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Validation of Blended Fertilizer for Maize Production Under Limed Condition of Acid Soil

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Abstract
Maize is one of the important cereal crops in the world's agricultural economy. In southwestern part of Ethiopian countries farmers have focused mainly on the use and application of N and P fertilizers and totally neglected the application of S and B, which is deficient in soils. For intensive and continuous crop production, these inputs should aim at balanced application of nutrients along with the efforts of maintaining the soil acidity pH at optimum level by liming. Soil acidity is a complex of numerous factors involving nutrient/element deficiencies and toxicities, low activity of beneficial microorganisms and reduced plant root growth that limit nutrient and water uptake...Therefore, objectives of validate blended fertilizer under limed condition and importance of lime on nutrient release of acid soil important for improving acid soil productivity. Field experiment was conducted on maize for three concicarive cropping seasons on acid Nitisols of Jima (Kersa woreda) , altitude 1800 meters above sea level. mean annual temperature of the woreda ranges from 17.6-25ºC and the average annual rainfall is about 1300-2000 mm per year. Maize BH661 varieties were used. Split plot design with three replications main plot as lime and un lime, sub plot as blended fertilizer (control, NP, NPSB, NPSZnB, MNPSZB and NPSKZnB). Lime requirement based on exchangeable aluminum (Al) of exchangeable acidity of soil, full doses of lime(CaCO3) used kg ha-1 in the 2015 cropping season once. Analysis of variance using SAS software packages and mean separation was done using LSD at 5% probability leve. Balanced blended fertilize and lime increase yield significantly in all seasons and yield difference observed compare to recommended fertilizer and. no interaction between lime and blended fertilizer in all seasons.. The result revealed that in first, second and third cropping season, NPSZnB, NPSB, NPSB gave significantly highest grain yield of Maize 7295Kg/ha,5439.5kg/ha and 6894kg/ha, respectively. In partial budget analysis the highest net benefit was obtained from NPSZnB, NPSB and the highest marginal rate of return (MRR) recommended NP treatments applied.. Grain yield was significantly affected by blended fertilizer and lime. Maximum grain yield was scored for blended fertilizer compare to recommended NP fertilizer. More research needs to be approved out for more seasons to determine the recommended rate of the balanced blended mineral fertilizer and evaluate the consistence of these result
Keywords: Nitosols, Maize, Lime, Blended fertilizer, soil pH, Exchangeable acidity

1. INTRODUCTION

Crop yield on acid soils are frequently reduced to 50% and can be reduced to zero in severe cases. In Ethiopia, maize had been growing from moisture stress areas to high rainfall areas and from lowlands to highlands of the country. Among cereals, maize is the first and second crop in terms of volume of production and area coverage followed by and next to teff (Eragrost is tef) (CSA,2012). Plant growth and production require an adequate supply of balanced amounts of macro- and micronutrients in order to maximize productivity by optimizing the plant nutrient uptake (Fageria, 2009). However, in southwestern part of the country farmers have focused mainly on the use and application of N and P fertilizers in the form of urea and DAP for almost all cultivated crops and totally neglected the application of S and B, which is deficient in soils of south western Ethiopia.

soil acidity is a complex of numerous factors involving nutrient/element deficiencies and toxicities, low activity of beneficial microorganisms and reduced plant root growth that limit nutrient and water uptake (Fageria & Baligar, 2003). It was the most important soil factors which affect plant growth and ultimately limit crop production and profitability and its problems are common in all regions where precipitation is high enough to leach appreciable amounts of exchangeable bases from the soil surface (Achalu, *et al.,* 2012)

There are considerable evidence in literature showed that at soil pH < 5.5 affects the growth of crops due to high concentration of aluminum (Al) and manganese (Mn), and deficiency of P, nitrogen (N), sulfur (S) and other nutrients (Abreha, 2013)

According to Mesfin (2007) and soil inventory data of EthioSIS (Ethiopian Soil Information System) these soils appear to be acidic in nature and deficient in N, P, S and B which result in sever yield loses and deteriorate nutritional quality of the crop.

According to IFPIR (2010) huge portion of soil is found in south western and western part of the country where annual precipitation is high so as to leach basic cations out of rooting zone. However, to overcoming soil acidity is by using liming material and organic amendments the primary options to raises soil pH at which crops vigorously grow properly. Moreover, liming contributes appreciable amount of basic secondary macronutrients like Ca^{+2} and Mg^{+2} which are essential for plants. Wherever Fe and Al imbalances exist, a corresponding P

stress occurs until recently.

The process of acidification results the replacement of basic cations Ca, Mg and K in the soil exchange sites with Al, Mn and Fe and increased the concentration of H^+ ion in the soil solution. Where soil pH is lower than optimal (5.5 and below) the availability of nutrients needed for growth is reduced. This condition also usually lead to Al and Mn toxicity plus deficiency in N, P, K, Mg, Ca and various micronutrients. This has multiplication for the plant growth and nutrient management as this lead to lack of or reduced response to applied fertilizers due to high P fixation by Al and nutrient deficiency which can results 50% and above yield reduction (IFPIR, 2010).

The work of Shiferaw and Anteneh (2014) have also indicated that lime application with balanced fertilization acidic soil significantly increased Barley yield both at *Alisols*of Chencha and *Luvisols* of Hagereselam..

A standard application of 100 Kg urea and 100 Kg DAP has conventionally been recommended across the country for most crops and soil types. However, this recommendation fails to address the current fertility status of the soil and specific crop needs. Urea, CO $(NH_4)_2$ and DAP $(NH4)_2PO_4$ are acid forming fertilizers. Therefore, an issue of balanced fertilization and liming was immerged for improving acid soil productivity. However the blended fertilizer recommendation on acid soils under un-limed and limed conditions so far not done. Therefore, it is now found relevant to determine blended fertilizer levels under limed conditions.

Objectives:

- To validate blended fertilizer formulae under limed condition
- To investigate the impact of blended fertilizers on acid soil productivity under limed condition
- To investigate the importance of lime on nutrient release of acid soil

Materials and methods

Field experiment was conducted on maize for three concicarive cropping seasons on acid soils of Jima (Kersa woreda) zones, in South Western Ethiopia. The woreda was located at a distance of 320 km, south western of the capital Addis Ababa. Geographically, the woreda lies between latitudes of 7° 44' 59.99" N longitudes of 37° 04' 60.00" E with altitude 1800 meters above sea level and 25 km East of Jimma. The climate of site is sub humid type with mono-modal rainfall pattern and the main rainy season is between June to September and mean minimum, maximum and average temperatures at 1800 m altitude (Jimma station) being 11 °C, 25 °C and 17 °C, respectively and the average annual rainfall is about 1300-2000 mm per year The dominant soils of the area was reported (Mesfin ,1998) Nitisols and moderately to strongly acidic. soils have clayey in texture and strongly to moderately acidic in reaction.

Before commencement of the experiment, initially on composite soil sample from site was collected before lime application and subjected to analyses of acidity attribute and other characterized for selected soil physical and chemical properties, soil samples were collected from 0-15 cm depth for initial determination of soil fertility parameters. Thereafter, and to evaluate changes in soil as a result of applied treatments, soils were sampled at harvest. Soil samples also were collected before planting and after harvesting of the test crops and dried crushed with mortar, passed 2 mm sieve and subject to soil physic-chemical analysis. Lime Requirement (LR) of site and crop was determined based on exchangeable acidity (Ex. Ac) (Kamprath, 1984)

Maize BH661 varieties were used in the investigation. Maize seeds were sown by 80cm x 50cm spacing. The experiment was laid out in split plot design with three replications main plot as lime and un lime, sub plot as blended fertilizer formula (untreated control, NP, NPSB, NPSZnB, MNPSZB and NPSKZnB) was used in the investigation. Lim requirement treatment was calculated based on exchangeable aluminum (Al) of exchangeable acidity of soil, comprise full doses of lime(CaCO3) used KG ha-1 in the 2015 cropping season, lime was applied by hand broadcast and thoroughly mixed with soils one month before planting of the test crop. In 2016 and 2017 lime was used as residual effect. Whole dose of Blended fertilizers and half dose of N fertilizer as urea were basally applied at planting after one month of lime application. Permanent plot was used. The rest half of N fertilizer was top dressed at knee height. Agronomic operations were done when necessary. Data collected from the crop and on yield and yield contributing parameters soil were subjected to analysis of variance using SAS (SAS,2000) software packages and mean separation was done using LSD (Gomez and Gomez, 1984) at 5% probability leve.

RESULTS AND DISCUSSION

This activity has been proposed with objectives to investigate the using different blended fertilizer formula and recommended NP nutrients from urea and DAP for validation on acid soils properties under un-limed and limed conditions for major crop grown on acid soils for maize production in location Jimma (Kersa) of South-west part of the country so far not done. Results of soil samples analysis of the site before planting (kersa) was strongly acidic with low *p*H according to soil classification based on soil pH (Eyasu, 2016), low available P, high

exchangeable acidity, Soil organic C was adequate and TN was low to medium and the soil chemical analysis results are illustrate in. (Table 1) .

Table 1. Soil chemical properties of the soil (0-15 cm depth) prior to planting

Parameter	soil
pH water (1:2.5)	4.50
Exchangeable acidity (cmol kg-1 soil)	1.20
Avai. P (ppm)	1.62
Total N (%)	0.15
% OC	2.15

OC = organic carbon, TN =Total Nitrogen, AvP =available phosphorus, Ex. Ac = exchangeable acidity

Soil results after two years application of lime and blended fertilizer showed that increased the soil pH value above 5.0 at location and reduced the concentration of exchangeable acidity (Table 2). This higher *p*H value from *p*H 4.5 to 5.28 increments due to lime and blended fertilizer application. This result is in agreement with (A. D. Mongia et al., 1998) who reported the ameliorating effect of lime in reducing soil acidity by increasing soil pH and reducing activity of aluminum ion in soil solution and reduce exchangeable acidity.

Soil not treated with lime not improve *P*h and P fertilizer and also increasing tendency of exchangeable acidity and decreasing total % of N and % OC from the initial chemical properties of soils. However, results of soil collected at harvesting of Maize from un limed treatments indicated decreasing trend of soil *p*H and increasing trends of exchangeable acidity; if no other lime applied to the soil on time this tendency may prolong to acidity . The result was similar with Ruwanda, Rutugna and Neel(2005) decrease in pH value and increase in exchangeable acidity due to plant removal of nutrient and fixation and also losses through leaching, soil pH was higher in few days after lime application and progressively decreased with time (Table 2).

Table 2. Mean of some soil chemical properties of soils of testing site of Jimma (Kersa) after lime application

Treatment	pH(1:2.5)	Avai.P(ppm)	% TN	OC %	Ex. Ac.(Cmol kg^{-1})
Control	3.90	1.256	0.127	1.535	1.83
Recom. NP	4.20	1.343	0.134	2.065	1.26
NPSB	4.03	1.239	0.130	2.117	1.34
NPSZnB	3.97	1.462	0.132	2.133	1.22
NPSZnB	4.27	1.307	0.142	2.115	1.29
NPKSZnB	3.90	1.163	0.136	2.168	1.22
L + F0 (Control)	5.16	4.080	0.189	2.446	0.36
L + Recom. NP	5.28	3.550	0.191	2.357	0.33
L + NPSB	5.28	3.584	0.168	2.306	0.31
L + NPSZnB	5.18	3.809	0.172	2.335	0.40
L + M NPSZnB	5.13	3.615	0.207	2.423	0.48
L + NPKSZnB	5.23	2.530	0.150	2.372	0.52

L=Lime F0=No fertilizer

Soil pH increased significantly from 4.044 in the main plot without lime to 5.212 with lime ($CaCO_3ha^{-1}$) and Ex. Ac. (Coml. kg^{-1}) decrease significantly from 1.357 in the main plot without lime to 0.403 with lime ($CaCO_3ha^{-1}$) main plot. The soil pH (H_2O), % TN and Ex. Ac. (Coml. kg^{-1}), values were significantly increased ($P \leq 0.01$) with application of blended fertilizer, where as Avai.P (ppm) and OC% non significant. No interaction effect of lime and blended fertilizer on soil properties of Avai.P (ppm),,% TN and OC %, but independently reveal significant result. Interaction effect of lime and blended fertilizer on soil chemical properties significantly ($P \leq 0.01$) increase pH (1:2.5) and decreased Ex. Ac. (Coml. kg^{-1}) of the soil at Jimma (Kersa) location (Table 3). Moreover, lime when applied in the soil reacts with water leading to the production of OH-ions and Ca2+ ions which displace H+ and Al3+ ions from soil adsorption sites resulting in an increase in soil pH,these findings are similar to those of Adeniyan et al. (2011).

Table 3. Effect of lime and blended fertilizer application on acidic properties of soil of Jimma (kersa)

Treatment				
Lime level	pH(1:2.5)	Avai.P(ppm)	% TN	Ex.Ac.(Cmol kg^{-1})
L0 (Un limed)	4.044b	1.295b	0.134b	2.022b
L1 (Limed)	5.212a	3.528a	0.179a	2.373a
$LSD_{0.05}$	0.0785	0.513	0.013	0.234
Blended fertilizer				
Control(No fert.)	4.532c	2.668	0.158ab	1.991
Recommended NP	4.740a	2.447	0.162ab	2.211
NPSB	4.658a-c	2.412	0.149b	2.212
NPSZnB	4.575bc	2.636	0.152ab	2.234
NPSZnB	4.700ab	2.461	0.175a	2.269
NPKSZnB	4.565bc	1.846	0.143b	2.270
$LSD_{0.05}$	0.136	NS	0.022	NS
Lime * B. Fertilizer	**	NS	NS	NS
CV%	2.45	30.76	11.93	15.43

NP= Nitrogen, Phosphorus NPSB= Nitrogen, Phosphorus, Sulfur, Boron
NPSZnB= Nitrogen, Phosphorus, Sulfur, Zink,Boron MNPSZnB= Modified, Nitrogen, Phosphorus, Sulfur, Zink, Boron , NPKSZnB= Nitrogen, Phosphorus, potassium, Sulfur, Zink ,Boron

The trial was well established at location and the yield observed from less average to higher. Yield of location less due to strong acidity of soil. In location and seasons negative control treatment shown lowest yield and. no interaction between lime and blended fertilizer in all seasons. The effect of recommended fertilizer increase yield or highly significant in 2016 and 2017 seasons similar to balanced blended fertilizer (Table 4) but less yield difference observed compare to some balanced blended fertilizer and this is may not significant economically (Table 4). However, recommended fertilizer not significant increase yield like balanced blended fertilizer in 2015 season . The application of blended fertilizer combined with lime influenced crop growth, yield components and yield of maize. These results are similar with the results reported by Blended fertilizer is a source of balanced nutrients, thus supplying the necessary elements for soil and plant growth Chiezey and Odunze (2009).

At permanent location for consecutive two years (2015,2016) significant result observed independently, but not significant at last season (2017) between main plots lime and un lime. Significant result observed in all seasons among sub plots (fertilizers). However, no interaction between lime and blended fertilizer in all seasons. Blended fertilizer significantly ($P < 0.05$) influenced yield of maize crop in all seasons. The result revealed that in first (2015), second (2016) and third (2017) cropping season, NPSZnB,NPSB,NPSB gave significantly highest grain yield of Maize (7295Kg/ha),(5439.5kg/ha) and (6894kg/ha), respectively. While the lowest values (3352kg), (1125.5kg) and (3633kg) were recorded for control treatment for the respective years (Table 1). In 2015 cropping season blended fertilizer formulas shown significant grain maize difference over the recommended NP fertilizer, but not significant for 2016 & 2017 cropping seasons. Over season grain yield analysis indicate that lime effect significantly ($P < 0.05$) influenced yield of maize crop. The result revealed that lime application gave significantly highest grain yield of Maize (5826.4kg/ha) over un limed (5377kg/ha) and blended fertilizer NPSB significantly ($P < 0.05$) gave 6341kg/ha grain yield of Maize. While the lowest values (2688kg/ha) were recorded for control treatment in both cases (Table 4). There is significant interact of lime and season. However, no significant interaction between lime and fertilizer across the season. The significant interact of lime and season may be indicating the presence of residual effect of lime. This was indicate that applied lime had residual effect and more efficient residual effect in the second year. Application of lime might contributed in releasing some amount of fixed P to be available for the crop. Therefore, for better maize production, enough amount of blended fertilizer should be applied with lime. But application of lime alone could not help crop production to be increased. This also indicates that deficiency of nutrient cannot be replaced by lime. As a result in acidic soils which are deficient in nutrient, it is important to apply blended fertilizer together with lime to increase production

Application of lime significantly ($p < 0.01$) increased grain yield 1.1 times over the year more than un limed . Yield increment over the year observed between lime and un lime main plot was 7% Maize grain yield increment over control (un limed), also yield increment over the year observed between control and fertilizer treatments, by recommended fertilizer 116% maize grain yield increment over control recorded. However, the new fertilizer formulas shown greater 136% yield increment over the control and 9% over recommended fertilizer NP (Table4 4). This may be from the new blended fertilizer content is improved.

New blended fertilizer NPSZnB & modified NPSZnB Shown 6% greater mean yield increment over the recommended fertilizer without lime application over years, Besides, blended fertilizer NPSB Shown 10%

greater mean yield increment over the recommended fertilizer with lime application (Table 5)

The results of partial budget analysis data according to CIMMYT (1998) shown that the highest net benefit was obtained from NPSZnB treatment applied without lime and followed by NPSB rate, and the highest marginal rate of return (MRR) was obtained from recommended NP and followed by NPSB treatment applied without lime. On contrary, from lime applied treatments the highest net benefit was obtained from NPSB treatment applied and the highest marginal rate of return (MRR) was obtained from Recommended NP treatment applied followed by NPSB treatment. But in both cases the yields of Maize recorded from these treatments (recommended NP fertilizer) were marginal low (Table 6).

Table 4 :-Effect of blended fertilizer and limed on Maize grain yield (kgha^{-1}) (2015-2017)

Treatment **Lime level**	**Kersa** 2015	2016	2017	over year	Mean Over year GY KG/ha	%GY Increment Over control	%GY Increment Over Recomm.NP
L0 (Un limed)	5954b	4118.4b	6178	5377.0b	5416.80		
L1 (Limed)	6414a	4932.4a	6088	5826.4a	5811.47	7	
$LSD_{0.05}$	407	683.85	NS	235.66			
Blended fertilizer							
Control(No fert.)	3352c	1125.5b	3633b	2688.2b	2703.50		
Recomm.NP	6093b	5075.5a	6313a	5943.6a	5827.17	116	
NPSB	6799a	5439.5a	6894a	6341.8a	6377.50	136	9
NPSZnB	7295a	4857.5a	6887a	6294.8a	6346.50	135	9
Modified NPSZnB	6947a	5238.8a	6588a	6199.8a	6257.93	131	7
NPKSZnB	6619ab	5415.8a	6483a	6142.0a	6172.60	128	6
$LSD_{0.05}$	704	1184.5	858.52	408.18			
CV%	11	16.82	11.69	9.91			

Table 5. Blended fertilizer and limed on Mean GYKg Over years (2015-2017) and % mean Maize grain yield (kgha^{-1}) increment over Control and Recommended NP fertilizer

Treatment	2015	2016	207	Over Year Mean GY KG/ha	% GYield Increment over control	% GYield Increment over Recomm.NP
(Control)	3129	1008	3972	2703	-	
Recom. NP	6162	4494	6636	5764	113	
NPSB	6585	4522	6788	5965	121	3
NPSZnB	6697	4305	7248	6083	125	6
Modified NPSZnB	6549	5199	6565	6104	126	6
Formula 5 NPKSZnB	5888	5184	5857	5643	109	-2
Control + Lime	3483	1244	3294	2673	-	
Recom. NP + Lime	6723	5657	5990	6123	129	
NPSB + Lime	6798	6358	7000	6719	100	10
NPSZnB + Lime	7583	5411	6526	6507	143	6
Modified NPSZnB + Lime	6997	5279	6611	6296	135	3
NPKSZnB + Lime	7167	5648	7109	6641	148	8

Table 6. Partial budget analysis for the mean grain yield of Maize Jimma(Kersa)

treatment	mean GY KG/ha	Adj.GY KG/ha (10 %)	Gross ben. Birr/ha	Cost of- Birr/ha			TVC	Net benefit birr/ha	MRR %
				Lime	Fertilizer	labor			
Control	2703	2433	19460	0	0	2605	2605	16855	
Recom.NP*	5764	5188	41502	0	2880	2780	5660	35842	335
NPSB	5965	5368	42948	0	3144	2780	5924	37024	20
NPSZnB	6083	5475	43797	0	3444	2780	6224	37573	9
MNPSZnB	6104	5494	43950	0	3872	2780	6652	37298	-4
NPKSZnB	5643	5079	40629	0	3920	2780	6700	33929	-50
Control +Lime	2673	2406	19248	5690	0	4105	9795	9453	
Recom.NP +Lime	6123	5511	44086	5690	2880	4280	12850	31236	170
NPSB +Lime	6719	6047	48374	5690	3144	4280	13114	35260	31
NPSZnB +Lime	6507	5856	46847	5690	3444	4280	13414	33433	-14
MNPSZnB +Lime	6296	5666	45328	5690	3872	4280	13842	31486	-14
NPKSZnB +Lime	6641	5977	47816	5690	3920	4280	13890	33926	18

Price of inputs: Lime = 2.5 birr/kg, Urea = 10.00 birr/kg, DAP = 12.00 birr/kg, KCl = 12.50 birr/kg, NPSB= 15.00 birr/kg , NPSZnB= 16.70 birr/kg , Seed material=22.00 birr/kg, Labor cost 40-50 birr/day, Oxen plough cost = 100.00 birr/day, Farm get price of Maize = 8.00 birr/kg,

* Current technology being used DAP

** Modified or more rate of NPSZnB

-Any technology that costs more than the previous one but yields less net benefits is said to be "dominated" and can be excluded from further analysis

CONCLUSION AND RECOMMENDATIONS

Applications of lime with blended fertilizer gave the Mean maximum maize grain yield as compared with un limed plots. Lime application increase soil pH values favorable for crop production and this also permitted the highest release of available P. This indicates that liming vital to ameliorate the acid condition of the experimental soil.

Use of lime alone could not help crop production to be increased, but might contributed in releasing some amount of fixed P to be available for the crop. Therefore, for better maize production and enhance soil nutrient status, balanced amount of blended fertilizer should be applied with lime.

Grain yield was significantly affected by blended fertilizer and lime . Maximum grain yield was scored for blended fertilizer compare to recommended NP fertilizer. Application of lime significantly ($p < 0.01$) increased grain yield 1.1 times over the year more than un limed . Yield increment over the year observed between lime and un lime main plot was 7% Maize grain yield increment over control (un limed), also yield increment over the year observed between control and fertilizer treatments, by recommended fertilizer 116% maize grain yield increment over control recorded. However, the new fertilizer formulas shown greater 136% yield increment over the control and 9% over recommended fertilizer NP (Table4 4). This may be from the new blended fertilizer content is improved.

In partial budget analysis the highest net benefit was obtained from blended fertilizer and the highest marginal rate of return (MRR) recommended from NP treatments applied.

The groundwork results suggest the use of balanced blended mineral fertilizer together with lime to increase maize yields. More research needs to be approved out for more seasons to determine the recommended rate of the f balanced blended mineral fertilizer and evaluate the consistence of these result

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