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Evaluating Yield Response of Faba bean (*Vicia faba* L.) Through Integrated Use of Rhizobium Strains and Lime on Acidic Soils of Aneded District Northwestern Ethiopia

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Abstract

Rhizobial strains have contributed to enhance N_2 fixation, soil fertility and yield of legume crops when they are sufficient quantity in the soil under favorable soil environment. A field experiment was implemented to evaluate yield response and economic profitability of faba bean through inoculation of strain together with lime. The experiment consists four types of strains [(BF-17, BF-04, BF-1018 and BF-1035), control, 21kg ha^{-1} urea and 150 kg ha^{-1} urea under limed and unlimed condition). The treatments were arranged in split plot design where, strains were sub-plots and lime was the main plot with three replication. The collected data was analyzed using SAS using 9.3 software version. Based on the results obtained, number of pods $plant^{-1}$, number of seeds pod^{-1} , seed yield and above ground biomass yield of faba bean was significantly ($P<0.01$) affected due to integrated use of inoculants with lime. The result revealed that inoculation of BF-04 strain together with lime produced the highest number of pods $plant^{-1}$ (14.33), number of seeds pod^{-1} (2.44) and seed yield (3623.6kg ha^{-1}) where the seed yield obtained due inoculation of BF-17 strain with lime was stastically comparable with application of BF-04 strain + lime(3612.5 kg ha^{-1}). In case of biomass yield, similar to seed yield combined use strains with lime recorded the highest value but among each strain no significant variation was observed. This result clearly suggested that proper inoculation of effective strains along with lime improved soil fertility and faba bean yield. The highest net income was also obtained from plots treated with strain+lime compared with other treatments. Reducing soil fertility constrains through the integrated use of strain and lime could be a possible option to increase yield. However, to draw a conclusive recommendation, the study has to be repeated over several seasons as lime and strains have long-term effects.

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Economic analysis, strain, seed yield, soil acidity.

Introduction

Soil acidity is one of the most important constraints for faba bean production in Ethiopia highlands (Endalkachew, 2018). Different research findings revealed that acidic soil covers about 43% of the arable lands of which strong soil acidity covers 28.1% of the entire country (Tegbaru, 2015). To fulfill the increasing

demand for food and raw materials, soil health and fertility has remained as the major factor to increase and sustain crop yields. This calls for proper use of knowledge of soil acidity and its amelioration to maximize agricultural productivity.

Faba bean is ranked first among cool season food legume crops based on area of production and foreign exchange

earnings (CSA, 2010). It has also a great contribution for sustainable soil fertility management due to its ability to fix unavailable atmospheric N₂ in a form available for plants (Beck *et al.*, 1991). Since legumes are more sensitive to soil acidity compared with cereals, faba bean yield in the country showed a reduction in acidic soils due to low P availability and deficiency of major basic cations (Ca and Mg) or toxicity of Al, Fe, and Mn because the solubility and availability of important nutrients to plants is closely related to the pH of the soil (Norton and Tyndall, 2017).

Soil acidity and associated low nutrient availability also led to poor nodulation, stunted growth, and reduced biomass and grain yields in faba bean (Hajkowicz and Young, 2005). Soil acidity with particularly at a pH lower than 5 also seriously affects the survival and multiplication of rhizobia (Kucuk and Kivanc, 2008). Therefore, rhizobia-faba bean symbiotic association is importantly hindered by soil acidity that leads to no or reduced nodulation, in turn to the absence of symbiotic N₂ fixation.

The most widely employed technology in acidic soil reclamation is application of lime in combined with acid-tolerant rhizobial strains for optimum benefit (Adane, 2014). Such an integrated approach will be economically feasible, and environmentally sound (Abebe and Tolera, 2014). In northwestern part of the country in general, and Aneded district in particular, deficiency of microbial population and soil acidity is a well-known problem that limits crop productivity.

As part of the solution to such a problem in soils, the combined application of lime and inoculation of resistant strains on faba bean was not been investigated so far, in which faba bean was one of the potential legume crops in the area. Thus, this study was conducted with the purpose to evaluate the yield response and economic importance of faba bean through integrated use rhizobial strains with lime.

Materials and Methods

Description of the study area

The experiment was conducted at Debre Markose Agricultural Research Center Aneded district during main cropping season. The experimental site is geographically located at 10° 15'58.9" N latitude and 037°46'33.5"E longitude and an altitude of 2486 meter above sea level. The average annual maximum and

minimum air temperature ranges from 11.8°C to 27.2°C and, the area receives adequate amount of rainfall, 1500 mm per annum with monomodal pattern of rain fall distribution.

Soil Sampling and Physico-chemical analysis

Prior to conducting the experiment, representative soil sample was collected from experimental site at plow depth of 0-20cm and analyzed following standard laboratory procedures. The soil sample was air-dried and ground to pass through a 2mm sieve mesh. Soil pH was determined (1:2.5 soil to water ratio) using a glass electrode attached to a digital pH meter (Page, 1982), soil texture was determined by hydrometer method (Day, 1965). Methods as described by Walkley and Black for organic carbon, and wet oxidation Kjeldahl method was used to determine total N, as described by Jackson (1967). Exchangeable acidity was determined from a neutral 1 N KCl extracted solution through titration with a standard NaOH solution based on the procedure described by McLean (1965). Available P was determined using Olsen extraction method (Olsen and Dean, 1965). Cations exchange capacity (CEC) of the soil was determined following ammonium acetate extraction method.

Experimental design and procedure

The experimental treatment includes (Control, four types of strains [FB-17, FB-04, FB-1018, FB-1035], 21 kg ha⁻¹ urea and 150 kg ha⁻¹ urea under limed an unlimed soil condition). The treatments were arrangement in split plot design with three replications. The amount of lime applied was determined based on the exchangeable acidity, mass per 0.15m furrow slice and bulk density of the soil, considering the amount of lime needed to neutralize the acidity of the soil up to the permissible level for crop growth.

The total experimental area contains 42 treatments accommodating ten rows plot⁻¹ and gross plot area was 3m*4m (12m²). The experimental plots were kept with 0.1 m and 0.4 m spacing between plants and each row respectively. Treatments were assigned randomly to experimental plots within a block. Planting was done according to farmer's local planting calendar and the seeds per hill were put in a row and covered with thin soil on rows made. To ensure that all the applied inoculum stick to the seed, the required quantity of strain was suspended in sugar solution. The thick slurry of the inoculant was mixed gently with dry seed so that all the

seeds received a thin coating of the inoculant. All inoculations were done just before sowing under shade to maintain viability of bacterial cells. The inoculated and un-inoculated seeds were then sown separately. Seeds were covered immediately with soil after sowing to avoid the death of bacterial cells due to direct sun light radiation. Triple super phosphate (46% P₂O₅) which was used as a source of phosphorus (P) was applied to all plots uniformly at sowing, while nitrogen (N) in the form of urea was applied in two splits to avoid losses by leaching i.e. half at sowing time and the remaining half was applied a month after planting. Harvesting was done at physiological maturity by leaving the outer most rows on both sides of each plot to avoid border effects.

Data collection and analysis

Yield and yield related parameters

Representative plants were randomly selected from net plot to collect yield and yield attributes of faba bean during harvesting. The recorded parameters include number of pods plant⁻¹, number of seeds pod⁻¹, seed yield and above ground biomass yield. The number of pods plant⁻¹ was counted from five randomly selected plants of the middle rows from each plot and their averages were recorded. To estimate the number of seeds pod⁻¹, the total number of seeds pod⁻¹ was counted from five randomly selected representative plants and their averages were used. Seed yield of faba bean (kg ha⁻¹) was measured from each net plot and converted into hectare base. Similar to seed yield, above ground biomass yield from the net plot area was harvested, after gained constant weight the dried above ground biomass was weighed and converted into hectare base.

Statistical analysis

The collected data was subjected to analysis of variance (ANOVA) as per the design used in the experiment using statistical analysis software version 9.3 (SAS, 2012), and interpretation were made following the procedure of (Gomez and Gomez, 1984). Mean separation was conducted using the least significant difference (LSD) at 5% probability level to assess differences among treatment means where significant differences were obtained by the analysis of variance.

Economic analysis

To determine the economic feasibility of the treatments, mainly the costs of inputs and the prices of outputs

(yield) was used based on the procedure recommended by CIMMYT (1988) manual. It was analyzed separately by calculating gross benefit, total costs that vary and net benefit for each treatment. Economically optimum yield levels were identified using net benefits (additional income obtained). The field price of 1kg of faba bean that farmers receive from sale was taken as 110 birr. Costs of fertilizer and strains were 40.00 birr kg⁻¹ and 50.00 birr packet⁻¹ respectively.

Seed yield of faba bean was adjusted downwards by 10% to more closely approximate yields. The cost benefit analysis was calculated as follows: Cost of cultivation = the sum of cost input, adjusted seed yield = grain yield*10/100, gross benefit = adjusted grain yield*cost of cultivation (price of yield) and net benefit = gross benefit-total variable cost (cost of cultivation).

Results and Discussion

Soil Properties before Sowing

Before implementing the experiment, the soil result was clay in textural class: sand (38%), silt (16%) and clay (46%). The pH value was 4.90 which fall under strongly acidic in reaction according to the rating done by Tekalign (1991). Total N and cation exchange capacity (CEC) of the soil, were found 0.19% and 17.8 cmol (+)/kg, respectively. The total N CEC of soil was rated as medium, according to Tekalign (1991) and Hazelton and Murphy (2007) respectively. The organic carbon content of the soil was 2.14 rated as medium according to Tekalign (1991). The value of available P and carbon to nitrogen ratio (C:N) were found 7.33 ppm and 11.26%, respectively. Available P in soil was low, according to the rating of Jones and Benton (2003). The lower nutrient level and other chemical properties indicated that the experimental soil had some limitations with regard to its use for crop production.

Effects of Strains and Lime on yield and yield attributes of faba bean

Number of pods per plant

Analysis of variance showed there was a highly significant interaction effect (p<0.01) due to inoculation of different rhizobium strains with lime on number of pods plant⁻¹. Accordingly, the highest number of pods plant⁻¹ (14.33) was recorded from plots treated with inoculation of FB-04 strain under limed condition which produced 35.19 more number of pods plant⁻¹ compared

with inoculated seeds with FB-04 strain alone. However, the lowest number of pods plant⁻¹ (0.01) was recorded from the control plots, indicating almost no faba bean yield is expected without inoculating the seeds with strains and lime application in highly acidic soils. The highest value recorded indicates that there was a synergistic effect between the two factors (strains and lime) which in turn favored height increments through biological N₂ fixation and by minimizing the effect of soil acidity due to liming. Inoculation of sufficient strains on faba bean seeds plays an important role in physiological and developmental processes in plant life and the favorable effect of these strains might accelerate the growth processes, which ultimately resulted in increased yield and quality. The current result was in agreement with (Farfour, 2013) who reported that inoculating mung bean and soybean with Bradyrhizobium significantly increased pod number and pod weight.

In general, when the number of viable rhizobia inoculated per seed increases, the number of pods plant⁻¹ formed is influenced by the treatment given by Bradyrhizobium strain thereby nodulation and yield are improved whenever the soil is neutral in reaction.

Number of seeds per pod

Analysis of variance showed that inoculation of seeds with strain along with lime significantly affects number of seeds pod⁻¹. The maximum number of seeds pod⁻¹ (2.40) was obtained from inoculation of seeds with FB-04 strains under limed condition which produced 12.68% seed advantages over inoculating seeds with FB-04 strains alone. The possible reason for an increase in the number of seeds pod⁻¹ might be availability of P via liming for nodule formation, protein synthesis, fruiting, and seed formation, and strain can be made to the availability of growth-limiting primary nutrients such as N insufficient amount in the soils, which in turn promotes vegetative growth.

Inoculation of efficient N₂-fixing symbioses most directly related to effective nodule formation for enhanced plant growth. However, the population density, effectiveness in forming nodules, competitive ability, concentration of available soil N and acidic level of the soil are the major factors that determine the degree of inoculation response. Thus, advantages of inoculation of legume crops can be an important practice if the farmer's field is low in N availability or if the faba bean cultivar has large N demand (Kubota *et al.*, 2008).

Seed yield

Analysis of variance showed that there was significant effect observed on seed yield of faba bean due to combined use of inoculation with lime. The maximum seed yield (3623.6kg ha⁻¹) was obtained from plots treated by FB-04 strain under limed condition which was stastically at par with FB-17 strain under limed condition, whereas the minimum seed yield (175.00kg ha⁻¹) was recorded from the control plots. Integrated use of inoculants along with lime produced 1781.83-1970.63% too much yield advantages compared with control plots. In comparing only inoculants, all strains produced stastically similar yield indicating farmers can use either of the stains in soils which are not acidic in reaction. The current results demonstrated that soil N is a limiting factor and the existing rhizobium bacteria may not be able to supply the required amount of N through biological fixation unless the soil ameliorated by liming.

Thus, the seed yield could be strongly improved by means of inoculation seeds by resistant strain coupled with lime. The result is in agreement with the finding of Carter *et al.*, (1998) who reported that forming effective N₂ fixing symbioses between legumes and their N₂ fixing bacteria is developed whenever there is low nutrient availability (N and P) which can affect the development of the plant. Unless this condition is avail, the most effective rhizobium strains cannot form effective association in nodulation and N fixation with the host plant.

In general, separate application of strains and lime individually was not adequate to increase the seed yield of faba bean significantly when compared with integration of lime and strains in the study area. This indicates that the synergistic effect of applied lime along with strains was significant in ameliorating soil acidity and increasing the overall economy of the crop.

Biomass yield

The highest aboveground biomass yield (8261.9 kg ha⁻¹) was obtained from plots treated with FB-1018 strain coupled with lime which was stastically at par with plots treated by FB-17, FB-04 and FB-1035 strains under limed condition whereas the lowest value (811.9 kg ha⁻¹) was obtained from control plots (uninoculated and unlimed plots). Inoculation of faba bean seeds with effective strains in conjunction with lime produced 884.97 to 917.60% biomass yield advantages over the control (Table 3.).

The increase in aboveground biomass yield due to the application of lime integrated with strain to the soil probably creates more favorable physicochemical conditions in the soil, such as reduced Al³⁺ toxicity and increased nutrients availability. At the end this condition ultimately enhances growth, provide growth-regulating substances and improves the physicochemical and microbial properties of soils.

Furthermore, there is reduction of Al³⁺ toxicity, which restricts roots growth and creates difficulty in accessing nutrients and water from a longer distance in the soil. Finally, application of lime along with inoculants could improve root nutrient uptake of the plant through promoting its growth.

Table.1 Physico- chemical properties of the soil of experimental site before sowing

Soil depth (cm)	Physical properties					Chemical properties					
	Clay (%)	Silt (%)	Sand (%)	Textural class	BD (gcm ⁻³)	pH (H ₂ O)	TN (%)	Av.P (ppm)	CEC cmol(+)/kg	OC (%)	Ex.acidity (meq/100g)
0-20	46	16	38	Clay	1.25	4.90	0.19	7.33	17.8	2.14	0.98

BD= Bulk Density, CEC = Cation exchange capacity, OC = Organic carbon, TN = Total nitrogen, Av.P = Available phosphorus.

Table.2 Effects of rhizobium inoculation and lime on number of pods plant⁻¹ and number of seeds pod⁻¹

Rhizobium inoculants	Limed	Unlimed	Limed	Unlimed
	NPP	NPP	NSPP	NSPP
FB-17	13.47abc	9.73de	2.40a	2.13abc
FB-04	14.33a	10.60cd	2.33ab	2.13abc
FB-1018	13.67ab	9.60de	2.27abc	2.00c
FB-1035	10.80bcd	10.33d	2.07bc	2.17abc
Control	8.20de	0.01g	2.13abc	0.01d
21 kgha⁻¹ urea	7.87de	4.60f	2.00c	2.00c
150 kgha⁻¹ urea	10.73bcd	7.13ef	2.20abc	2.00c
Mean	11.30	7.43	2.20	1.78
LSD (5%)	2.94		0.30	
CV (%)	18.80		8.95	

Where, NPP= Number of pod per plant, NSPP= Number of seed per pod.

Table.3 Effects of rhizobium inoculation and lime on seed yield, biomass yield and HI of faba bean

Rhizobium inoculants	Seed yield (kgha ⁻¹)		Biomass yield(kgha ⁻¹)		Harvest Index (%)	
	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed
FB-17	3612.50a	2516.2c	8038.70a	6214.30b	45.38ab	40.81a-d
FB-04	3623.60a	2551.9c	7997.00a	5842.30b	46.11a	44.31ab
FB-1018	3550.3ab	2533.3c	8261.90a	5701.20b	43.16abc	45.29ab
FB-1035	3293.20b	2416.5c	8114.60a	5583.30b	40.60a-d	44.79ab
Control	920.40f	175.00g	2529.8de	811.90f	35.64a-e	22.16e
21 kgha⁻¹ urea	1241.50e	314.50g	3946.4cd	1283.90ef	32.23b-e	28.05de
150 kgha⁻¹ urea	1791.40d	634.90f	4916.7bc	2306.50e	37.87a-d	30.25cde
Mean	2576.13	1591.76	6257.87	3963.34	40.14	36.52
LSD (5%)	309.68		1445.00		13.66	
CV (%)	8.89		16.91		21.30	

Table.4 Economics of inoculation and lime application on faba bean production

Treatments	SY (kg ha^{-1})	Adj.SY (kg ha^{-1})	Economics			B:C (ETB ha^{-1})
			Cost of Cultivation (ETB ha^{-1})	Gross income (ETB ha^{-1})	Net income (ETB ha^{-1})	
BF ₁ L ₁ = BF-17+lime	3612.5	3251.25	8870.00	250346.25	241476.25	28.22
BF ₂ L ₁ = BF-04+lime	3623.6	3261.24	8870.00	251115.48	242245.48	28.31
BF ₃ L ₁ = BF-1018+lime	3550.3	3195.27	8870.00	246035.79	237165.79	27.74
BF ₄ L ₁ = BF-1035+lime	3293.2	2963.88	8870.00	228218.76	219348.76	25.73
F ₀ L ₁ = lime alone	920.4	828.36	8470.00	63783.72	55313.72	7.53
F ₁ L ₁ = 21kg ha^{-1} urea +lime	1241.5	1117.35	9310.00	86035.95	76725.95	9.24
F ₂ L ₁ = 150kg ha^{-1} urea +lime	1791.4	1612.26	14470.00	124144.02	109674.02	8.58
F ₀ L ₀ =Control (no strain & lime)	175.0	157.50	0.00	12127.50	12127.50	-
BF ₁ L ₀ = BF-17 strain alone	2516.2	2264.58	400.00	174372.66	173972.66	435.93
BF ₂ L ₀ = BF-04 strain alone	2551.9	2296.71	400.00	176846.67	176446.67	442.12
BF ₃ L ₀ = BF-1018 strain only	2533.3	2279.97	400.00	175557.69	175157.69	438.89
BF ₄ L ₀ = BF-1035 strain only	2416.5	2174.85	400.00	167463.45	67063.45	418.66
F ₁ L ₀ = 21kg ha^{-1} urea alone	314.5	283.05	840.00	21794.85	20954.85	25.95
F ₂ L ₀ =150kg ha^{-1} urea alone	634.9	571.41	6000.00	43998.57	37998.57	7.33

Adj.SY = Adjusted Seed Yield down to 10%, SY = Seed Yield, ETB = Ethiopian Birr, B:C benefit cost ratio

The current result is in line with the finding of (Beck and Duc, 1991) who reported that inoculation of faba bean was significant for total biological yield, seed yield and total N in the soil.

Harvest Index

The highest harvest index (46.11%) was recorded for yields obtained from plots treated with FB-04 strain with lime, whereas the lowest value (22.16%) was for yields obtained from control plot. The possible reason could be that combined application of lime and strain efficiency of faba bean to partition the dry matter into the reproductive seed sinks. Integrated use of lime with effective strains significantly affected yield and yield components of faba bean.

Economic analysis

The integrated use inoculants with lime recorded the highest seed yield and additional income compared with control. The highest net income was obtained from plots treated with inoculation of strains under limed condition (Table.4.). It was conclusively proved that integrated use of strains and lime is highly remunerative in the study area. Similarly the highest B:C ratio (28.31) was recorded from plots treated with dual application of strains with lime, though this treatment has highest benefit over control. In case of only bio-fertilized plots, FB-04 strain showed highest benefit cost ratio of

(442.12). From the outcome of the current study it can be concluded that combined use of rhizobium strains along with lime increases yield and produced the highest economic return.

Conclusion

Based on the results, we conclude that, integrated application of appropriate strain with lime improved yield and yield components of faba bean following improvement of soil properties. The highest seed yield (3623.6 kg ha^{-1}) was obtained from the combined application of strain with lime. On the other hand the lowest seed yield (175 kg ha^{-1}) was recorded from control plots that showed a huge yield difference of about 3448.6 kg ha^{-1} compared to the highest seed yield.

Moreover, combined application of strain with recommended lime based on exchangeable acidity produced the highest net benefit of 242245.48 ETB ha^{-1} compared to other treatments. The results of this study clearly indicate that the combined application of strains with lime ameliorate the adverse effects of soil acidity thereby the overall economy of the crop. Therefore, application of lime with effective strain could be suitable combinations not only yield but also from an economic benefit, to ameliorate soil acidity and improve soil fertility for sustainable faba bean production.

References

- Abebe Z. and Tolera A. 2014. Yield response of faba bean to fertilizer rate, rhizobium inoculation and lime rate at Gedo highland, western Ethiopia. *Global Journal of Crop, Soil Science and Plant Breeding*, 2(1):134-139.
- Adane B. 2014. Effects of liming acidic soils on improving soil properties and yield of haricot bean. *Journal of Environmental and Analytical Toxicology*, 1(5): 248-252.
- Beck D and G. Duc. 1991. Improving N,-fixation in faba bean: Rhizobium inoculation and N nutrition. Options Méditerranéennes - Series Seminars', 10: 97-103.
- Burns H., Norton, M. and Tyndall P. 2017. Improving yield potential of legumes on acidic soils. Australian government grain research and development program corporation.
- Carter J M, Gardner W K and Gibson A H.1998. Improved growth and yield of faba bean (*Vicia fabae*) by inoculation with strains of rhizobium in acid soils in South West Victoria. *Australian Journal of Agricultural Research* 45(3): 613-623.
- CIMMYT Economics Program, International Maize and Wheat Improvement Center.1988. from agronomic data to farmer recommendations: an economics training manual (No. 27). CIMMYT.
- CSA (Central Statistical Authority). 2010. Report on the preliminary results of area, production and yield of temporary crops
- Day PR.1965. Hydrometer method of particle size analysis pp. 562-563.In: Black, C.A. (Ed.). Methods of soil analysis. Am. Soc. Agron. No. 27. Madison. Wisconsin.
- Endalkachew F., Kibebew K., Asmare M. and Bobe B. 2018.Yield of faba bean (*Vicia faba* L.) as affected by lime, mineral P, farmyard manure, compost and rhizobium in acid soil of lay gayint district, northwestern highlands of Ethiopia. *Journal of Agriculture and Food Security*, 7(16): 1-11.
- Farfour A. S. 2013. Enhancement of the growth and phenolic content of faba bean (*Vicia faba* L.) by applying some bio fertilizer agents. *Journal of Food Study*, vol. 2, no. 2, 2013.
- Gomez, K. A. and Gomez, A. A. 1984. Statistical procedure for agricultural research. 2nd Edition. International Rice Research Institute. John Wiley and Sons Inc.
- Hajkowicz S, Young M. 2005.Costing yield loss from acidity, sodicity and dry land salinity to Australian agriculture. *Land Degradation and Development* 16: 417-433.
- Hazelton, P. and B. Murphy. 2007. Interpreting soil test results: What do all the numbers mean? 2nd Edition. CSIRO Publishing. 152p.
- Jackson M L. 1967.Soil Chemical Analysis. Prentice-Hall of India, New Delhi.
- Jones, J. B. 2003. Agronomic Handbook: Management of Crops, Soils, and Their Fertility. CRC Press LLC, Boca Raton, FL, USA. 482p.
- Kubota, A., Hoshiha, K., and Bordon, J. (2008). Effect of fertilizer-N application and seed coating with rhizobial inoculants on soybean yield in eastern Paraguay. *Brazilian Journal of Soil Science*. 32: 1627-1633.
- Kucuk and Kivanc M. 2008. Preliminary characterization of Rhizobium strains isolated from chickpea nodules. *African Journal of Biotechnology*.
- McLean K O. 1965. Aluminium. pp. 978-998. In: Black, C.A. (Ed.). Methods of soils analysis, Agro.No. 9. Part II. Am. Soc. Agron, Madison, Wisconsin, USA.
- Olsen S R and Dean L A. 1965. Phosphorus. In: Methods of Soil Analysis. Agronomy 9: Pp 920-926. Amer. Soc. Agron., Madison, Wisconsin, USA.
- Page A L. 1982. Methods of soil analysis. Part II. Chemical and Microbiological Properties. Madison, USA.
- SAS (Statistical Analysis System). 2012. SAS 9.3 Macro Language: Reference. Cary, NC: SAS Institute.
- Tegbaru B. 2015. Soil fertility mapping and fertilizer recommendation in Ethiopia: Update of EthioSIS project and status of fertilizer blending plants. Presented at 2nd IPI – MoANR-ATA-Hawassa University Joint Symposium 24th November 2015, Hawassa.
- Tekalign Tadesse. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.
- Wood M, Cooper J E and Holding A J. 1984. Soil acidity factors and nodulation of *Trifolium repens*. *Plant and Soil*. 78: 367-379.

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