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Article

Fertibility Effect of Eucalyptus Bottom Wood Ash on Yield and Yield Components of Maize (Zea Mays) Ethiopia

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ABSTRACT

Bottom wood ash has been dumped anywhere around the residential area, this could negatively affect the environment by reducing the permeability of soil, over fertilization of soil and pollute surface water. Since it has substantial amount of potassium, it could be soil fertility management option if it used properly. The Objective of research was, to investigate utilizing potential of eucalyptus wood bottom ash combining with different organic fertilizers (MBM, dung and compost) as a source NPK fertilizer on maize crop. Pot and field plot experiment was conducted under wire house and rain fed condition respectively. The experiment was designed in the way to give fixed amount of N (87 kg ha^{-1}) and different amount of potassium (30 kg, 60 kg and 90 kg ha^{1}). The obtained result was compared with both convectional mineral fertilizer and control unfertilized treatments. There was a increase in yield, yield component and potassium concentration of maize crop relative to the use of mineral fertilizer and control. The maximum grain yield and yield components such as total biomass, grain number per cob, plant height thousand seed weight and potassium concentration of maize were observed in pots and plots at treatment of dung + bottom wood ash and compost + bottom wood ash which give together 60 kg and 90 kg ha^{-1} potassium application rate.

Keywords: Biochemical, Compost, Composition, Nutrient, Waste

Introduction

Soil is an upper layer of the lithosphere, which contains an essential nutrient for plant growth. In the history of human crop cultivation, soil is the only suitable environment for crop production. However, repetitive cultivation causes soil to lose its fertility. In Ethiopia Although, the country has potentially rich land resources, agricultural productivity is low (Tena and Beyene, 2011) mainly due to soil nutrient depletion (Tadesse et al., 2013). Crop yield is more likely to decrease when soil depletes in its nutrients (Chavez et al., 2014). (Smaling et al., 1993) estimated that in the arable lands of Ethiopia annual net nutrient depletion exceeded 30 kg nitrogen (N) and 20 kg potassium (K) ha^{-1}. To amend nutrient losses, farmers have been applied chemical fertilizer on their farm for fertilization of soil.

Various research has shown, synthetic mineral fertilizers in longer perspective they are unsustainable, bring several detrimental implications to environment and as well as to human health (Yang et al., 2015). Plant nutrients (N-P-K) in synthetic chemical fertilizers are designed to dissolve quickly in water to promote rapid results, but this make a nutrient easily leach out (Schröder, 2014). This, rapid release of nutrient to the plant causes rapid growth this leads the plant to deplete its stored energy, which is biologically reserved for hard times. Even worse, the excess is easily washed away in heavy rains, ending up in water ways where they cause havoc with aquatic life (Hamid et al., 2013). Soils with long-term applications of synthetic fertilizers can be also more acidic, this acidity can reduce ability of soil to support beneficial microorganisms (Tammeorg, 2010). In addition to unsustainability and its pollution potential chemical fertilizers are unaffordable by small farm land holder farmers like Ethiopia. For these reasons, using organic source offertilizer in optimal wayisbest option to fertilize soil andenvironmentally friend.

Organic fertilizers are derived from natural organic sources such as animal manure and dead Organic Fertilizers are gentle to soil microorganisms and release slowly over an extended period of time and can improve soil fertility (Stępień and Wojtkowiak, 2015) plants bodies. However, most of organic source of fertilizers are containinsufficient plant nutrients (NPK) proportionally as required. (Jeng et al., 2006) has indicatedthat, meat and bone meal is contains surplus amounts of organic nitrogen, phosphorus and calcium but it lack potassium which is major plant nutrient. Similarly the chemical analysis of compost animal manure indicates they contain low amount of potassium as compared to nitrogen and phosphorus to apply it individually at soil deficit of potassium. Therefore using the organic fertilizer combining with each other may enable it to fulfill composition requiredto apply. (Juárez et al., 2015) shows bottom wood ash has surplus amount of potassium (K) as a form of K_2O and other metal oxides.

The objective of research is, to investigate theeffect and potential utilizing of eucalyptuswood bottom ashcombining with different N-P containing organic fertilizers as a source NPK fertilizeron maize as test crop.

Material and Method

Material Collection and Preparation

Eucalyptus bottom wood ash from stove burning eucalyptuswood was used as potassium component source of fertilizer. Meat and Bone meal was collected from nearby slaughter house. After collection it was crushed and the flesh part of crushed bone coagulated by heating (80-90^{0}C) and solid and liquid material was separated by pressing. After solid liquid separation the MBM was Calcinated in Furness chamber with electric heating at the temperatures of 925^{0}C for 3 hours (Jeng et al., 2006) for analysis of P, K and Ca. The solid fraction dried at temperature of 110^{0}C, the dry product was screened. Compost which was prepared from Animal manure and agricultural residue by local farmers and cow dung were collect and ground and calcinated at a temperature of 550^{0}C for two and half hours for analysis of P, K and Ca. After calcination 0-2 g ashed organic fertilizers were weighed and extracted with 25 ml HCl solution of 1N of and boiled gently for 15 minute at hot plate after gentle boiling it were diluted in 100 ml volumetric flask according to an ignition method of total phosphorus (Andersen, 1976). After extraction total P and metal concentration were determined by determined by orthophosphate ascorbic acid reduction method (Murphy and Riley, 1962) by UV/ Vis Spectroscopyand by ICP-AES according to (van de Wiel, 2003) using (inductively coupled plasma-atomic emission spectrometry) respectively. Readily plant available phosphorus and plant available metal also extracted from clacinated samples by a solution of 0.4 M acetic acid and 0.1M ammonium lactate (pH 3.75) in a solid-to-solution ratio of 1:20 (W/ v) (Schüller, 1969) and determined by orthophosphate ascorbic acid reduction method by UV/ Vis Spectroscopyand by ICP-AES (inductively coupled plasma-atomic emission spectrometry) respectively. The total Nitrogen was determined by Kjeldahl Method (Scales and Harrison, 1920, Bremner, 1965). The physicochemical properties of organic fertilizer are mention in Table 1.

Table 1.Physicochemical Property of Organic Fertilizer

Parameter	pH	DM g (100) g-1	LOI	Total N g (100)g-1	Total P g (100)g-1	P-AL g (100 g-1	Kg (100) g-1	N:P ratio	Ca g (100) g-1
BWA	12	100	0.02	0.08	1.7	0.2	6.7	0.05	8.2
MBM	6.2	97	73	8.4	4.7	1.5	0.45	1.8	4.3
Cow Dung	7.8	32	38	3.5	1.8	0.07	1.1	2	0.21
Compost	6.9	38	30	5.7	2.18	0.1	1.8	2.6	0.6

Table 2.The Chemical Characteristics of Soil used in Field

pH	TOC g (100) g^{-1}	DM	Total Ng (100) $^{g-1}$	P-Al mg (100) $_{g-1}$	K mg (100)g^{-1}	(100) g^{-1}	bulk density (g cm^{-3}
5.71	6	95.70%	0.4	5	17	313.65	1.3

The soil used was clay soil and was collected through standard procedures (Ryan et al., 2007) from Experimental Farm, Bahir Dar college of agriculture and Environmental Science. The collected Samples soil was allowed to dry in the labroomair. Airdried sample was ground, screened througha 2 mm sieve and calcinated at a temperature of 550^{0}C for two and half hourfor analysis of P and metals were by the method described for organic fertilizers used in experiment. Calcium carbonate and potassium nitrate were used for preparation of standard solution of ICP-AES for the detection of Ca and K and potassium phosphate was used for preparation standard solution to calibrate UV/ Vis Spectroscopy. The chemical characteristics of soil are shown in above Table 2.

Experimental Design

Pot Experiment

The experiment was conducted to investigate the effect of K on growth of maize bodies above and below ground (shoot and root) and to investigate the effect of K fertilizer treatment on soil and maize K uptake it has been designed according to (Jeng et al., 2006). It experiment was conducted outdoor under transparent synthetic roof where the plant was protected from precipitation but exposed to day sunlight and other outdoor weather. Three replicate potsexperimentswere usedto perform with total of 33 pots. The soil and required doses of organic fertilizers were thoroughly mixed and filled in pots of 8 kg. The soil depth was 20 cm in accordance with the depth of cultivated topsoil. The experimental crop was maize. In this experiment, the crop was sown at seed rate of 25 kg ha^{-1} (80,000 seedsha^{-1}) on the field (Abuzar et al., 2011). The experiment was designed on the bases of 100 kg DAP and 150 kg ha^{-1} UREA application rate maize fertilization of local farmers. Fixing the rate of N applied constant, the rate of K applied was 30 kg K ha^{-1}, 60 kg K ha^{-1}and 90 kg K ha^{-1} (Kubar et al., 2013) from combination of BWA with different organic fertilizers and the combination was compared with mineral fertilizer (DAP and UREA) application rate biomass production.

Field Experiment

The field experiment was conducted to observe K treatment effect on maize grain yield, matured plant height, number of grain per cob and other field observed maize growth parameters. The experiment was conducted Bahir Dar city administration in Zenzelma Keble, Bahir Dar University College of agriculture and environmental science Experimental Farm land under rain fed conditions during the main rainy season of 2015 GC cropping season. The experimental field was plowed three times and was laid out in Randomized Complete Block Design (RCBD) with three replications. The space between block was 1.5 m and plots 1 m. The space between each row was 70 cm and planted seed was 30 cm the total plot size was 4 m by 4.4 m (17.6 m^2) (Admas et al., 2015) the total area for this research was 196.6 m^2. The net plot area was 4 m by 3 m (12 m^2). Design of experiment for fertilizer application rate and seed similar per hectare as it was in pot experiment. The collected data maize grain yield, number of grain per cob thousand seed weight and plant height was measured during maturity stage. Finally the combination of BWA with different organic fertilizers and the combination was compared with mineral fertilizer (DAP and UREA) application rate biomass production.

Statistical Analysis

Statistical Analysis (T-test) was performed with all data to confirm variability of data and validity of results according to experimental design Table 3. The differences amongst treatments were separated using least significance difference test at 0.05 probability level.

Result and Discussion

Effect of K Fertilizer Treatments on Biomass Production

The dry total biomass production under the application of 30 kg ha^{-1} BWA combining with Dung and Compost resulted in similar amount of dry biomass production (Table 4) (36.8-37.8 g pot^{-1}) under treatment of the same N amount but different P the fertilizers rate application. the

Table 3.Experimental Design for Pot and Field Trials of Organic Fertilizer Applied and Mineral Fertilizers with N, P and K in Kg Ha-1 (Base Fertilization 87 Kg N Ha-1 ,46 Kg P Ha-1 and 0 Kg K Ha-1 in 100 Kg Dap and 150 Kg Urea)

Treatment	Potassium kg ha^{-1} application rate													
	30						60						90	
Fertilizers	Mixing ratio		(kg)	N	P	K	Mixing ratio		Sum (kg)	N	P	K	Mixing ratio	
DAP+UREA	100	150	250	87	46	0	100	150	250	87	46	0	100	150
MBM+BWA	1,035	375	1410	87	55	30	1,025	825	1850	87	62	60	1,025	1269
Dung+BWA	2,480	37	2517	87	45	30	2,480	490	2970	87	53	60	2,460	940
Compost+BWA	1,530	40	1570	87	34	30	1,520	490	2010	87	41	60	1,520	940

difference is insignificant. It increased (90-96%) over the black treatment (without fertilizer). A biomass production under the application of 30 kg ha-1 BWA combining with MBM resulted less amount of dry biomass production compared with the convectional DAP + UREA and others organic fertilizer and the difference was significance. All in all the dry total biomass production of Dung and Compost samples treated with combination of BWA of 60 kg and 90 kg K ha^{-1} together are significantly different from unfertile control treatment, convectional (DAP + UREA) and MBM+ BWA treatments. However, the difference in biomass production between Dung and Compost under 60 kg and 90 kg K ha^{-1} application rate was not significance. All in all total dry biomass production of MBM treatment is less compared to the convectional DAP and UREA treatment dry biomass production. This suggest extractable nutrients could release more from MBM bio-fertilizer under acidic soil nature(Jeng et al., 2006).

The shoot and root length of under treatment of convectional mineral fertilizer (DAP and UREA) increase 33% and 80% over unfertilized treatment (control) respectively. Application of 30 kg ha-1K increase the shoot by 29% and root length by 62% over control treatment combined with MBM which was a minimum shoot and root length of maize under application of fertilizer treatment. Applying 30 kg K ha-1 combined with dung increased shoot length 31 % and 85 % root length and increased 35% shoot 90.5% root length combined with compost. The maximum shoot and root length was obtained at 90 kg K ha^{-1}(BWA) combining with compost. In this case (42 cm) root length was recorded which exceed by 10% over convectional DAP and UREA fertilizer treatment and 97.6% over unfertilized control treatment. Similarly highest shoot length (70.5 cm) (Table), was recorded under 90 kg K ha^{-1} treatment combining with compost fertilizer which increased by 36% over the control treatment. The application effect of 60 kg K ha^{-1}.

Table 4.Effect of Different Potassium Fertilization Rates on Various Growth Parameters of Maize Grown in Rain Protected Pot Experiment

Fertilizer				control	DAP + UREA	MBM + BWA	Dung + BWA	Compost + BWA
Potassium kg ha^{-1} application rate	30	shoot weight	wet	92	124	112	128	131
			dry	15.2	28.5	26.2	28.9	29
		Root weight	wet	25	37	35	39.1	41.6
			dry	4.1	7.8	6.6	8.1	8.8
		Total Dry biomass		19.3	36.8	32.8	37	37.8
		shoot length		52	69	67	68	70
		root length		21	38	34	39	40
	60	shoot weight	wet	91.16	123	118.4	130.1	136
			dry	14.7	27.8	26.5	31	33
		Root weight	wet	25.2	36.6	37.1	41	42.6
			dry	4.2	7.1	7.6	7.9	8.6
		Total Dry biomass		18.9	35.9	34.1	38.9	41.6
		shoot length		51	70	67.5	69	70.4
		root length		21.7	37.2	36	40.3	41.2
	90	shoot weight	wet	93	123.5	119	132	136.9
			dry	15.1	27.8	26.8	31.4	33.6
		Root weight	wet	26	37.1	37.6	41.6	42.8
			dry	4.4	7.4	7.7	8	8.8
		Total Dry biomass		19.5	35.2	34.5	39.4	42.4
		shoot length		52.2	68.4	67	69.3	70.5

Effect of K Fertilizer Treatment on K in Maize and on Soil ph

The highest potassium concentration in roots and shoots of maize was observed under the application of 90 kg K ha-1 (Table 5), combining with compost. It gave 110% more K concentration in shoots and 237.5% more K concentration in roots, compared with control. These values are increased by 41% in shoot and 100% in root over the convectional DAP and UREA treatment. The minimum K concentration in roots and shoots was under the control where neither K fertilizer nor NP fertilizers were applied. As K application increased, the concentration of K in roots and shoots increased and reached up to its maximum when K was applied at 90 kg ha-1 Potassium application improved nutrient concentration in root and shoot of maize (Table 5).

treatment in similar with biomass production. This is fort the reason that MBM fertilizer is more effect in acidic soil. The minimum K uptake was observed in control (Table 5). Even though the N application, under all circumstances were equivalent with other fertilizer applied, the uptake of K at a treatment of convectional fertilizer DAP and UREA were less compared with other fertilized experiments. This indicates there might substantial deficit of K for this particular soil used in experiments. Over all there was an only minor effect on soil pH as a result of reaction in the experimental soil which was due to relatively high clay nature of soil used in experiments. The application of BWA fertilization tended to result in higher pH (Table 5), values than the unfertilized treatment but the effect was not significant.

Table 5.Potassium Concentration (%) in Roots and Shoots of Maize Grown in Rain Protected Wire House as Affected by Different K Application Rates

Treatment		Fertilizer	control	DAP + UREA	MBM + BWA	Dung + BWA	Compost + BWA
Potassium kg ha^{-1} application rate	30	shoot K	1.12	1.68	1.91	2.0	2.1
		Root K	0.32	0.54	0.67	0.9	0.9
		pH	5.71	5.67	6.17	6.21	6.26
	60	shoot K	1.23	1.75	2	2.11	2.28
		Root K	0.37	0.58	0.72	0.97	1.02
		pH	5.71	5.67	6.2	6.26	6.27
	90	shoot K	1.24	1.78	2.09	2.17	2.37
		Root K	0.42	0.62	0.77	1.01	1.08
		pH	5.71	5.67	6.3	6.32	6.31

Potassium application 60 kg ha-1 combined with compost was increased shoot and root K concentration by 103.5 and 218.75%, respectively, compared with control. The application of Potassium at 60 kg and 90 kg ha-1 exhibited similar K uptake by roots and shoot and the difference was insignificant. This shows the application of K above 60 kg ha-1 was not further increase the K uptake of the maize for soil used in experiments. The K application combined with one of the organic fertilizer used in this paper was dung. Similarly maximum K uptake in roots was observed when K was applied at 60 kg and 90 kg ha-1 which were 93.75% and 215% at rate of 90 kg ha-1 and 88.4% and 203% at rate of 60 kg ha-1 more, compared with control in shoot and root respectively. The K uptake by maize under treatment of dung combine BWA which was equivalent rate of K application at 60 kg and 90 kg ha-1 were increased by 29.2% and 87% at rate of 90 kg ha-1 and 25% and 79.6% at rate of 60 kg ha-1 more, compared with control in shoot and root respectively. The 30 kg ha-1 K application uptake was minimum compared with 60 kg and 90 kg ha-1 both in Dung combined with BWA and compost with BWA. MBM K uptake was less compared with other organic fertilizer

Effect of K Fertilizer on Maize Yield and Yield Componantes

This section contains results of field experimental investigation of K application effect on maize different growth parameter and yields. Plant height at maturity (m). Plant height is an important component which helps determining the growth attained during the growing period. The data showed the mean tallest plant height was (2.32 m) (Table 6). It was recorded in plots tested with 90 kg ha^{-1} K combining with compost and fixed amount of N (87 kh ha^{-1}). The value shows the plots under treatment of 90 kg ha^{-1} K combining with compost is increased over convectional fertilizer DAP and UREA by 7%. While the shortest maize height was observed at control treatment plots (1.32 m) which revealed an increase of about 75%. According to (Haseeb-ur-Rehman et al., 2010) Plant height is an important yield component, as the more green area the more will be photosynthetic activities and share to gain yield. Furthermore (Dilshad et al., 2010) has indicated plant height is an important parameter of yield in maize as usually taller plant bears more yield.

The mean data regarding 1000 grain weight are presented in (Table 6). Perusal of the data revealed that grain weight was affected by fertilizer types and K application rate. The treatment having 90 kg ha^{-1} K with a combination of Compost fertilizer produced the highest grain weight of 417 g.

The increase in grain weight might be due to availability of more K nutrient resources and special effect of compost which acted as store house of different plant nutrient, reduce P fixation, root penetration, increase water storage capacity of soil and host different microbes (Desta, 2015). The lowest grain weight (228 g) was recorded in unfertilized treatment. Application of dung combining with K (BWA) was the second best organic fertilizer under all K application following the compost with K in this study, as explained in (Table 6). MBM was the lowest in all circumstances compared with convectional DAP and UREA and as well with other organic fertilizers.

The data given in (Table 6), indicated that number of grains cop^{-1} was influenced by different K application rate and types of fertilizers. The maximum number of grains cop^{-1} were obtained at 90 kg ha^{-1} K of dung and compost combined with BWA (534 and 536) respectively. Whereas the lowest (211) was recorded in control which indicates an increase of 153 and 154% respectively in dung and Compost combined with BWA. On the other hand grain number per cob is directly affect the grain yield (Haseeb-ur-Rehman et al., 2010).

Grain yield is a function of integrated effects of genetic make-up of cultivars and the growing conditions. The data on grain yield revealed that grain yield was significantly affected by types of fertilizer and K application. The maximum grain yield (4.93 ton ha^{-1}) was recorded in application compost integrating with BWA which account to give 90 kg K ha^{-1} together. This yield increased by 19.3% over the convectional mineral fertilizer DA and UREA and the difference was significant. The grain yield of dung with BWA resulted in similar yield in all different K application rate with convectional mineral fertilizer Table 6. Whereas MBM combined with BWA yields less amount of grain ha^{-1} compared with convectional mineral fertilizer. Minimum (1.32 ton ha^{-1}) yield was obtained at control plots under unfertilized treatment. Potassium deficiency can lead to a reduction in both the number of leaves produced and the size of individual leaves(Pettigrew, 2008). Integrating this decreased amount of photosynthetic source material with a reduction in the photosynthetic rate per unit leaf area, and the result is an overall reduction in the amount of photosynthetic assimilates available for growth. The construction of less photosynthetic assimilates and decreased assimilate transport out of the leaves to the developing seed greatly impart to the negative consequences that insufficiencies of potassium have on yield and quality production. Particularly many researches has shown maize yield and yield component could be negatively affected by soil deficiency of K than other crop (Heckman and Kamprath, 1992, Ebelhar and Varsa, 2000).

Table 6.Effect of K Fertilizer Application on Maize Yield and Yield Componantes

Control		Yield ton ha-1	1.32		
		1000 seed weight (g)	228		
		height (m)	1.42		
		grain cop^{-1}	211		
DAP + UREA		Yield ton ha^{-1}	4.13		
		1000 seed weight (g)	379.67		
		height (m)	2.17		
		grain cop^{-1}	470		
Treatment		Fertilizers	MBM + BWA	Dung + BWA	Compost + BWA
Potassium kg ha^{-1} application rate	30	Yield ton ha^{-1}	3.7	4.01	4.6
		1000 seed weight (g)	369.2	370.6	386
		height (m)	1.97	2.10	2.16
		grain cop^{-1}	423	513	521
	60	Yield ton ha^{-1}	3.8	4.14	4.87
		1000 seed weight (g)	372	396.7	412
		height (m)	2.02	2.13	2.24
		grain cop^{-1}	432	531	533
	90	Yield ton ha^{-1}	3.82	4.2	4.93
		1000 seed weight (g)	373.4	398.5	417
		height (m)	2.04	2.18	2.32
		grain cop^{-1}	433.54	534	536

Conclusion

Pot and field experiment was performed to investigate the effect of BWA on yield and yield component combining with organic fertilizer such as MBM, Dung and compost in the way to give fixed amount of N(87 kg ha^{-1}) and different amount of K(30 kg, 60 kg and 90 kg ha^{-1}). The obtained result was compared with both convectional mineral fertilizer and control unfertilized treatments. The topmost grain yield and yield component of total biomass, grain number per cob, plant height thousand seed weight and K concentration of maize were observed in pots and plots at treatment of dung + BWA and compost + BWA which give together 60 kg and 90 kg K ha^{-1}. This is because of maize is relatively demands high K compared with other crop and dung and compost acted as store house of different plant nutrient, reduce P fixation, root penetration, increase water storage capacity of soil and host different microbes. Although maize yield and some yield component were slightly different at 60 kg and 90 kg K ha^{-1} K application, the difference was not significant. So, further application of BWA in the way to give above 60 kg ha^{-1} K could not be more influential on maize yield and yield component for this particular soil under study. These field and pot experiments showed that farmers may get considerable productivity if they use organicfertilizerintegrating with BWA which has been dumped unconsidered its environmental impact as K source for soil fertility management option. Therefore, the use of BWA fertilizer combining with other organic fertilizers are recommendable for farmers particularly for farmer's small farm holders because the fertilizers could be affordable and increase options to improve soil fertility.

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