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Response of common bean (*Phaseolus vulgaris* L.) Genotypes to application of lime on acidic soil of Benishangul Gumuz, Western Ethiopia

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Abstract

Among abiotic constraints of crop production in western Ethiopia, soil acidity is the major ones. With this regard an experiment consists of fifteen common bean genotypes was conducted at Bambasi woreda by applying lime to the experimental plots with soil acidity problem. The experimental design was RCBD in split plot arrangement. Lime application (treated and untreated) was assigned to main-plot while genotypes were assigned to sub-plots with objective of determining the response of common bean genotypes to lime application for growth, yield and yield components. Data for phonological, growth, nodulation yield component and seed yield were collected and analyzed using SAS soft ware. Common bean genotypes were responded differently (significantly affected by) to lime application for their days to flowering, days to maturity, nodulation, and pod per plant while the response of evaluated fifteen genotypes were non-significantly affected by lime application to the acidic soils. The highest seed yield (1539kg/ha) was recorded for ALB212 genotype whereas the lowest yield (700kg/ha) was recorded for Roba genotype. The result of this experiment implied that the application of lime to acidic soils has not so much influence on crop yield in the first year or so thereby to know the effects of lime application it is important to look thoroughly for three to four years.

Keywords: Common bean, lime application, genotype, soil acidity, Main-plot

1. Introduction

Common bean (*Phaseolus vulagris* L), is one of the most important and widely cultivated species of *Phaseolus* in Ethiopia. Being mostly known as ‘Boleqe’ in Ethiopia, it is also known as dry bean and haricot bean, in different parts of the world. Common bean is an annual pulse crop which belongs to the family Fabaceae. It grows best in warm climate at temperature of 18 to 24^{o}C (Teshale *et al*., 2005). It is thought to be introduced to Ethiopia by the Portuguese in the 16th century (Wortman, 1997). In Ethiopia, common bean is grown predominantly under smallholder producers as an important food crop and source of cash. Its high protein content (20-25%) supplements diets of small holder farmers whose diet is based on cereals, root and tuber crops and banana; a balanced diet can be obtained if cereals and legumes are consumed in the ratio 2:1 (Broughton *et al.*, 2003).

Nowadays, in addition to its subsistence value, common bean is an important commercial crop contributing significant incomes to the majority of the rural peasants in Sub-Saharan Africa (Wortman *et al*., 2004). It is one of the fast expanding legume crops that provide an essential part of the daily diet and foreign export earnings for the country (Girma, 2009). The current national production of common bean in

Ethiopia is estimated at 323,317.99 hectares; with a total production of 513,724.807 tons and average productivity of 1.59 tons per hectare (CSA, 2015) in the main season only. Further, substantial amount of land is also covered at short rainy season (belg) cropping. The productivity of Common bean is very low, 1.59 tons/ha in Ethiopia (CSA, 2015). This low productivity of the crop is mostly due to lack of high yielding varieties adapted to diverse agro ecological conditions and adoption of better agronomic practices and biotic and abiotic factors that hinders the crop production.

Soil acidity is a significant problem that agricultural producers in tropical and subtropical regions are facing and limit legume productivity (Bordeleau and Prevost, 1994). This is aggravated by the inherent poor fertility and acidity in most tropical soils (Okalebo *et al*., 2006). Soil acidity occurs when there is a build-up of acid forming elements in the soil. The production of acid in the soils is a natural process which is caused by rainfall and leaching, acidic parent materials and organic matter decay (Havlin, 2005). Acidification from rainfall does not occur in one growing season but instead over hundreds of years of high rainfall amounts. Rain can change the pH more quickly in sand, partially because sand does not bind basic elements very well, but also because water drains quickly through sand. This allows more water to flow through the soil particles, taking basic elements along with it.

Acidic soils cause poor plant growth resulting from Aluminum (Al^{+3}) and Manganese toxicity (Mn^{+2}) or deficiency of essential nutrients like phosphorus, calcium and magnesium. According to Mesfin, 2007, about 40% of the Ethiopian total land is affected by soil acidity out of which 27.7% are dominated by moderate to weak acid soils (pH in KCl) of 4.5 to 5.5, and around 13.2% by strong acid soils (pH in KCl) <4.5). Restoring, maintaining and improving fertility of this soil is major priority as a demand of food and raw materials are increasing rapidly. This can be achieved by adding limestone to the soil (Maheshwari, 2006). This use of lime is a potential option for soils sustainable management among the other options for restoring soil health and fertility.

Acid soils constrain crop production but can be very productive if nutrients and lime are constantly applied and appropriate soil management is practiced (FAO, 2000). Liming is an effective and widespread practice for improving crop production on acid soils. Usually, liming acidic soils improve soil physical, chemical, and biological activities (Fageria and Baligar, 2005). Also liming is an effective and dominant practice to raise soil pH and reduce acidity-related constraints to improve crop yields (Fageria and Baligar, 2008). Lime applied to acid soils raises the pH of soils, resulting in enhanced availability of nutrients, such as P, Ca, Mg, Mo etc. and improved crop yields (Kisinyo *et al*., 2009). Although studying soil acidity problems and response to lime application estimation have been done in some part of the country, quantitative analysis using soil laboratory tests to acquire appropriate solution for the problem was very limited. Thus, evaluating the response of bean genotypes to management measures of acidic soil is very important to generate relevant information for western Ethiopia.

Thus, this study was conducted with the objective of determining the effects of lime application on growth, yield and yield components of common bean in the study area.

2. Materials and Methods

2.1 Description of Experimental Sites

Field experiment was conducted at Bambasi woreda of Assosa zone, Benishangul Gumuz regional state of Ethiopia in 2016 main cropping season. Bambasi woreda is located at the distance of 616km West of Addis Ababa and 45 km from Assosa town on the waay to Addis Abeba at an altitude of 1425 meters above sea level (m.a.s.l.). Bambasi located at the latitude of $9^0$75’ North and longitude of $34^0$73’ East longitude. It receives mean annual rainfall of 1433 mm in a bi-modal pattern with extended rainy season from May to October. The mean annual maximum temperature is 26^0C, whereas the mean annual minimum is 12^0C. The soil of the location is Entisols (Fluvisols), which is very dark brown to black in colour and clay loam in texture. The pH of the soil is 5.3 which is strongly acidic (Tekalign (1991). The available P (Olsen) content of the centre’s soil is 6.02 mg kg^{-1}, which is rated as low for most of the crops. Total nitrogen content varied from 0.0327 % and is rated as very low.

2.2 Experimental Materials and Design

Crop: The experiment was conducted by using fifteen common bean genotypes selected based on their background on adaptability to low soil fertility and acid soil. The seeds were obtained from Melkassa Agricultural Research Center (MARC), Lowland Pulse Research program and were evaluated at the selected sites.

Fertilizer/Liming material: Recommended rate of both urea (50kg/ha), as a source of nitrogen and Triple Super Phosphate (46% P_2O_5), as a source of phosphorus were used uniformly to all the experimental units. Ground lime (85% calcium carbonate) with fineness of 25% was used as sources of liming material. The experiment was conducted using split plot design with lime treated and untreated as main plot and by assigning genotypes to sub-plots. The experimental plot size was $9.6m^2$ with 6 rows 4 of which were harvestable with the net plot size of 4 rows x 0.4 m x 4 m= $6.4m^2$.

2.3 Soil Sampling and Analysis

Composite soil sample was collected from the experimental site before planting in a zigzag pattern from the depth of 0-30 cm before planting. Uniform volumes of soil were taken at each sub-sample by vertical insertion of an auger. Working samples were obtained from each submitted samples and analyzed for organic carbon, total N, soil pH, available phosphorus, cation exchange capacity (CEC) and textural analysis using standard laboratory procedures. Soil pH is important phsico-chemical property of the soil which influences the nutrient availability to the crop. According to the soil analysis test, the soil pH of the experimental site was low and rated as strongly acidic (Table 1) according to Tekalign (1991) rating. Common bean has been found to do well in pH values of 6.5-8.0 but the optimum growth is attained at pH 6.5-7.0 and any pH below these values will affect its growth and development. These showed that the need to manage this acidic soil or search for tolerant/adaptable genotype is the research priority. The major means of ameliorating soil acidy is by applying lime to the acid soil (Anetor and Ezekiel, 2007), because it has very strong acid neutralizing capacity, which can effectively reduce the existing acidity of the soil.

Organic carbon is another important soil physico-chemical property. It was determined by the volumetric method (Walkley and Black, 1934) as described in Food and Agriculture Organization of the United Nations (FAO) guide to laboratory establishment for plant nutrient analysis (FAO, 2008). The laboratory analysis of the experimental soil showed that the total carbon content in the soils was rated as medium (Table 1) as per the classification of Landon (1984).

Total nitrogen is the other most important soil nutrient for bean crop development. It measures the total amount of nitrogen present in the soil, much of which is held in organic matter and is not immediately available to plants. It may be mineralized to available forms. However, total nitrogen cannot be used as a measure of the mineralized forms of nitrogen ($NH4^+$, $NO3^-$, and $NO2^-$) as much of it is held in the organic matter in the soil. Total nitrogen was analyzed by Micro-Kjeldhal digestion method with sulphuric acid (Jackson, 1962). The pH of the soil was determined according to FAO (2008) using 1:2.5 (weight/volume) soil sample to water ratio using a glass electrode attached to a digital pH meter. The laboratory analysis result showed that the total nitrogen percentage was medium for the testing site (Table 1) as per the rating of Landon (1984).

Cation exchange capacity is also the other factor which influences the nutrient availability in the soil. It is the capacity of the soil to hold and exchange Cations. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. The total number of exchangeable cations a soil can hold, cation exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH4OAc) and displacing it with 1N NaOAc (Chapman, 1965).The result showed that the cation exchange capacity of the soil in the experimental site was rated as moderate (Table 1) according to Tekalign (1991).

Available P is the other important soil physico-chemical property. Available phosphorus was determined by the Olsen's method using a Spectrophotometer (Olsen *et al.*, 1954). According to Landon (1984) rating, the available P level in the experimental site was medium at the testing environment (Table 1). This low available phosphorus could be due to fixation in such acidic soils.

Particle size distribution was done by hydrometer method (differential settling within a water column) according to FAO (2008). Based on the soil analysis made, the soil texture of the study area was sandy loam (Table 1). In their previous work, some researchers stated that such types of soils are suitable for common bean production (Tekalign and Haque, 1987).

2.4 Experimental Procedures

The land was ploughed, disked, and harrowed. The lime was incorporated for the quickest and maximum effect; limestone was evenly spread and incorporated into the soil 20 cm deep by using hoe one month before planting for the lime treated main plots. Urea (46% N) and TSP (46% P_2O_5) were used as the sources of N and P; respectively. Urea (23 kg N ha^{-1}) and NPS (100kg/ha) were applied to all experimental units at planting, whereas calcite limestone ($CaCO_3$) was used as the source of lime. All cultural practices such as weeding, cultivation, etc were applied uniformly to all plots.

2.5 Data Collection

Data for Agronomic, phenological and morphological traits of each genotype under both management measures were collected following *Phaseolus vulgaris* L. descriptors (Debouck and Hidalgo, 1986).

Phenological Traits

*Days to flowering***:** Number of days taken by each genotype from the day of sowing to the day on which 50 per cent of the plants on a plot produced a flower.

*Days to maturity***:** Number of days taken from sowing to the stage when 90% of the plants in a plot changed the color of their pods from green to lemon yellow.

Morphological Traits

Plant height: The height of the plant from the ground surface to the tip of the main stem was recorded in centimeters from 5 plants.

*The total number of nodules***:** was determined by counting from five plants randomly taken from each plot at flowering. Roots were carefully exposed with the bulk of root mass and nodules. The nodules were separated from the soil, washed and the total number of nodules was determined by counting.

*Effective and non-effective nodules***:** were separated by their colors where a cross section of the nodule was cut using surgical blade and the effectiveness of the nodule was rated by visual observation, where a pink to dark-red color is considered as an effective nodule and a green and/ or white color indicates non-effective nodule.

Seed Yield and Its Components

*Seed yield***:** Central four rows were harvested and threshed from each plot and seeds obtained from them were adjusted to standard moisture level (10%) and weighted to get the seed yield per plot in grams and converted into ton/ha.

*Biomass Yield***:** Obtained by weighing the total air dried above ground biomass yield of five randomly taken plants from the four middle rows.

*Harvest Index***:** The ratio of seed yield by the biological yield

$$\text{Harvest Index} = \frac{\text{Grain Yield}}{\text{Above ground biomass}}$$

*Pods per plant***:** Fertile (fully developed) numbers of pods from 5 sampled plants were counted.

Seeds per pod**:** were determined from the average number of seeds per 10 pods per 5 sampled plants.

Hundred Seed weight**:** was determined from the 100-seeds randomly taken from the plot yield at (10%) moisture content

Stand count at harvest: Number of plants in the harvestable net plots were counted and recorded during harvesting.

2.6 Data Analysis

SAS and different statistical software packages were used to analyze the data. Analysis of variance was computed using the Genstat statistical software.

Table 1 selected physico-chemical properties of the experimental site before planting

Soil characters	Bambasi
Soil Texture	Sandy loam
Soil PH	5.3
Organic carbon (%)	2.57
Total Nitrogen (%)	0.327
Avaliable P(mg kg^{-1})	6.02
CEC [cmol (+) kg^{-1})	16.39

3. Results and Discussion

3.1 Phenological and growth parameters

Analysis of variance showed that there is a highly significant ($P \leq 0.0001$) variation among genotypes on their days to 50% flowering but application of lime has non-significant effect on the flowering time While common bean genotypes have a significant response ($p = 0.024$) to lime application. Roba genotypes flowered lately (47.33 days) on lime treated soils while genotype ALB133 flowered earlier on lime untreated soils (37.0 days) than the other genotypes (Table2). Application of lime reduces Al/Fe toxicity and makes the soil media slight to neutral for the availability of most of nutrients and also improves the physico-chemical conditions of the soil for good aeration and circulation of nutrients (Bassetti and Westgate, 1994). In contrary Hirpha (2013) found that the application of lime hastened flowering and maturity dates of the common bean plants.

Similarly, the results of analysis of variance for days to maturity showed that application of lime has non-significantly affected the days to maturity while the tested genotypes have significantly responded ($P \leq 0.0001$) to the lime application. Roba genotypes matured lately (78.33 days) on soils with lime treated while genotype ALB 149 matured earlier (73.33 days) than the other genotypes (Table2). The result of this experiment indicated that application of lime had non-significantly affected the physiological maturity while the variations on the days are mainly of genotypic variation. Similarly, Tesfaye (2015) reported that lime application did not significantly influence days to physiological maturity.

The analysis of variance also indicated that plant height was non-significantly affected by the lime application on acidic soils while, genotype had significantly ($P=0.035$) responded to the application of lime **(**Table2). The tallest (43.33cm) plant height was recorded on lime untreated Roba genotype, and the shortest (31.20cm) plant height was recorded from lime treated Nasir genotype (Table 2). This result is in agreement with the finding of Tesfaye (2015), who also reported application of lime has non-significant effect on plant height.

Table 2: Phenological and growth parameters fifteen common bean genotypes evaluated at Bambasi

	DTF		DTM		Plant Height	
Variety	LUT	LT	LUT	LT	LUT	LT
ALB133	37.00	37.67	73.50	73.67	38.00	36.37
ALB149	38.33	38.67	73.33	73.00	36.80	35.53
ALB163	40.33	39.33	75.67	76.67	33.58	33.13
ALB179	39.00	39.33	75.00	76.33	36.73	38.60
ALB204	42.00	40.33	76.33	76.67	36.53	32.33
ALB207	44.00	43.00	76.67	76.67	41.93	40.13
ALB209	38.00	39.33	74.00	73.67	37.47	37.33
ALB212	39.33	38.00	75.33	75.00	37.67	36.07
ALB25	41.00	40.67	74.33	74.33	34.13	33.13
BFS24	38.33	39.00	75.00	75.33	33.87	31.07
BFS320	39.33	40.67	74.33	73.67	29.27	32.27
BFS35	43.67	41.67	75.67	76.00	34.67	34.87
BFS39	42.33	44.67	76.00	77.00	41.27	39.40
Nasir	38.33	39.33	76.33	77.00	40.50	31.20
Roba	46.67	47.33	77.67	78.33	43.33	38.53
CV	**2.44**		**0.95**		**13.86**	
LSD	**0.26**		**0.311**		**2.18**	
P-Value: *Lime*	**0.681**		**0.09**		**0.12**	
Variety	**<0.0001**		**<0.0001**		**0.035**	
Lime * variety	**0.024**		**0.49**		**0.91**	

DTF: *Days to flowering, DTM: Days to maturity, LT: Lime treated, LUT: Lime untreated, CV: Coefficient of variation, Lsd: Least significant difference*

NB: Traits with P-value <0.05 & ≤ 0.01 are significant at 5% and 1% respectively

3.2 Nodulation

Analysis of variance revealed that application of lime on acidic soils had significantly affect the number of effective nodule where as the tested common bean genotypes were non-significantly responded to the lime application for their nodulation character (Table3). The highest number of effective nodule (6.33) was recorded on lime treated Nasir genotype whereas the lowest number of effective nodule (0) was recorded on lime untreated BFS 320 genotypes. Generally, higher number of effective nodule was recorded from lime treated soil than lime untreated for most of the genotypes (Table 3). Effective nodulation is essential for a functioning of legume/*Rhizobium* symbiosis. Plants which produce effective nodules should have greater potential to fix more atmospheric nitrogen. Nitrogen fixing ability of the legumes depends on the effectiveness and compatibility of the root nodule bacteria which nodulate it. The adverse effects of soil acidity on nodulation and nitrogen fixation were also reported by Bambara and Ndakidemi (2010).

Analysis of variance indicated that the application of lime on acidic soil had significantly (P<0.014) affected the number of non-effective nodule and the tested genotypes had responded significantly (P<0.0001) to the lime application on acidic soils for their non-effective nodulation. Different tested genotypes had responded differently to the application of lime to the acidic soils of the testing environment. The highest number of non-effective nodule (10) was recorded on BFS24 genotype from lime treated soil where as the lowest number of non-effective nodule (0) was recorded from BFS320 genotype on lime untreated (Table 3).

Table 3: Nodule data for fifteen common bean genotypes evaluated at Bambasi

	EN		NEN		TNN	
Variety	LUT	LT	LUT	LT	LUT	LT
ALB133	0.50	2.67	0.50	3.33	1.00	6.00
ALB149	2.33	4.33	3.00	4.00	5.33	8.33
ALB163	0.67	1.67	2.33	4.00	3.33	5.33
ALB179	1.33	3.00	2.67	2.67	4.00	5.33
ALB204	2.33	4.00	6.00	5.67	8.67	9.67
ALB207	2.00	3.33	3.67	3.67	5.67	7.00
ALB209	0.67	5.67	1.67	6.00	2.33	11.67
ALB212	4.00	3.33	4.67	2.67	8.67	6.00
ALB25	2.00	4.00	3.33	4.67	5.00	8.00
BFS24	1.67	6.00	6.00	11.00	7.67	17.00
BFS320	0.00	1.00	0.00	5.00	0.00	5.00
BFS35	0.67	2.67	3.00	2.00	4.00	5.00
BFS39	1.33	3.00	2.33	4.33	3.67	7.00
Nasir	3.00	6.33	6.33	7.00	9.33	13.33
Roba	1.67	2.00	6.33	1.67	8.00	4.00
CV	**28.1**		**25**		**17.95**	
LSD	**2.74**		**0.8**		**1.33**	
P-Value: *Lime*	**0.0005**		**0.014**		**0.0002**	
Variety	**0.204**		**0.0001**		**0.0003**	
Lime * variety	**0.84**		**0.007**		**0.05**	

EN: Effective nodule, Non-effective nodule, TNN: Total number of nodule, LT: Lime treated, LUT: Lime untreated, CV: Coefficient of variation, Lsd: Least significant difference

***NB*: Traits with P-value <0.05 & ≤ 0.01 are significant at 5% and 1% respectively**

Similarly, analysis of variance revealed that the application of lime to acidic soils was significantly affect the total number of nodules. The evaluated bean genotypes had responded significantly in a different manner to the lime application. The highest total number of nodule (13.33) was recorded for Nasir genotype on lime treated soil where as the lowest number of total number of nodule (0) was recorded from BFS320 genotype on lime untreated acidic soils of the testing environment (Table 3). Similar result was also reported by Buerkert *et al*. (1990) confirming that liming acid soil significantly increased nodulation of beans and alfalfa. The reason for the increment of nodule at limed soil were due to the direct effect of lime on reducing the H^+ concentration and toxic level of Al and Mn, and subsequently reducing the deficiencies of Ca, P, and Mg.

3.3 Yield and Yield Components of Common Bean

3.3.1 Yield Components

Analysis of variance showed that the lime application to acidic soil had a significant ($P<0.05$) effect on the total number of pods per plant. The tested genotypes had responded significantly ($P<0.01$) in a different way to the application of lime to the acidic soil in its pod setting abilities. The highest total number of pod per plant (14) was recorded for ALB149 and ALB209 genotypes which were treated with lime, while the lowest total number of pod per plant (7) were recorded for Roba and BFS 24 when the lime was not applied to the acidic soils (Table 3). The finding of this study indicated that, application of lime promoted vegetative growth thereby enabled the plant to bear higher number of pods per plant than the untreated plot. In line with this result, Okpara and Muoneke (2007) reported as liming had significantly increased number of pod per plant on soybeans.

Table 3. **Yield component data for fifteen common bean genotypes evaluated at Bambasi**

Genotypes	Pod/plant		Seed/pod		Seed/plant		HSW		Yield(kg/ha)	
	LUT	LT	LUT	LT	LUT	LT	LUT	LT	LUT	LT
ALB133	11.0	11.0	4.00	4.67	42.50	43.33	15.12	15.51	1307	1055
ALB149	13.3	14.0	4.00	3.67	47.33	50.33	17.06	17.98	1066	1328
ALB163	8.3	8.7	5.00	5.67	35.67	36.00	15.06	15.97	926.6	1032
ALB179	11.3	10.7	4.33	4.33	43.67	42.67	18.53	20.43	1354	1528
ALB204	10.0	10.7	4.00	4.33	38.67	38.33	19.79	18.97	1311	1331
ALB207	13.0	12.7	5.33	4.33	49.33	47.33	18	17.66	1274	1345
ALB209	10.0	14.0	3.67	4.33	34.67	50.33	17.52	19.61	1132	1115
ALB212	10.7	13.0	4.00	5.00	36.67	51.33	19.4	19.55	1408	1539
ALB25	10.3	12.3	4.00	3.33	38.33	37.00	16.93	16.15	1141	1068
BFS24	7.0	7.7	4.67	4.67	30.67	33.33	20.05	17.54	1136	1289
BFS320	10.7	12.0	5.00	4.33	42.67	49.33	17.03	17.95	1096	1219
BFS35	8.3	9.3	4.00	4.00	34.00	33.33	19.49	19.54	1229	1235
BFS39	9.3	11.7	4.00	4.00	35.33	41.00	17.55	19	1301	1086
Nasir	7.7	9.0	4.67	4.00	36.33	42.33	18.33	17	1033	1261
Roba	7.0	9.3	4.33	4.67	28.67	34.33	13.53	14.33	700.1	736.8
CV	**24.24**		**12.95**		**25.01**		**8.09**		**13.728**	
LSD	**3.02**		**0.245**		**4.37**		**0.62**		**70.75**	
P-Value: *Lime*	**0.032**		**0.86**		**0.083**		**0.48**		**0.084**	
Variety	**0.0046**		**0.002**		**0.092**		**<0.0001**		**<0.0001**	
Lime * variety	**0.98**		**0.138**		**0.94**		**0.365**		**0.588**	

HSW: Hundred seed weight, LT: Lime treated, LUT: Lime untreated, CV: Coefficient of variation, Lsd: Least significant difference

***NB*: Traits with P-value <0.05 & ≤ 0.01 are significant at 5% and 1% respectively**

The result of analysis of variance also showed that the lime application to acidic soil had non-significantly (P=0.86) affect the number of seeds per pod whereas the tested genotypes had responded significantly (P<0.01) in a different way to the application of lime to the acidic soil in its seed setting abilities among the pods on the plant. The highest total number of seed per pod (5.67) was recorded for ALB163 which was treated with lime, while the lowest total numbers of seed per pod (3.33) were recorded for ALB25 when the lime was not applied to the acidic soils (Table 3). In contrary to this finding, Buerkert *et al*., (1990) reported from his experiment conducted at four locations on bean that liming increased seed number per pod by 18%.

Analysis of variance also showed that treating acidic soil with lime had non-significantly (P=0.083) affect the number of seeds per plant. Similarly, there were statistically non significant variations among the tested genotypes in their number of seed per plant on acidic soils of Bambasi. The highest total number of seed per pod (50.33) was recorded for ALB149 on acidc soil which was treated with lime, while the lowest total numbers of seed per pod (28.67) were recorded for Roba genotype when the lime was not applied to the acidic soils (Table 3).

The result of analysis of variance showed that the application of lime to acidic soils had non-significantly affected the hundred seed weights of the tested common genotypes. Whereas, the tested common bean genotypes had significantly (p<0.0001) varied for the hundred seed weights (Table3). This result indicated that hundred seed weight was mostly genetically controlled trait rather than being affected by environment. The highest hundred seed weight (20.43) was recorded for ALB179 genotype on lime treated acidic soil while the lowest hundred seed weight (13.53) was recorded for Roba genotype on lime untreated soil. In line with these findings, Tanaka and Fujita (1979) stated that number of seeds per pod and weights of hundred seeds were strongly controlled genetically in field bean.

3.3.2 Seed yield

Analysis of variance showed that application of lime had non-significant (P=0.084) effect on seed yield of fifteen common bean genotypes evaluated on acidic soils. On the other hand, the tested genotypes had shown statistically highly significant (P<0.0001) variation in their seed yield on the testing environment. The highest seed yield (1539kg/ha) was obtained from ALB212 genotype whereas the lowest yield (700kg/ha) was recorded for Roba genotype. The result of this study showed that application of lime by itself does not bring a significant yield increment in the first yield. Similar result was reported by Tesfaye (2015), who also reported application of lime has non-significant effect on the seed yield of common bean.

Conclusion

Common bean is one of the most important pulse crop in Ethiopia provided that it is a major source of protein for the large rural part of the country and also serve to generate income. But, the national average production of the crop was too low with 1.59 t/ha. This is mainly contributed by drought, soil acidity, poor cultural practices, disease, and shortage of high yielding varieties adapted to the production environment. The heist yield obtained in this experiment was even around 1.54ton/ha which verified that soil acidity hinders the production of common bean. So, in order to increase production and productivity of common bean on acidic soils, applying appropriate amount of liming material at appropriate time is very important. Similarly, Even if appropriate amount of liming material is applied at appropriate time, the significant change in common bean yield may not be attained because the amelioration of acidic soil takes place gradually and the significant change can be attained after two or three years of applying the liming material to the acidic soil.

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