	13.97	42.13	33.15
13.N23P0K0	11.31	54.77	20.65	23.86	57.73	41.33	28.76	65.59	43.84
14.N23P0K25	12.56	71.59	17.54	11.96	70.35	17.00	17.32	60.84	28.46
15.N23P0K50	10.00	70.92	14.10	11.61	61.19	18.97	13.43	59.85	22.43
16.N23P10K0	19.93	68.55	29.07	14.22	52.61	27.02	23.41	49.33	47.45
17.N23P10K25	12.65	59.49	21.26	15.50	63.09	24.56	13.66	46.04	29.66
18.N23P10K50	10.51	54.52	19.27	11.59	76.14	15.22	10.46	38.78	26.97
19.N23P20K0	16.37	58.16	28.14	23.32	50.42	46.26	21.62	70.76	30.55
20.N23P20K25	11.11	53.71	20.68	14.75	69.74	21.15	13.77	65.55	20.97
21.N23P20K50	10.72	53.16	20.16	12.49	78.79	15.85	10.28	42.92	23.95
22.N23P30K0	15.68	54.12	28.97	21.75	58.60	37.11	20.20	57.43	35.17
23.N23P30K25	12.70	53.53	23.72	14.78	70.35	21.00	14.90	57.42	25.94
24.N23P30K50	10.96	49.75	22.03	13.28	78.88	16.83	12.14	47.22	25.70
25.N46P0K0	11.13	54.08	20.58	10.81	52.25	20.68	17.34	57.04	30.39
26.N46P0K25	11.05	53.42	20.48	12.69	78.97	16.06	12.74	50.64	25.15
27.N46P0K50	10.41	51.82	20.08	12.29	77.54	15.84	12.44	50.60	24.58
28.N46P10K0	18.03	65.00	27.73	15.54	50.19	30.96	32.16	59.38	54.15
29.N46P10K25	13.12	65.00	19.96	12.18	77.28	15.76	23.08	56.86	40.59
30.N46P10K50	11.95	60.16	19.88	10.59	61.18	17.30	18.07	49.02	36.86
31.N46P20K0	15.33	68.93	22.24	14.10	61.54	22.91	28.07	48.88	59.47
32.N46P20K25	14.54	66.28	21.93	11.02	71.17	15.48	21.73	48.31	44.98
33.N46P20K50	12.34	64.40	19.16	10.31	70.24	14.67	15.38	47.79	32.18
34.N46P30K0	23.10	71.26	32.41	18.42	51.32	35.89	25.52	59.93	42.58
35.N46P30K25	17.49	68.58	25.50	18.93	73.00	25.93	20.00	59.60	33.55
36.N46P30K50	14.85	66.74	22.25	12.67	67.43	18.78	18.05	56.94	31.70
Means	13.30	56.26	23.27	14.65	60.80	24.53	18.14	51.16	34.63
CV (%)	10.33	3.15	5.58	5.44	2.67	6.28	1.92	0.84	1.04
$LSD_{(0.05)}$	2.71	3.55	2.57	1.59	3.27	3.08	0.69	0.87	0.72

The results of the laboratory analysis for physical and chemical properties of the composite soil samples resented in Table 1. The results revealed that the texture of the soils varied from clay to clay loam in the soils might be attributed to the removal of fine soil particles from the soils, and the variability's in the degree of weathering, parent material and soil erosion. The soil reactions of the experimental sites were strongly acidic and moderately, which could be accumulation of exchangeable bases contributed to a moderate soil pH and high erosion and leaching of exchangeable bases from the soils, organic carbon, total nitrogen and available P were low in all locations. The positive effects of organic carbon on barley yield resulted from changes to the soil, including lower total nitrogen, soil pH and contents of available P and possibly K and micronutrients, as the soils t all sites have in sufficiently low pH to affect P availability and barley growth. In agreement with Fageria and Baligar (2008) excessive soil acidity results in a shortage of available P and Mo on the one hand, and an excess of soluble Al. The data indicated that fertilizer applications were effects on yield however, NPK application of nutrients generally increased total biomass yield of barley. The applied with N_{23} $P_{20}K_{50}$and $N_{46}P_{30}K_{50}$ of the total nutrients applied as higher biological yields (6710 and 6036 kg ha^{-1}), respectively, as compared with 2761kg ha^{-1} produced in plots applied with no NPK nutrients. With increased levels of NPK, increase in total biomass results in accumulation of dry matter which enhances total biomass of barely. Moreover, N, P and K alone treatments' also showed the same the trend like NPK. This increased yield might in part be due to increased N and P. Similarly, increase in K levels also increased total biomass biological yield of barely and, N. P and K alone did not affect the yield in experimental sites but their combined application significant affect barley yield. Similar trend of the effects of fertilizer was noticed in barley by Alam (2003) and in wheat by Rahman (2004); Khaleque (2005). The observation of yields indicated that the highest grain and straw yields were recorded with the application of 46 kg N ha^{-1} and $N_{46}P_{30}K_{50}$ kg ha^{-1}, followed by a treatment of $N_{46}P_{30}K_{50}$ kg ha^{-1} (Table 2). The statistical analysis for significant test of the main effects of NPK showed that application of $N_{46}P_{30}K_{50}$ kg ha^{-1} gave grain and straw yields which were significantly different ($P < 0.05$) compared to the yields of other rates. However, there was no significant difference in grain yield due to application of 25 kg K ha^{-1} and 50 kg K ha^{-1} (Table 2). This might be due to the low cationic exchange of the 1:1 clay in Nitisols. These findings are in accordance with the research findings of Alam (2003); Rahman (2004); Khaleque (2005) in wheat; Mollah (2007) who reported that spike length of barely was significantly affected by NPK levels and the highest number of grains per spike (33.4) and the lowest (15.6) was in no fertilizer application treatment. The result showed that the total N uptake both by grain and straw were more prominent due to combined application of fertilizers. This is in agreement with Getachew *et al.,* (2016), who reported that N, P and K uptake and total uptake were increased as the NPK fertilizer rates increased in barely and the result was also corroborated with Tariq *et al.,* (2011); Steingrobe and Claassen (2000) who reported that the levels of K increases the apparent recovery, agronomic and physiological use efficiency decrease under wheat, barley and sorghum production system. Similarly, the findings of Yang *et al.,* (2003) stated that the agronomic and physiological efficiency decreased with the increase of K levels. Regarding to physiological efficiency of crop explained that high physiological efficiency on N usage cereal achieved when high portion of N taken up is used for grain formation, these losses have been attributed to the combined effects of denitrification, volatilization and leaching in the soil.

It is concluded in this study, nutrient supply to estimate N, P, and K requirements for barley and their use efficiencies of nutrients as affected by fertilizer levels. The experiment was laid out in a randomized complete block design in a factorial arrangement with three replications. Soil samples were collected from surface soil (0-20 cm depth) for selected chemical and physical analysis, TN, OC and Av. P were low and CEC and $CaCo_3$ were medium in the both sites, as a result of its substantially lower values of TN, OC and Av.P, which negatively affects the uptake of other elements. The grain yield exhibited significant differences in response to NPK rates, the highest mean grain yields (2858, 2800 and 3090 kg ha^{-1}), at Doga Mashido, Kokat and Gurimo Koyisha, respectively, in treatment ($N_{46}P_{30}K_{50}$ kg ha^{-1}) and the lowest mean grain yields (956,1203 and 815.3kg ha^{-1}) were obtained from control treatment in both sites, whereas the highest and lowest mean grain yields (3090 kg ha^{-1}) and (815.3kg ha^{-1}) were obtained at Gurimo Koyisha, barely grain yield consistently increased as the rate of applied NPK increased to the highest level of NPK.

In line with this, the highest NPK contents and total nutrient uptakes of barely were obtained at the highest level of NPK irrespective of their initial soil NPK content. Similarly, the highest total nutrient uptakes by grain and straw were found at a level of NPK $kgha^{-1}$. However, the highest apparent recovery, physiological and agronomic use efficiencies were found at the lowest NPK rates in both sites. Finally, experiments have done using input and yield date from fertilizer trials in other party of Wolaita zone for sound recommendation.

Acknowledgements

We acknowledge the staff members of Department of Plant Science, Wolaita Sodo University and Hawassa research center of soil Laboratory, for providing us with the necessary support to conduct this study.

Funding

This work was supported by Ethiopian Ministry of Education and Wolaita Sodo University

Author contributions statement

Conceived and designed the experiments; performed the experiments; analyzed and interpreted the data; contributed reagents, materials, analysis tools or data; and wrote the paper.

Competing interest statement

'The authors declare no conflict of interest.

Dual publication statement

The manuscript is not under consideration for publication elsewhere.

Funding statement

This work was supported by Ethiopian Ministry of Education and Wolaita Sodo University.

Publication ethics

All tables included in manuscript are true representations of the experimental data and have not been inappropriately manipulated.

Availability of data

All data required to support the results and conclusions of our study is either provided with the submission or deposited into a publicly available database

Abbreviation

NUE Nutrient use efficiencies
NPK Nitrogen, Phosphors and Potassium
AE Agronomic use efficiency
PE Physiological efficiency
RE Recovery fraction
RCBD randomized complete block design

References

Alam, M. Z. 2003. Influence of planting dates and nitrogen levels on growth, grain yield and nitrogen utilization of barley (*Hordeum vulgare L*). Ph.D. Thesis, Crop Physiology Laboratory, Department of Botany, Rajshahi University, Rajshahi. pp. 61-292.

Agegnehu, G., Liben, M., Molla, A., Feyissa, A., Bekele, A., Getaneh, F. 2011. Research achievements in soil fertility management in relation to barley in Ethiopia. In: Mulatu, B., Grando, S. (Eds.), Barley Research and Development in Ethiopia. ICARDA, Addis Ababa, Ethiopia, pp. 137–152.

Araya, Alemi., Solomon, Habtu., Mitiku, Haile., Sisay, F., Tadesse, Dejenie. 2011. Determination of local barley (*Hordeum vulgare*) crop coefficient and comparative assessment of water productivity for crops grown under the present pond water in Tigray, Northern Ethiopia

Ayele, G., Tekalign, Mamo. 1995. Determinants of demand for fertilizer in a Vertisol cropping system in Ethiopia. Trop. Agric. (Trinidad) 72: 165-169.

Benton, Jone J. 2003. Agronomic Hand book; Management of crop, Soils and fertility. CRS press. New York. p. 482

Bray, H.R.,T, Kurtz. 1945. Determination of organic and available forms of phosphorus in soils. Soil Sci. 9: 39-46

Chapman, H.D. 1965. Cation exchange capacity by ammonium saturation. 891-901. *In:* Black, C.A., Ensminger, L.E. and Clark, F.E. (Eds). Method of soil analysis. *American Society of Agronomy*. Madison Wisconsin, USA

Day, P.R. 1965. Particle size distribution and Particle size analysis. *In:* Black, C.A. (ed.) *Methods of Soil Analysis*, p. 545. American Society of Agronomy, Madison, Wisconsin, USA

Fageria, NK., Baligar, VC., Li, YC. 2008. The role of nutrient efficient plants in improving crop yields in the twenty first century. *J Plant Nutr* 31:1121–1157. doi:10.1080/01904160802116068.

Fageria, N., Baligar, V. 2005. Enhancing nitrogen use efficiency in crop plants. *Adv. Agron*. 88, 97–185.

Fageria, N.K., Filho, M.P.B.2007. Dry matter and grain yield, nutrient uptake, and phosphorus use efficiency of lowland rice as influenced by phosphorus fertilization. *Commun. Soil Sci. Plant Anal.* 38: 1289–1297.

FAO (Food and Agricultural Organization), 2008. Guide to laboratory establishment for plant nutrient analysis, fertilizer and plant nutrition bulletin 19, Rome

FAO (Food and Agriculture Organization). 2006. Plant nutrition for food security: A guide for integrated nutrient management. FAO, Fertilizer and Plant Nutrition Bulletin 16, Rome.

Getachew, Agegnehua., Paul, N., Nelsona, Michael., I. Birda.2016. Crop yield, plant nutrient uptake and soil physicochemical properties under organic soil amendments and nitrogen fertilization on Nitisols. *Soil & Tillage Research* 160, 1–13.

ICARDA (International Center for Agricultural Research in the Dry Areas). 2003. Improving barley production. ICARDA and Ethiopia. http://www.icarda.org/Publications/Donors/Ethiopia

Jackson, M.L. 1973. *Soil Chemical Analysis*, p. 498. Prentice Hall of India Pvt. Ltd., New Delhi–India

Karltun, E., Tekalign, Mamo,Tay, Bekele., Sam, Gamedal., Selamyihu, Kidan.2013. Towards improved fertilizer recommendation in Ethiopia-Nutrient indices for categorization of fertilizer belands from EthioSIS woreda soil inventory data. A discussion paper. The Ethiopia Agricultural Transformation Agency and the Ministry of Agriculture. Addis Ababa.

Khaleque, M. A. 2005. Study on growth and yield of modern wheat varieties in different agronomic management practices. PhD. Thesis, Institute of Biological Sciences, Rajshahi University. Rajshahi. pp. 53-243.

Landon, J.R. 1991. Booker tropical soil manual: A handbook for soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. p. 474

Marschner, H. 2011. Marschner's Mineral Nutrition of Higher Plants, 3rd ed. Academic Press, UK.

Mollah, M. S. I. 2007. Studies on the physiological attributes and their relationship to yield of barley (Hordeum vulgare L) under different soil moisture regime and NPN fertilizers. Ph.D. Thesis, Crop Physiology Laboratory, Department of Botany, Rajshahi University, Rajshahi. pp. 115-156, 168-194.

NMA (National Meteorological Agency). 2016. National Meteorological Agency, Hawassa Meteorological Service Center, Ethiopia

Page, A.L. 1982. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Madison, USA.

Rahman, M. A. 2004. Effect of irrigation on nitrogen uptake, yield attributes of wheat varieties. PhD. Thesis, Crop physiology Laboratory, Department of Botany, Rajshahi University. pp. 45-257.

SAS institute. 2009. Statistical Analysis Systems, SAS/STAT users Guide. Version 9. 2th edn.SAS institute Inc., Cary, USA

Spiertz, JHJ., Ewert, F. 2009. Crop production and resource use to meet the growing demand for food, feed and fuel: opportunities and constraints. NJAS-Wageningen *J Life Sci* 56:281–300. doi:10.1016/S1573-5214(09)80001-8

Steingrobe, B., N, Claassen. 2000. Potassium dynamics in the rhizosphere and K efficiency of crops, *Journal Plant Nutrition Soil Science*, 163:101–106

Tan, KH. 1996. Soil sampling, preparation, and analysis. Marcel Dekker, Inc. New York, USA.p68.

Tarekegne, A., Tanner, DG., Amanuel, Gorfu., Tilahun, Geletu., Zewdu, Yilma.1997. The effect of several crop management factors on bread wheat yields in the Ethiopian Highlands. *Afr. Crop Sci*. J. 5: 161-174.

Tariq m., A. Saeed, M. Nisar, I.A. Main., M. Azfal. 2011. Effect of potassium rates and sources on the growth performance and on chloride accumulation of maize in two different textured soils of Haripur, Hazara division. *Sarhad Journal of Agriculture*, 27(3): 415-422

Walkley, A, Black, CA. 1934. An examination of the degrjareff method of determining soil organic matter and a proposed modification of chromic acid titration method. *Soil* **37,** 29-38.

Worku, M., B.E. Friesen., O.A, Diallob., W.J, Horst. 2007. Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. *Crop Sci.*, 47: 519-528.*Science*

Yang X., Liu J.X., Wang W.M., Li H. 2003. Genotypic differences and some associated plant traits in potassium internal use efficiency of lowland rice (*Oryza sativa L.*), *Nutrient Cycling in Agro ecosystems*, 67: 273– 282.

How to cite this article:

Mesfin Kassa, Fassil Kebede and Wassie Haile. 2018. Effect of Nutrient Supply on Nutrient Use Efficiency and Yield of Barley (*Hordeum vulgare L.)* in Wolaita, Southern Ethiopia. *Int.J.Curr.Res.Aca.Rev*. 6(12), 48-58.
doi: https://doi.org/10.20546/ijcrar.2018.612.006