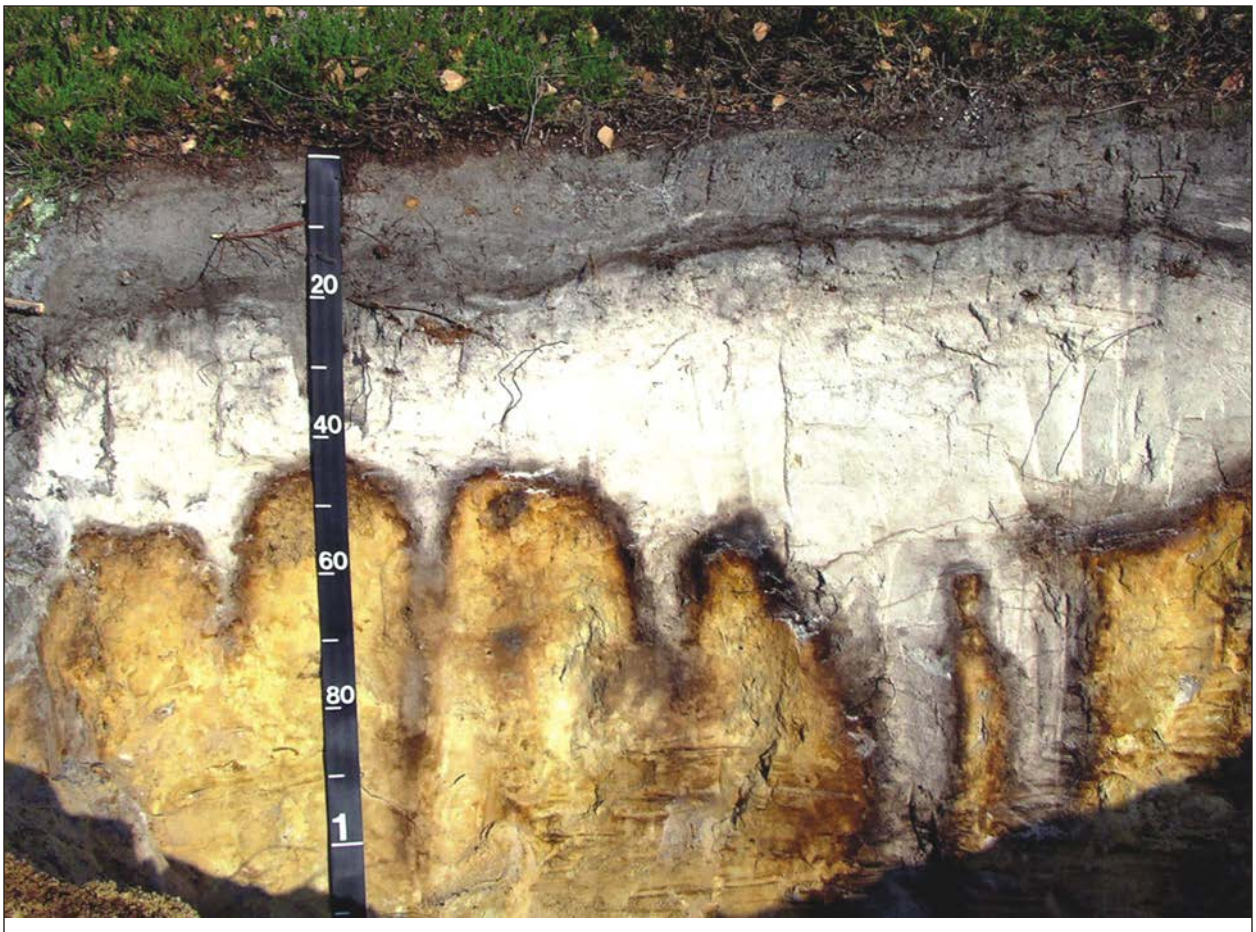

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Liming Effects on Yield and Yield Components of Haricot Bean (*Phaseolus vulgaris* L.) Varieties Grown in Acidic Soil at Wolaita Zone, Ethiopia

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ABSTRACT

A field experiment was conducted at two locations (Bolosso Sore and Damot Sore) in Wolaita Zone of SNNPRS to evaluate the response of two varieties of haricot bean (*Phaseolus vulgaris* L.) with two rates of lime (0 and 0.4 t ha^{-1} $CaCO_3$) were used on acidic soils. The treatments were arranged in factorial RCBD with three replications. Analysis result of soil samples showed that OC, Av.P, TN and soil pH values were very low. Application of lime resulted significant changes on these chemical properties of the soils in the two locations. Availability of P and soil pH was improved due to the application of lime and maximum values of these parameters were recorded. Growth parameters, yield and yield components were significantly increased with increasing rates of liming at the two locations (year 1 and 2). Maximum grain yields (1282.49 and 1416.99 kg ha^{-1} for Hawasa Dume at Gununo and Dolla, respectively and 1079.40 and 1122.58 kg ha^{-1} for Omo-95 at Gununo and Dolla, respectively) were recorded at rates of 20 kg P ha^{-1} with lime of 0.4 t ha^{-1} at both locations. From the result of this study it could be conclude that liming improve soil pH, Av.P and performance of haricot bean varieties but till now there is some gap on correcting acidity of the soils and also grain yield of the varieties. So application of lime should be repeated in the coming season soil until comes to neutral and increased the production of the crops.

Key words: Hawasa dume, Omo-95, soil acidity, yield

INTRODUCTION

Haricot bean (*Phaseolus vulgaris* L.) is annual pulse crop with considerable variation in habit, vegetation characters, flower color and the size, shape of pods and seeds (Onwueme and Sinha, 1999). It was probably first cultivated with maize and it seems likely that the two crops evolved together in a cereal-Legume farming system in much the same way as cowpeas and sorghum in West Africa. It is widely cultivated thought out different parts of Ethiopia. It is produced in four major agro ecological zones, including the central, eastern, southern and western zones. Haricot bean is mainly used as source of food and cash. It is exported to earn foreign exchange and is also one of the cash crops locally used by farmers as source of food. Additionally farmers also grow the bean to use as forage for livestock and mulching. Haricot bean cultivation can be carried out without large input and intensive practices and this makes it suitable for poor farmers where the need in food supply is important. It can be used in intercropping system with maize and between young trees until canopy closure.

Yield of legumes in farmer's field is usually less than 0.65 t ha^{-1} against the potential yield of 1.2 t ha^{-1} suggesting a large yield gap (CACC, 2002). Low yield potential of legumes has made them less competitive with cereals and other high value crops. The yield of haricot bean increase with P application and its nodulation and fixation of N can be also improved with the application of P (Gedno, 1990). The average national productivity of haricot bean is 0.72 t ha^{-1} (CACC, 2002) and its regional productivity is 0.81 t ha^{-1}.

The major haricot bean producing area in the southern zone includes Gamo Goffa, Sidamo and Wolaita (Gedno, 1990). Haricot bean is also one of the most communal cultivated pulse crops in the Wolaita area where its yield is lower than regional and national yields. The low yield is contributed from acidity of soils which reduce availability of P and basic cations as Ca and Mg and also affect activities of soil microorganisms (Havlin *et al.*, 1999).

Lime application neutralizes soil acidity, reduces toxicity levels of Al, Fe and Mn and improves physiological, chemical and biological properties of soils (Kisinyo *et al.*, 2005). It also improves soil productivity by providing Ca and Mg (Oster, 1982). It is found that as the lime and P application to acid soils increased plant available Fe, Mn, Zn and Cu, but B contents of soil decreased, whereas pH, Ca, Mg and available P increased which in turn improve crop performance (Ponette *et al.*, 1996). The extension of this approach in semiarid region of Ethiopia appears to be promising.

Even though application of lime with P brings positive effect on soil conditions and crop performance, in Wolaita area where the problem of soil acidity is very chronic, little or no work is done to verify whether there is response of crops to P application rates with liming or not. Furthermore, to use lime as source of nutrients, there should be site specific recommendation to maintain optimum level of nutrients. Therefore, this study was initiated with the following objectives:

- To evaluate the response of haricot bean varieties to different rates of liming
- To compare the performance of haricot bean varieties with liming
- To observe the interaction effect of lime with haricot bean varieties

MATERIALS AND METHODS

Description of the study site: The researches were conducted during the 2012-2013 rainy season at two locations which is located in Wolaita Zone, Southern Nations Nationalities and People's Regional State (SNNPRS). The first one was at Boloso Sore district which is located at 307 km south of Addis Ababa and 5 km from Areka town, at 7°04.196'N and 37°41.330' E and altitude of 1790 m above sea level.

The second location was Damot sore district which is located 330 km south of Addis Ababa and 2 km from Gununo town, at 6°56"N and 37°.39' E and altitude of 1790 m above sea level. There was no meteorological station in the study area which is found 3 km far from Boloso Sore district. The two districts are with mean annual rainfalls of 1460 mm with a bimodal pattern which extends from March to September. The peak rainy months are April, July, August and September. The mean minimum and maximum temperatures are 15 and 26°C, respectively. The representative date was collected from Areka Agricultural Research Center.

Methods and approaches: To fill the knowledge gap on application of liming with fertilizer rate on acidic soil, various knowledge enhancement activities were carried out. They included training of 30 subject matter specialists, 30 farmers and 8 development workers, introduction of liming application on acidic soils on selected two farmers training centers in two woredas.

Treatments and experimental design: Hawassa Dume and Omo-95 haricot bean varieties were used for test crop to compare its response to liming rate (0 and 0.4 t ha^{-1} $CaCO_3$). The treatments were arranged in factorial RCBD with three replication. Five rows each have fifteen plants were used on plot having size of 2.0 by 1.5 m. Spacing of 10, 40, 50 and 100 cm were used between plants, rows, plots and blocks, respectively. Urea at rate of 50 and 20 P kg ha^{-1} were applied at planting time. TSP for P and urea for N were used as source of fertilizer.

Agronomic data collection: Flowering and maturity dates (when 50% of the plants were at respective phonological stage), No. of branches per plant, plant height, No. of pods per plant, No. of leaf per plants, pod length, No. of seeds per pod and seed yield were recorded. Three central rows were harvested for determination of grain yield and total biomass.

Soil sampling and analysis: The soil samples were air-dried and ground to pass 2 and 0.5 mm (for total N) sieves. All samples were analyzed following standard laboratory procedures as outlined by Taye *et al.* (2000). Organic carbon and total N contents of the soil were determined following the wet combustion method of Walkley and Black and wet digestion procedure of Kjeldahl method, respectively. Available P was extracted by Olsen method Olsen *et al.* (1954). Soil texture was analyzed by Bouyoucos hydrometer method. The pH (H_2O) of the soils was measured in water using pH meter with glass-calomel combination electrode.

Statistical analysis: The data obtained from soil and crop, were statistically analyzed using the PROC ANOVA function of SAS and means were compared using LSD at a probability level of 5%.

RESULTS AND DISCUSSION

Physicochemical properties of soil: Soil analysis of the two locations before sowing in two years (Table 1) showed that pH values (5.0 and 5.6) found in the range of strong acid based on Herrera (2005) classification. Whereas the application of lime resulted in a significant increase in soil pH compared to 0 t ha^{-1}, the application of lime combined with P 20 kg ha^{-1} it's led to slight decrease soil acidity in both year 1 and 2, but this was not significant (Table 1). Lime combined with P fertilizer gave the mean highest value of soil pH (6.3) at Dolla site while P fertilizer applied alone had the least (5.2) at Gununo site. This result clearly indicated that the area is seriously affected by soil acidity which is not satisfactory for growth of most crops (Havlin *et al.,* 1999).

The range of available phosphorous contents of the two locations (0.6 and 1 mg kg^{-1}) before sowing was very low (Table 1) this was in range of very low based on (Herrera, 2005). This low concentration of available P may be related to acidity of the soil which bring fixation of P (Havlin *et al.,* 1999). The available phosphorous concentration increased with increased liming. The highest concentration of Av.P (5.2-6.1 mg kg^{-1}) was recorded under year 2 in Gununo and Dolla site respectively, whereas the lowest Av.P was found at year 1 at 0 t ha^{-1} liming at two

Table 1: Physico-chemical properties of the soil before sowing at Dolla and Gununo, 2012-14

	Soil pH		Av. p (mg kg^{-1})		TN (%)		OC		
Location	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Textural class
Dolla	5.3	5.6	1.00	6.12	0.15	1.75	0.15	0.31	Sandy loam
Gununo	5.0	5.4	0.60	5.22	0.12	0.18	0.10	1.70	

locations. The differences in Av.P concentration in soil might be resulted from changes in biological and geochemical processes at different activities after human disturbances.

Application of lime might contributed in releasing some amount of fixed P to be available for the crop. But application of lime alone could not help haricot bean production to be increased. This also indicates that deficiency of P cannot be replaced by lime. As a result in acidic soils which are deficient in Av.P, OC and TN are important to apply P together with lime to increase crop production. The same result was obtained in the year 1 and 2 of the OC and TN in experiment site. First year and second years lime application with fertilizer had been affect haricot bean production. This is in agreement with Anetor and Akinrinde (2007) who indicated that lime increased pH and available P in Nigeria. However, potassium (K) and exchangeable acidity were decreased with increasing application. On the other hand, lime did not influence TN and OC of the soil. This indicates that application of lime is required to increase the soil nutrient availability. Textural analysis showed that the same textural class according to the present study soil textural class was sandy loam in both locations and textural class there are no significantly difference between year 1 and 2. The lack of soil textural class difference between year 1 and 2 at both location its might be attributed to the similarity in parent material from which the soils originate.

Soil analysis results of soil sample showed that pH values at harvested were higher than values before sowing both in year 1 and 2 which may be attributed to application of P fertilizer and the positive effect of lime in neutralizing acid soils (Table 1). Statistically there was no significant difference on TN and OC of soils in both locations except for available P of Dolla soil with the absence of liming. On the other hand, application of lime resulted significant variation on soil pH and available P in the two locations of year 1 and 2. These changes of soil pH and Av.P of soil may be attributed to the neutralizing of acid soil due to application of lime and also application of P fertilizer at increasing rates (Tisdale *et al.,* 1993). Soil pH, Av.P, OC and TN were measured by year 2 with lime rates (0.4 t ha^{-1}) exhibited significant effect on Soil pH and Av.P. These dates were year 1 and 2 content of the soil exhibited an increasing trend with increasing rates of liming material application. The lime (0. 4 t ha^{-1}) produced the highest mean phosphorus concentration (4.0 mg kg^{-1}), implying a greater effect of the applied lime material on the availability of phosphorus in two years. Therefore, applying higher amounts of liming materials in acidic soils maximized the availability of phosphorus nutrient in the soils which is very important for crop production (Smith *et al.,* 1994). The highest phosphorus value (30 kg ha^{-1}) and the lowest phosphorus value (0 P kg ha^{-1}) was obtained from two years.

Interaction effect of lime on growth performance of haricot bean varities: Application of lime at different rates resulted significant variation on growth parameter of plant in the two locations both with and without lime (Table 2). Growth parameters such as plant height, leaf and branches number were increased significantly as the rates 0.4 t ha^{-1} increased. Maximum values of plant heights, leaf and branches numbers were recorded at application rates of 20 kg P ha^{-1} in the two locations both with and without lime (Table 2). Additionally, Hawassa Duma had better performance than Omo-95. In line with this result Kisinyo *et al.* (2005) indicated that growth of plant increased in acid soil as application of P increased with and without lime. This positive growth response of haricot bean for application of P in acidic soil may be a related with better availability of P as the rates of P application increased. Furthermore, plant did have better performance due to liming (Table 2) which may come from the effect of lime in neutralizing soil acidity and in turn improve the availability of P for crops. Similar result was also reported by Singh and Tripathi (1994).

Table 2: Mean value of lime on growth performance of haricot bean varieties at Gununo and Dolla in 2011/12-2013

		Gununo			Dolla		
Lime (t ha^{-1})	Varieties	Height	Branch No.	Leaf No.	Height	Branch No.	Leaf No.
0	Omo-95	42.61	2.55	10.42	62.10	4.80	13.16
	Hawassa dume	38.39	3.46	12.98	60.36	5.76	16.90
0.4	Omo-95	43.25	2.70	9.72	62.42	4.21	13.06
	Hawassa dume	46.83	2.85	9.90	62.82	5.99	14.46
CV		39.59	17.40	31.70	35.70	28.50	16.27
LSD		4.37 g	0.58	1.53	13.03	0.99	1.65

Table 3: Mean value of lime on yield and yield components performance of haricot bean varieties at Gununo and Dolla in 2012-2013

		Gununo				Dolla			
Lime (t ha^{-1})	Varieties	Pod No.	Seed No.	Pod length	Seed yield	Pod No.	Seed No.	Pod length	Seed yield
0	Omo-95	8.80	5.42	8.35	826.32	8.85	5.62	8.72	875.17
	Hawassa dume	9.25	5.17	8.47	930.30	8.62	5.22	8.72	972.96
0.4	Omo-95	8.77	5.02	8.17	1079.40	7.77	4.90	8.52	1122.58
	Hawassa dume	9.35	5.17	8.47	1282.49	8.67	5.22	8.40	1416.99
CV		27.70	17.14	9.50	34.27	22.70	11.90	0.79	46.0
LSD		1.43	0.44	0.57	201.0	1.65	0.65	3.11	200.0

Effect of lime on yield and yield component of haricot bean varieties

Pods number and length: Analysis of variance showed that there was significant interaction effect of lime and phosphorus rates on number and length of pods for both varieties in two locations. Maximum number and length of pods were recorded at 0.4 t ha^{-1} with the absence and also application of lime for Hawassa dume while Omo-95 had lower performance (Table 3). Such increment of pods number and length with increasing rate lime with P may be attributed to the better availability of P for plants as the rate of external P application increase which in turn observed on better plant performance. Furthermore, better performance of both varieties with liming may be related with neutralizing of acid soil by lime which in turn increases availability of P for plant uptake (Kisinyo *et al.,* 2005). In agreement with this result Abebe (2009) also stated that pod numbers of haricot bean increased with the increasing of lime. Interaction effects of lime and haricot bean varities were significant whereas, P fertilizer had interaction with lime and haricot bean varities were significantly ($p<0.05$) affected pod number of the hawassa dume verity (Table 3). Highest number of pods per plant (9.24) was produced when the crop was grown in lime. Effect of lime on pod per plant and Pod number recorded from lime treated alone hawassa dume verity alone was not significantly different. This may be because lime created better soil environment for naturally existing haricot bean varities. This finding is also in line with reports of Malik *et al.* (2006) and Bhuiyan *et al.* (2008) who indicated more pod number per plant of soybean.

Seeds number and seed yields: There was significant variation on seed number per pod and seed yield ha^{-1} due to application of lime and the two varieties. Maximum number of seeds per pod and seed yield ha^{-1} at the two locations were recorded for both varieties while they were treated by 0 and 0. 4 t ha^{-1} of lime (Table 3). Seeds number and seed yield were increased with increasing rates of lime for the two varieties which were treated by lime at rates of 0 and 0.4 t ha^{-1}. As stated

earlier available P with lime was increased when rates of lime application increased with crop production, these in turn improve crop performance such as seeds and pod number and at the end seed yield.

So, this result indicated that liming improves availability of P for crops and also external P application improved crop yield performance. The result may be attributed to the fact that applying phosphorus fertilizer increases crop growth and yield on soils which are naturally low in P and in soils that have been depleted (Mullins, 2001; Hammond *et al*., 2004).

The interaction effect of lime and haricot bean varities were significant ($p<0.05$) in case of seed number per pod of the haricot bean (Table 3). Regardless of P fertilization, lime and hawass dume gave significantly higher seeds per pod. This is in agreement with reports of Cassman *et al*. (1980) and Seneviratne *et al*. (2000) on nodulation parameters of soybean. Significantly lower number of seeds was recorded from haricot bean grown without lime. Seed yield of the crop was significantly affected by effect of lime and haricot bean (Table 3). When the crop was grown without lime, had no significant effect whereas the effect of the fertilizer was significant under two location. However, P with and without lime gave significantly more seed yield under the use of hawass dume verity (Table 3). This result is supported by Munns *et al*. (1981), Guo *et al*. (2009), Chalk *et al*. (2010) and Bekere *et al*. (2013) who reported beneficial effect of lime for legumes grown in acidic soil. When lime was applied, on acdic soils was significantly increased seed yield of the haricot bean. This may be because of the fact that acidic soil environment was neutralized by the applied lime. Earlier findings also showed that rhizobium and P fertilizer give almost similar weight in legumes like soybean, haricot bean and mung bean (Munns *et al*., 1981; Cassman *et al*., 1981).

SUMMARY AND CONCLUSION

A field experiments were conducted at the two locations on acidic soil to study the effect of lime and phosphorus application on haricot bean varities at Dolla and Gununo in Wolaita Zone, Southern Ethiopia. The research work was initiated to evaluate the response of haricot bean varieties to liming on acid soils. The experiment was laid out in factorial randomized complete block design with three replications. Hawasa dume and Omo-95 were treated by 0 and 0. 4 t ha^{-1} of lime.

Soil samples were collected from two locations before sowing and at maturity for analysis of some selected physical and chemical properties of soil (texture, Soil pH, Av.P, OC and TN). Laboratory analysis result of the soil samples taken before sowing and at harvest revealed that all the soil parameters were at lower rates even though the soil was treated by different rates of lime.

Available Phosphorus was showed increasing tendency with increasing soil pH and liming on both location with two seasons. The overall result of chemical properties in this study, demonstrated that most soil parameters were significantly different with lime application at two areas.

There was a significant increase on growth parameters of the two varieties as rates of lime increased both at Dolla and Gununo sites. Maximum values of plant height, leaves and branches number were recorded at application rates at both location with liming in year 1 and 2. Similarly, the highest grain yield and yield components were obtained at 20 kg P ha^{-1} with lime (0.4 t ha^{-1}) on both varieties at two locations. Furthermore, application of lime improved soil conditions and in turns varieties performance at both locations.

Therefore, applying of liming materials in acidic soil maximize the availability of nutrients especially phosphorus in the soil which is very important for better performance of crops. In general liming is important in the study area; this is because of strong acidity and low values of some chemical properties of the soil. The application of P fertilizer increased yields of haricotbean;

however, the grain yields were low compared with crop potential. This indicates that a two season treatment of lime can correct problem of soil acidity. So it is recommended that correcting of soil acidity should be done for growth seasons until soil comes to neutral conditions and increased crop production.

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