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RESEARCH PAPER

Status of Selected Properties of Soils and the Response of Malt Barley (*Hordeum distichum* (L.) to Lime and Phosphorus Fertilizer Rates at Chaliya and Jaldu Districts, West Shewa Zone, Ethiopia

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Abstract

Soil acidification and unavailability of phosphorus (P) are among the major problems limiting the productivity of crops in most highlands of Ethiopia. To improve these conditions lime and P fertilizer application is an important strategy. Accordingly, these field experiments were conducted to evaluate the effect of agro-lime and P fertilizer rates on the yield of malt barley and their influence on soil properties. Experimental treatments comprised four levels of agro-lime (0, 1.1 2.2 and 3.3 t ha-1) and four levels of P2O5 (0, 30, 60 and 90 kg ha-1) that was laid out in a randomized complete block design in a factorial arrangement and replicated three times. The results showed that the soils of the two sites were categorized as clay loam in texture and suitable for the production of malt barley. On contrary to this, pre-sowing soil analysis showed very low available phosphorus and acidic soil pH in both sites. The highest values of grain yield of malt barley 4.97 and 4.68 t ha-1 was obtained as a result of the application of 3.3 t ha-1 of lime rate and 90 kg P ha-1 fertilizer at Jeldu and Chaliya, respectively. Hence, the application of lime at the rate of 3.3 t ha-1 and 90 kg P ha-1 could serve as a reference for better malt barley production for the study areas. Nevertheless, the most generalized recommendation should be suggested after inclusion of economic analysis.

Keywords: Lime rates, p-fertilizer, malt barely, yield

Introduction

The problem of soil acidity is considered to be one of the major bottlenecks to malt barley production in the highlands of Ethiopia. Soils can be acidified under natural conditions over thousands of years, especially in high rainfall areas. Soil acidity is developed under high-rainfall conditions and it can be considered as one of the major limiting factors to acid-sensitive crop production. Soil acidification can also pose several problems for successful agricultural crop production and limit plant growth not only because of the deficiency of major nutrients such as phosphorus (P), calcium (Ca) and magnesium (Mg) but also due to toxicity of aluminum (Al), manganese (Mn), and hydrogen (H) ions as well as the depletion of the soil fertility. Over 41% of Ethiopia's agricultural land is impacted by acidity, featuring soil pH of 5.5 or lower. Soil acidity prevents plants from releasing the nutrients in the soil, and thus biomass production on acid soils is stunted. Thus, soil acidity is best addressed through integrated soil fertility management, in which a series of technologies are applied in tandem to safeguard the health and fertility of the soil as well as to enhance the productivity of acid-sensitive major cereal crops such as barley, bean, and wheat (Achalu *et.al.*, 2012a; Aboytu, 2019; Achalu, 2022).

Soil acidity has grown in scope and magnitude across different highland areas of Ethiopia. The effect of soil acidity in these areas has caused mineral stress in the soils. Because of these circumstances, a number of adverse effects are observed such as loss of crop diversity, decline in the yield of existing crops, lack of response to ammonium phosphate and urea fertilizers, and complete failure of cropping land. Studies on plant growth-limiting nutrients, like P, show that acid soils dominate most of the southern and southwestern parts of the country and generally have low P content (Mesfin, 1998, Achalu, *et al.,* 2012a). In Ethiopia, soil acidity is a problem that has not been addressed in depth and most of these soils are found in the highlands which receive high rainfall areas. Currently, there is increasing awareness that soil nutrient depletion from the agro ecosystem is a very widespread problem and it is an immediate crop production constraint in Ethiopia. Low soil fertility resulting from land degradation, soil erosion, crop removal of nutrients from the soil, total removal of plant residue from farmlands and lack of proper crop rotation programs are some of the major factors causing low agricultural production and productivity in western highlands of the country.

Furthermore, crop diversity and yields are declining due to the pronounced influence of soil acidity on plants and soil infertility. Barley is one of the major cereal crops that are largely produced in the central and southeast mid and high altitude areas of Ethiopia. It is the staple food grain for Ethiopian highlanders who manage the crop with indigenous technologies and utilize different parts of the plant for preparing various types of local food such as *Kita, Kolo, Beso, Enjera,* local beverage called *Tela* and as an important raw material for many industries (Achalu *et al.,* 2012b). Although barely crop is the major staple food in the highlands, used as the source for many nutritional values and industrial applications, there was no much research work done on the combined application of different liming and P-fertilizer rates to improve its productivity in acidic soils in the particular districts of the present study. Due to the lack of sufficient and detailed scientific research work in the area, barley production and productivity have been decreasing from year to year and the crop is forced to go out of production leading to a shortage of barley food sources in most areas of western Oromia Region. Moreover, most of the crops that are very susceptible to soil acidity like barley, bean, and wheat are almost forced to be out of production in the region. Therefore, the present study was initiated to evaluate the effects of different rates of lime and P fertilizer application on yield of malt barley and selected soil properties.

Materials and methods

Description of Study Areas

The study was conducted in Jaldu and Chaliya districts, which are located in west Shewa zone of Oromia National Regional State (Figure 1). The two districts are located at a distance of about 115 and 193 km, respectively, from Addis Ababa.

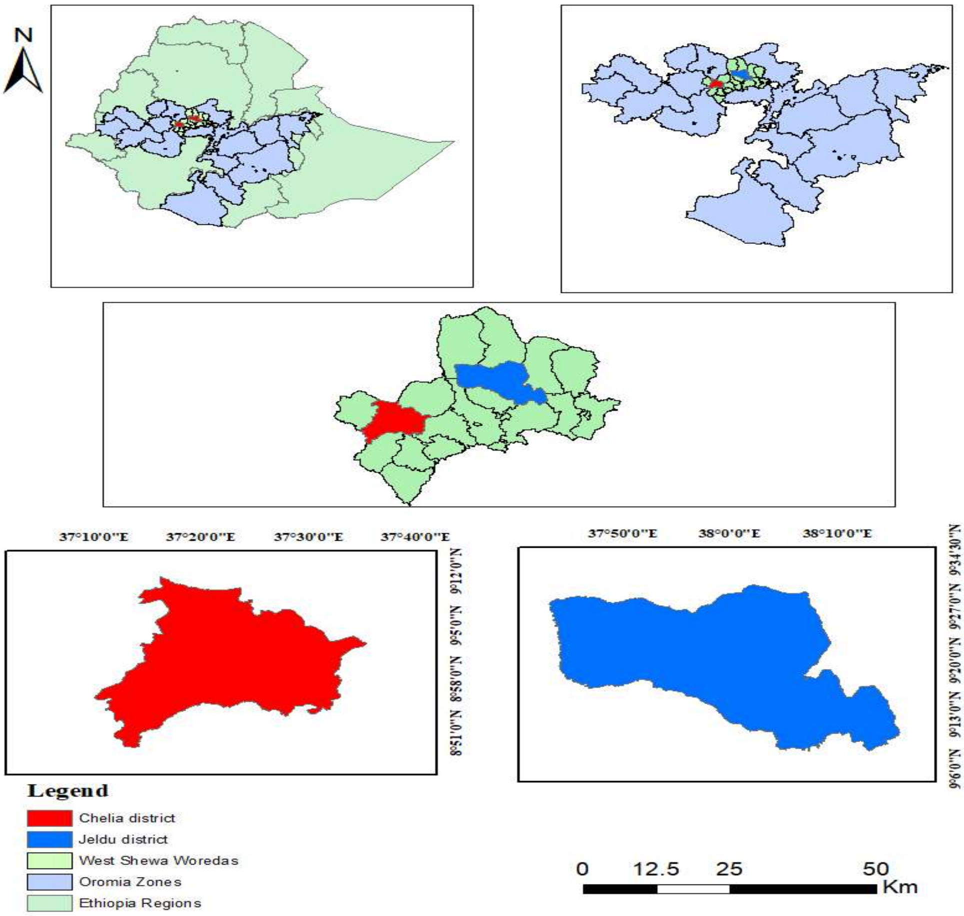

Figure1. Location map of the study areas

Climate, Topography and Farming Systems of the Study Areas

As per the local and traditional practice, the study areas are agro-climatically classified as highland (*Baddaa)* and mid-altitude *(Badda Darree) (*Districts Agricultural Extension Office, 2020). According to the weather data recorded at the west Shewa zone Meteorological Station, the average annual rainfall of the study areas is 875 mm and 900 mm for Jaldu and Chaliya, respectively and the mean minimum and maximum temperatures are 17 and 22 ^{0}C for Jaldu, and 8 and 25 ^{0}C for Chaliya districts (Districts Agricultural Extension Office, 2020). The topography of both study districts is largely mountainous and has gentle sloping landscapes. The economic activities of the local community of the study areas are primarily mixed farming system that involves crop production and animal husbandry (MOFED, 2002). The major crops in the study districts are Potato (*Solanum tubersoum),* Tef (*Eragrostis tef*), Wheat *(Triticum aestivum)*, Faba bean (*Phaseolus vulgaris*), Maize (*Zea mays*), and Barley (*Hordeum vulgare*) are usually produced once a year.

Treatments, Experimental Design, Experimental Procedures and Field Management

The experiment was laid out in a randomized complete block design and arranged in a factorial arrangement with three replications. The treatments were four levels of agro-lime (0, 1.1, 2.2 and 3.3 t ha-1) and four levels of P2O5 (0, 30, 60 and 90 kg ha-1). After site selection was done in each area; ploughing was done three times with traditional oxen-driven practices. Agricultural lime obtained from Guder lime factory was broadcasted by hand and the whole P fertilizer was applied to each experimental plot per site except the control.

Malt barley variety was used as a test crop and hand drilled at a recommended seeding rate of 75 kg ha-1. Sowing was conducted in the last week of June 2020. The experimental malt barley seeds were drilled by hand at 0.2 m spacing between rows for both test fields in the plot with an area of 10 m2 (2.5 m x 4 m). The spacing between plots and blocks was 0.5 m and 1 m, respectively. Weeds were removed 40 days after planting and the second weeding was 35 days after the first weeding periods. The lime requirement of the soil was calculated based on its exchangeable acidity as described by Kamprath (1984). Soil samples of (0-20 cm) were collected from test fields before sowing. Representative soil samples were collected for soil physioc-chemical determination. The yield was recorded from each experimental plot. The yield was measured after harvesting was done from a net plot area of 4.4.m2. All management aspects (seed bed preparation, sowing, fertilization, weeding, harvesting) were done by adopting the recommended practices of malt barley production and local practices of the farmers of the two districts. Soil sample preparation and analysis were done at Oromia Water Work and Construction Design Soil Laboratory Center.

Soil Sampling and Analysis

Twelve representative soil samples per experimental site was randomly collected using auger at a depth of 0-20 cm and then one composite soil sample was prepared to determine the physioc-chemical properties of soils before sowing. The samples were air dried, ground by mortar and pestle and passed through a 2-mm sieve for analysis of selected physico-chemical properties, while total N was determined from soil samples sieved by 0.5-mm sieve.

Particle size distribution was determined by the hydrometer method (Day, 1965). Bulk density was determined using the core sampler method and computed from the values of oven-dry soil mass and volume of core sample as described by Jamison *et al*. (1950). The particle density (ρ_p) was considered as an average value of 2.65 g cm^{-3} for the calculation of the total porosity of the experimental soils at both study sites. Total porosity was calculated from the values of bulk density and the average value of particle density using the method described by Rowell (1994). Soil samples taken by core sampler were saturated and used in a pressure plate extractor for measuring water content at -33 and -1500 kPa matric potential. The equilibrium moisture content at -33 and -1500 kPa matric potential points was determined gravimetrically as described by Reynolds (1970). The gravimetric water content was converted into volume wetness by multiplying it with the ratio of dry bulk density to the density of water (assumed to be 1 g/cm^3). Available water holding capacity (AWC) was computed as the difference between water retained at field capacity (FC) and permanent-wilting point (PWP) (Hillel, 1998).

Soil pH in water was determined by the glass electrode pH meter (Peech, 1965) at 1:2.5 soil water ratios. The cation exchange capacity (CEC) was determined by the method described by Chapman (1965). Exchangeable potassium (K) and sodium (Na) were determined using a flame photometer as described by Rowell (1994), while calcium (Ca) and magnesium (Mg) were determined by the atomic absorption spectrophotometer method (Hesse, 1971; Rao *et al* 2005). Total exchangeable acidity was determined by saturating the soil samples with 1M KCl solution and titrating with 0.02M HCl as described by (Rowell, 1994). From the same extract, exchangeable Al^{3+} in the soil samples was titrated with a standard solution of 0.02M HCl. Then the exchangeable H^+ was obtained by subtracting exchangeable Al^{3+} from total exchangeable acidity, which is Al^{3+} and H^+ ions (Rowell, 1994). The percent base saturation of the soil samples was calculated from the sum of the exchangeable cations (Ca^{2+}, Mg^{2+} and Na^+) as a percentage of CEC (Baruah and Barthakur, 1997, Sahlemedhin, and Taye, 2000). Available P was analyzed using Bray II (Bray and Kurtz, 1945). Total N content in the soils was determined using the Kjeldahl procedure (Jackson, 1958). To determine organic carbon (OC), the Walkley and Black (1934) method was employed. Finally, the organic matter (OM) content of the soil was calculated by multiplying the OC percentage by 1.724. The relative amount of carbon to nitrogen was determined by taking the ratio of soil OC to total N.

Agronomic Data Collection

Grain yield was measured from all experimental units. Grain yield was determined by harvesting from the middle rows (4.5 m^2) area and converted into hectares bases after adjusting the grain moisture content to 12.5%.

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Data Analysis and Interpretations

The analysis of variance for grain yield was made for each site. The collected data on the grain yield of malt barely was subjected to analysis of variance (ANOVA) by using SAS version 9.4 statistical software (SAS Institute, 2002). All pairs of treatment means were compared using the Least Significant Difference (LSD) test at a 5% level of significance (Steel and Torrie, 1980).

Results and discussions

Pre-sowing status of selected physical and chemical properties of experimental soils

The mean value of analytical results of selected soil physico-chemical properties of Chaliya and Jaldu districts were shown below in Tables 1 and 2. The results of laboratory analysis for soil physical properties indicated that the soils have 32% sand, 40% silt and 28% clay for Chalyia, and 24% sand, 46% silt and 30% clay for Jaldu site. On the basis of the USDA (1999) soil textural triangle, the soils of the two districts could be categorized as clay loam textural class. The textural classes of both study sites were the same might be due to the similarity in the parent material. Malt barley is best adapted to loams, sandy loam and clay loam soils. Thus, in terms of textural class, the soils of the experimental sites were suitable for the production of malt barley.

Table 1. Pre-sowing of mean values selected physical properties of soils

Soil parameters	**Mean values and experimental sites**	
	Chaliya district	Jaldu district
Textural class	Clay loam	Clay loam
Sand (%)	32	24
Silt (%)	40	46
Clay (%)	28	30
Bulk density (BD) in (gcm^{-3})	0.91	0.93
Total porosity (%)	65.6	64.9
Field capacity (%)	35.9	36.6
Permanent wilting points (%)	26.1	25.9
Available water capacity (mm/m)	98	107

The BD in soils of Jaldu district was relatively higher than that of soils of Chaliya district. The relatively lower and higher BD of soils at Chaliya and Jaldu districts may be attributed to the high SOC, porosity and fewer disturbances of soils of Chaliya district. Basically, an increase in SOC lowers bulk density while compaction increases bulk density. Therefore, compaction of the soil surface caused by intensive field traffic by livestock for grazing and deforestation may cause an increase in the soil bulk density of the soils of Jaldu district.

The soil volumetric water content at field capacity, permanent wilting point and available water holding capacity at both study sites showed slight variation might be due to differences in their clay content and organic matter percentage. The relatively higher values of AWC of Jaldu district may be due to its higher clay contents. This was in agreement with the finding of Emerson (1995) who concluded an increase in AWC with an increase in the clay content of the soil. As per rating by Landon (1991) the values of available water holding capacity of both study areas were categorized under low class. The optimal AWC of soil for most crop production is greater or equal to 150 mm per meter depth. Soils under both study sites are by far below this threshold value, which indicates that the soils of the two sites are out of the optimum range of AWC for agricultural production.

Table 2. Pre-sowing mean values of selected chemical properties of soils

Soil chemical parameters	Experimental sites and mean values	
	Chaliya district	Jaldu district
pH(H_2O)	5.12	5.01
OC (%)	2.04	1.96
TN (%)	0.22	0.18
C:N ratio	9.27	10.89
Available P($mgkg^{-1}$)	9.53	9.22
Total P ($mgkg^{-1}$)	971.2	908.4
Exchangeable Ca(cmol(+)kg^{-1})	9.83	10.0
Exchangeable Mg(cmol(+)kg^{-1})	1.69	1.83
Exchangeable K(cmol(+)kg^{-1})	1.10	0.39
Exchangeable Na(cmol(+)kg^{-1})	1.07	0.27
CEC(cmol(+)kg^{-1})	31.00	28.63
Exchangeable Al(cmol(+)kg^{-1})	1.13	1.36
Exchangeable Acid(cmol(+)kg^{-1})	4.18	5.31
Acid saturation percentage (%)	13.5	18.84
Base saturation percentage (%)	49.22	46.10

The pH of the soils at Chaliya and Jaldu sites, respectively, were 5.12 and 5.01 which was in the very strong acidic soil reaction. Basically, in acidic soils with pH < 5.5, the solubility of

Al increases to toxic levels which severely restrict root systems and reduce the normal pattern of plant growth. Moreover, the acidic nature of soils with low soil pH obtained at the representative experimental soils of both districts may be attributed that, soils at both experimental districts were derived from weathering of acidic igneous granites and leaching of basic cations such as K, Ca and Mg from surface soils (Frossard *et al.,* 2000). The very strongly acidic soil reaction at the two sites indicated the unsuitability of the soil for malt barley production unless amendment options such as the application of agricultural limes to neutralize soil acidity (Achalu *et al*., 2012b; Achalu, 2022).

There was a variation of organic and total nitrogen between the two experimental sites. Across the two sites, the mean values were 2.04 and 1.96% (for soil organic carbon) and 0.22 and 0.18% (for total nitrogen), respectively, for Chaliya and Jaldu sites (Table 2). The most probable source of variation in soil organic carbon and total nitrogen contents between the two sites could be due to differences in slope, organic inputs, moisture content, temperature, pH and management practices. According to the rating suggested by Tekalign (1991), the soil organic carbon and total nitrogen percentage of the study areas can be categorized under the medium class. Comparatively, the higher mean percentage of total N recorded at Chaliya site than Jaldu site might be due to better organic carbon content scored at Chaliya site than Jaldu site.

The C: N ratio of both Chaliya and Jeldu sites was in the low rating class which might be accredited to continuous cultivation, plant uptake and volatilization. The low carbon-to-nitrogen ratio for the two sites further might be due to high microbial activity and more CO_2 evolution as a result of rapid decomposition and improvement in aeration during tillage operation which enhances mineralization rates in croplands. Similarly, Achalu *et al*. (2012a) reported that exposure of the topsoil to rainfall brings about erosion, rapid decomposition of soil OM and intense leaching of basic nutrients rendering the soil infertile and the agricultural production unsustainable.

Soil available P was 9.53 and 10.71 ppm, respectively, for Chaliya and Jaldu sites (Table 2). The relatively better available P content recorded at Chaliya site might be due to better SOM status at Chaliya site and the dominance of the $H_2PO_4^{1-}$ anion in strongly acidic soils than HPO_4^{-2} anion (Bati and Achalu, 2021). Available soil P of the study areas was categorized in the very low range as suggested by EthioSIS (2014). The very low soil available P could be due to continuous cultivation and lack of incorporation of enough organic materials into the soils, degree of P fixation, crop uptake, crop residue removal, and soil pH. The result of this study was consistent with Paulos's (2001) finding who observed that variations in available P contents in soils are related to the intensity of soil disturbance and the degree of P-fixation with Fe and Caions. Similarly, Dawit *et al*. (2002a) and Bati and Achalu (2021) reported SOM as the main source of available P and the availability of P in most soils of Ethiopia declined by the impacts of fixation, abundant crop harvest and erosion. The distribution of total P content followed a similar pattern to available P distributions and ranged from 908.2 to 971.2 mg kg^{-1}. The relatively lower amount of total P obtained in the soils of Jaldu site may be due to the intensive cultivation of lands which results in a decline in the distribution of soil total P in the area.

Before sowing mean values of exchangeable (Ca, Mg, K and Na), CEC, PBS and PAS according to FAO (2006) rating; soil exchangeable $Ca^{2+}$and Mg^{2+}were in medium class for both sites, exchangeable K^+ and Na^+ ions were relatively classified under high range in Chaliya and exchangeable K and Na ions were in low and medium classes, respectively, at Jeldu site. The order of exchangeable base cations is generally in the order of Ca > Mg > K > Na similar to what is in most agricultural soils. Variations in exchangeable bases among the two districts were insignificant. The insignificant variations might be due to differences in particle size distribution, degree of weathering, and the intensity of cultivation and the parent material from which the soil is formed (Table 1). In line with this, a study by Heluf and Wakene (2006) revealed that variations in the distribution of exchangeable bases depend on the mineral present, particle size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed.

As per the ratings recommended by Hazelton and Murphy (2007), the value of CEC of the topsoil (0-20 cm) depth of both sites can be classified as high status of CEC. The trends of the distribution of CEC showed similarity with the distribution of PBS, exchangeable Ca and Mg, since factors that affect these soil attributes also affect the cation exchange capacity (CEC) and percentage base saturation (PBS) suggesting that intensive weathering and might be the presence of more 1:1(kaolinitic) clay loam minerals in the soils of both districts. Previous research work conducted by Eyelachew (1999) on the fertility status of some Ethiopian soils indicated that exchangeable bases, especially Ca and Mg ions dominate the exchange sites of most soils and contribute higher to the PBS and CEC. The relatively higher CEC values recorded, respectively, in Chaliya districts may be attributed to the fact that the soil relatively accumulates high percent OC and has a greater capacity to hold cations thereby resulting in greater potential fertility in the soil.

There were inverse relationships between PAS and PBS of soils at both sites. Because the more acid the soil, the greater Al will be dissolved into the soil. Once the soil pH is lowered much below 5.5, aluminosilicate clays and Al-hydroxide minerals begin to dissolve and release Al-hydroxy cations from soil colloids and fractions of exchange sites occupied by Al-H. The soil chemical reaction processes that affect the extent of acidic cations ($Al^{3+}$and H^{+}) also affect the PAS. At low soil pH, oxides of Al and Fe get into the solution and through step-wise hydrolysis and release H^{+} ions resulting in further soil acidification. Basically, the relative severity of acidity of the soils in both districts comes from intensive cultivation, which results in the leaching of basic cations from soil solutions. Therefore, the soils in both districts need some reclamation options such as the use of agricultural liming materials. Because liming is commonly used to improve the productivity of acidic soils in agricultural systems and also increases the availability of nutrients, which would otherwise be strongly limited by low soil pH.

Effect of lime and P- fertilizer rates on grain yield of malt barley

The mean grain yield of malt barely grown in Chaliya and Jaldu sites is presented in Table 3. The mean values of grain yield were significantly ($p < 0.05$) affected by different rates of application of lime and P fertilizer at both experimental sites. However, the interaction effects of lime and P were not significant for yield at both sites; their main effects are presented in Table 3. The highest values of yield (4.97 t ha^{-1}) were obtained from the application of 3.3 t ha^{-1} of lime. For instance, the application of lime at the rate of 3.3 t ha^{-1}, increased the grain yield of malt barley by 48.8 and 64.21%, respectively, at Jaldu and Chaliya sites compared with the control plots. While the lowest values of grain yield (2.85 t ha^{-1}) were recorded from control plots of Chaliya site (Table 3). The highest yield following the application of lime might be due to increased pH which creates improved nutrient availability, increased available P to plants as a result of decreased Al toxicity and favorable effects of lime on soil chemical and microbial properties. In conformity to this, Getachew *et al*. (2017) and Temesgen *et al.* (2016) reported the amelioration of acid soils by additions of lime in order to increase the yield of barely. Similarly, Wang *et al*. (2011) reported increasing in yield due to liming which is mainly associated with an increase in soil pH and a reduction in acidic cations.

Similarly, the effect of different levels of P-fertilizer applications significantly (P<0.05) affected the grain yield (Table 3). The highest barley grain yield (4.21 t ha^{-1}) at Chaliya site, was obtained at Jeldu site due to the application of 90 P kg ha-1. For instance, the application of 90 kg ha^{-1} P fertilizer increased grain yield by 13.8 and 16.29% than the control plots, respectively, at Jaldu and Chaliya sites. Whereas the lowest grain yield (3.62 t ha^{-1}), was obtained at Chaliya site from control plots.

In general, successive applications of phosphorus fertilizer also resulted in increased grain yield of barley compared with control plots. Large levels of phosphate fertilizer application to acid soil better improved grain yield of barley crop by counteracting against Al toxicity. This could be due to the sufficient availability of P to barley crop as a result of soil sorption sites being satisfied and the decrease of sorption of soil P availability. In line with this, Anetor and Akinrinde, (2006) findings showed that with high rates of P fertilizer additions, the soil sorption sites are satisfied and P-level increases to a sufficient level for crop production in acid soils. Similarly, Haynes, (1982) reported that applications of phosphates to acid soils reduced the toxicity effects of Al ions by precipitating it from the soil and supplying enough phosphate for plant growth.

Table 3. Grain yield as affected by different rates of lime and phosphorus fertilizer

Treatments	Chaliya	Jaldu
Lime rate (t ha^{-1})	Grain yield (t ha^{-1})	
0	2.85^{d*}	3.34^{d}
1.1	3.92^{c}	4.21^{c}
2.3	4.38^{b}	4.62^{b}
3.3	4.68^{a}	4.97^{a}
LSD (0.05)	2.17	2.27
P rates (kg ha^{-1})		
0	3.62^{c*}	3.98^{c}
30	3.90^{b}	4.23^{b}
60	4.08^{ab}	4.40^{ab}
90	4.21^{a}	4.53^{a}
LSD (0.05)	2.17	2.27
CV%	6.21	6.42

LSD = least significant difference; CV = coefficient of variation; numbers followed by the same letter in the same column are not significantly different at 5% probability level

Conclusion

The results of this study showed that the soils of the two sites were categorized as clay loam in texture and suitable for the production of malt barley. In contrast to this, the very low value of available P, unsuitable values of available water holding capacity and soil pH of both experimental sites recorded from pre-sowing soil analysis revealed that the availability of essential nutrients such as P for malt barley crop is critically affected by low pH. Moreover, the mean values of grain yield of malt barley was significantly ($p < 0.05$) affected by different rates of agro-lime and P fertilizer at both experimental sites. The highest values of grain yield of malt barley 4.97 and 4.45 t ha-1 were obtained as a result of the application of 3.3 t ha-1 and 90 kg P ha-1 fertilizer at Jeldu site and the yield was increased by 48.8% and 13.8% compared with control plots, respectively, for 3.3 t ha-1 agro-lime rate and 90 P kg ha-1 fertilizer. Hence, the application of agro-lime at the rate of 3.3 t ha-1 and 90 P kg ha-1 could serve as a reference for better malt barley production at Chaliya and Jeldu districts even though malt barely gave maximum yield at Jaldu. Nevertheless, the most generalized recommendation should be suggested after inclusion of economic analysis.

Acknowledgments

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Data Availability

The data used to support the results of this study are included within the manuscript and any further information is available from the corresponding author upon request.

Conflict of interest

The authors declare that they have no competing interest.

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