International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Effect of Selected Legumes on Biomass Production, Nitrogen Mineralization and Grain Yield of Maize in Sub Humid Parts of Tanzania

Chilagane, E. A.[1], Rweyemamu, C.L.[2], Saidia, P.S[3]

[1]Agricultural Research Institute Uyole, Southern Highland Zone Crop Research, Mbeya, Tanzania

[2]Sokoine University of Agriculture, Department of Crop Science and Horticulture, Morogoro, Tanzania

[3]Agricultural Research Institute Ukiriguru, Lake Zone Crop Research, Mwanza, Tanzania

Abstract: ***Declining soil fertility is among major production constraint facing small holder's famers in sub humid areas of Sub Sahara Africa. The convenient of inorganic fertilizer in crop production is vivid, but famers are financial limited to buy and utilize. Residuals of velvets bean (MucunapruriensL.), dolichos (Lablab purpureusL.) and sunhemp (CrotolariaochroleucaG.) are low-input strategies that can be used by the small holder's famers to increase soil fertility and crop production in unfertile soils. This study aimed at assessing the effect of these legumes on biomass production and nitrogen mineralization. Also, to evaluate the effects of residues on soil characteristics and maize grain yield. Field and laboratory experiments were used in this study. Inorganic fertilizer UREA was used as a standard treatment. Results showed no significant difference (P=5%) on biomass production, however velvet bean produced relative higher biomass (15.13 t ha-^{1}) followed by dolichos and sunhemp of 12.67 and 11.75 t ha-^{1} respectively. Sun hemp had highest N content (2.77%) followed by velvet bean and dolichos with 2.49 and 2.42%N, respectively. The percentage mineral N released peaked at 10 weeks for control and sunhamp with 27.56 and 56.82%N, respectively, while N in inorganic fertilizer peaked at 6 weeks. Velvet bean and dolichos had similar trend of N releasing ability. Urea gave highest grain yield (3.96 t/ha) while famers practices scored the lowest (1.01 t/ha). Maize yield significantly increased by 2.5, 2.6 and 2.7 t/ha when dolichos, velvet bean and sun hemp residuals were used respectively. Use of such residues in crop production should be promoted of restoring soil fertility and increased maize yield in sub humid areas of Tanzania.***

Keywords: legume biomass, nitrogen mineralization

1. Introduction

Maize (*Zea mays* L.) is the staple food crop in Tanzania, and the estimated average consumption is 128 kg per person per year [1]. According to the Ministry of Agriculture Food Security and Cooperatives [2], maize is produced mainly under rain fed agriculture and yield is generally low of 1.3 t/ha compared to the national average yield of 4.5 t/ha [3] and world average yield of about 5.2 t ha^{-1}[4, 5].The crop is produced over a wide range of altitudes, from near sea level to about 2 400 m above sea level [6]. Low soil fertility is the constraint to crop production and productivity on smallholder farming systems in the semi-arid tropics (SAT) [7]. Most soils in SAT of Africa are of low fertility due continues cropping in the same field with no or little fertilizer input and removal of field crop residues for feed livestock. Also, off season overgrazing activities and burning of crop residues in the field to ease ploughing have resulted in deterioration of physical, chemical and biological soil properties [8]. Use of hybrid varieties with higher yielding ability and higher response to inputs call for increased use of fertilizer inputs [9]. The increase in rural population density and hence increase in land-use intensity are also causing a nutrient depletion among smallholder farming systems [4, 10]. This in turn poses an immediate threat to food production and causes environmental degradation. It is generally known that fertilizer application increases yield and counteracts nutrient deficiency in soils [11], but application of inorganic fertilizer become a big challenge to most of smallholder's famers as most of them are financial unstable to buy and apply inorganic fertilizer as it is expensive at current recommendations.

The use of organic resources such as leguminous crop residues can improve physical, chemical and biological condition of the soil. Organic matter additions to the soil have shown to be critical in improving soil quality and optimizing nutrient and water retention capacities and ultimately crop productivity [12]. It is estimated that herbaceous legumes can accumulate 25.6 to 246.6 kg N ha^{-1} year^{-1} in the tropics, with a significant portion of nitrogen (N) derived from biological nitrogen fixation [13]. The integration of green manure legumes as cover crops into the smallholder farming systems has the potential to enhance the yields of subsequent crops as a result of the N released from the decomposition of the legume residues. An understanding of efficiencies in biomass production their N mineralization patterns are crucial in the synchronization of N release from residue and its uptake by subsequent crops. This can enable farmers to utilize nitrogen released from decomposition of green manure legume cover crop residues and may offer a strategy to improve soil fertility and crop productivity in sub humid parts SSA of meet the nitrogen needs at the sometime improving physical properties of their field.

2. Materials and Methods

Location

This research work was conducted at Sokoine University of Agriculture (SUA) Morogoro. The experiment was laid at the crop museum in the Department of Crop Science and

Production located at latitude $6^0 51'5''$S and longitude $37^0 39'26''$E at an altitude of 526 masl. The site is dominated by sandy loam soil with pH of 5.16 and has bimodal rainfall pattern where short rains (Vuli) start from October to December and long rain (Masika) start from March and end in May [17]. The annual rainfall in this area ranges from 750 to 1050 mm with an average of about 900 mm. The annual temperatures in the area vary depending on the season, with average minimum and maximum of 17 and 28 ^{0}C, respectively (Tanzania Meteorological Agency SUA, 2012).

Experimental materials and treatments

The seeds of Velvets bean, Dolichos and Sunhamp were obtained from the southern highland zone at Agriculture Research Institute Uyole, Mbeya, Tanzania. Fertilizer material (urea 46% N) and maize variety "Staha" obtained from agrochemical shop (Imuka) in Morogoro. The treatments used for assessing the legume residues on maize growth and yield were control (T1) no fertilizer applied, Nitrogen applied in form of Urea (46% N) fertilizer (T2), Velvets bean residue (T3), Dolichos residue (T4) and Sunhamp residue (T5).

Experimental design and treatments application

Randomized complete block design RCBD were used in five replications to evaluate the effects of legumes residues soil characteristics and maize yield. Velvet bean and dolichos were planted; two seeds per hill at the spacing of 75 by 30 cm. Sunhamp seeds were drilled in rows where the spacing between rows was 30 cm. The legumes were slashed at the onset of the flowering stage, weighed and incorporated in the soil in their respectively plots. The amount of sunhamp, dolichos and velvet bean residues in fresh weight incorporated were 60, 70 and 80 kg/plot respectively and this was based on actual amount of residues produced at respective plots and left for two weeks for decomposition. At the end of the two week incorporation period, plots with and without legume residues were tilled using hand hoes and leveled using rakes then two maize seeds (variety Staha) were sown at the spacing of 75 cm by 30 cm. Triple super phosphate fertilizer (TSP 46% P_2O_5) was applied to all experimental units at the rate of 40 kg P ha^{-1} as recommended and urea (46% N) fertilizer was applied in inorganic N treated plots at the rate of 80 kg N/ha as described by[14]. Thinning was done one week after crop emergence and one plant was left per stand. Other crop management practices that included weeding, irrigation and insect control were performed as described by [14].

Laboratory experiment

Nitrogen mineralization experiment conducted at soil science laboratory at Sokoine University of Agriculture, Department of Soil and Geological Science. Before legume incorporation in the field, above-ground tissues of each legume per meter square were sampled, weighed and taken to the Department of Animal Science and Production Laboratory at SUA for dry weight determination. To determine dry weight, the materials were oven dried at 70^{o}C for 48 hr, and dry weights were determined. Further, materials were ground by labmill grinder No 49015, sieved at 0.5 mm sieve, packed in plastic bags and labeled accordingly. Total N and organic carbon contents of the samples were determined by the micro kjeldhal and the wet oxidation methods respectively. Nitrogen mineralization experiment was carried out as described by[15] Ground samples of legume residues were added to 2 mm sieved soil at the rate of 10 g residue kg-^{1} of sieved soil, on dry weight basis. Then five portions of 250 g of the residue treated soil sample (for each legume) including control (without residue) and standard (with inorganic N) were placed in plastic bottles, and moisture content of these samples were adjusted to 60% of field capacity with distilled water before the soils were incubated at room temperature. The bottles were covered with perforated aluminum (Al) foils and incubated for 16 weeks. Incubation temperature was recorded weekly. The 250 g portions of soil treated with treatments were replicated twice makes the total of 10 bottles, and appropriately labeled to show the treatment it contained. The incubated soils were weighed regularly and distilled water was added to bring the soil moisture to its original level (60% of field capacity). After 2, 4, 6, 10 and 16 weeks of decomposition, 20 grams of soil from each bottle were removed and mineral N (in form of NH^{+4}, NO^{-3}) was determined. Nitrogen mineralization from residues in mg/g were determined and further, nitrogen mineralized in percent were calculated from the difference in cumulative amount of mineral N between residue treatments and control treatment at each sampling time, divided by the initial N in the applied residue material.

Data Collection

- **Soil information**

Soil samples were collected from six spots at random before the initiation of experiment and four samples from each treatment after incorporation of legume residues at sampling depth of 0 – 30 cm and composite sample were made using quartering method. Second round of soil sampling were done six weeks after incorporation where i each plot samples were taken. Physical and chemical soil properties were determined using procedures described by [16] at Sokoine University of Agriculture, Department of Soil and Geological Science.

- **Weather information**

Daily weather parameters were collected from the nearest Tanzania Meteorological Agency (TMA) station at SUA.

- **Grain yield**

Yield components determined include cob length (cm), cob weight (g/cob), seed size (g/100 seeds) and grain yield (t/ha) were also determined. Further, the amount of nitrogen mineralized (mg N/kg soil) in the incubation experiment were weekly recorded.

- **Data analysis**

Descriptive and inferential statistical analysis was used where descriptive statistical analysis was used for weather data and inferential statistical analysis was used for crop data

Where Analysis of Variance (ANOVA) were conducted at 5% using Co-Stat statistical software with the statistical model: $Yij= \mu+Ti +Rj + \mathcal{E}ij$. Where; Yij represent the response for the experimental unit, μ is the overall mean, Ti is the treatment effect, Rj is the block effect, and Ɛij is the error/residues term [17]. Duncan Multiple Range Test (DMRT) for means separation were done, both at 5% level of significance. Soil analysis for chemical and physical characteristics was done at SUA, department of soil science.

3. Results and Discussion

Soil characteristics at the experimental site

The soil particle distribution (0-30 cm depth) was 54% clay, 1% silt and 45% sand (Table 1) and according to[16], the soil was classified as sandy clay soil. The percentage of moisture content of the soil at sampling time was 1.24%, indicating that the soil was very dry at that particular time. The soil had a bulk density (BD) of 1.32 g cm^{-3}, which was rated as medium (Table 1). Such low value of BD is regarded as having insignificant negative effect on plant root growth and penetration in the soil [18]. The soil had a pH of 5.16, rated as a strongly acidic, but was still within the preferable range for maize production [3]. The percentage total nitrogen (N) and organic carbon were medium values of 0.3% and 1.76%, respectively. Extractable P was also found to be medium at 12.5 mg kg^{-1}. The cation exchange capacity (CEC) was 17 cmolc kg^{-1}; while the exchangeable bases were 4.82 for Ca^{2+}, 4.41 for Mg^{2+}, 1.48 for K^+ and 0.21 for Na^+ (Table 1). According to [16], the soil had high exchangeable Mg^{2+} and K^+ but low exchangeable Ca^{2+} and Na^+. Overall, the soil was classified as that of medium fertility [16] and therefore appropriate for maize production [19].

Table 1: Soil characteristics at the initiation of the experiment (before legume planting) Soil characteristic

Physical	Values	Rating*	Chemical	Values	Rating*
Soil texture			pH(H2O)	5.16	Strongly
Clay (%)	54		Organic carbon (%)	1.76	Medium
Silt (%)	1		Total N (%)	0.3	Medium
Sand (%)	45	Sand clay	Extractable P(Bray 1,mg/kg)	12.5	Medium
Bulk density (g cm-3)	1.32	Medium	CEC (cmol/kg)	17	Medium
Soil moisture (%)	1.24	Very low	Exchangable Ca2+(cmolc/kg)	4.82	Low
			Exchangable Mg2+(cmolc/kg)	4.41	High
			Exchangable K+(cmolc/kg)	1.48	High
			Exchangable Na+(cmolc/kg)	0.21	Low

Rating for soil characteristics was according to [14]

Weather condition

The average minimum and maximum temperature for the whole period of this research ranged from 20.6to 30.9^{o}C (Table 2). The highest temperature was recorded in February, 2012 where it averaged 33.02^{o}C with the month's minimum value being 21.47 ^{o}C. The total amount of rainfall was 692.5 mm from November, 2011 to June, 2012 (Table 2) with poor distribution. The amount of rainfall collected for the whole research period was not enough to raise the maize crop properly (i.e. up to harvesting maturity) as the crop requires 600 to 1200 mm to perform well [19]. Therefore, irrigation was done on both crops (legume and maize) to facilitate their proper growth. However, the amount of water applied was not determined, but whenever there was dry spell, the soil was brought to field capacity. The RH at the research site for the whole research period ranged from 69.42 to 81.36%, with the average of 76.07 % (Table 2).The highest RH was 81.36%, recorded in April and May, 2012. This was probably influenced by the rainfall availability in terms of its amount and distribution for these months as compared to the months of November, 2011 to February, 2012. Solar radiation ranged from 15.19 to 36.59 MJ m^{-2} with the average of 19.89 MJ m^{-2} which is within the range for sub humid environment.

Table 2: Monthly weather data for the whole period of this research

Months	Temp oC(max)	Temp oC(min)	Radiation(MJm^{-2})	Rainfall(mm)	%Retative humidity
November, 2012	32.38	21.25	18.96	37	72.59
December, 2012	31.5	21.5	19.16	191.1	75.47
January, 2013	31.34	21.5	35.59	70.3	75.74
February, 2013	33.02	21.47	20.83	71.7	69.42
March, 2013	31.61	21.35	18.72	49.73	76.06
April, 2013	29.91	20.47	15.33	124.9	81.36
May, 2013	28.7	19.3	15.1	134.6	82.36
June, 2013	28.05	16.96	15.19	22.9	76.53
Average	30.96	20.62	19.89	T* 692.53	76.07

**Total rainfall;*
Source: Tanzania Meteorological Agency – SUA

Efficiency of biomass production

The biomass generated by the legumes ranged from 11.75 to 15.13 tons DM ha^{-1} (Table 3). There was no significant difference (P=5%) on biomass production among the tested legumes but velvet beans had relative higher efficiency of biomass production followed by dolichos and sun hem. The higher biomass produced by velvet bean might be due to its high potential of to extract water and other growth resources from the soil thus enables it to produce high biomass [20].This result is similar to that observed in Kenya and

Uganda that showed the potential of velvet beans to accumulate higher biomass as compared with other legume cover crops [7, 21]. Biomass produced by dolichos in the present is 12.67 tons ha^{-1} which was higher by 0.92 tons of biomass ha^{-1} compared that of sunhemp. Despite shortage of rainfall was experienced in November, 2011 to January, 2012, irrigation was undertaken to supplement moisture in the soil. This is the main reason that resulted into higher biomass production with average of 13.2 t ha^{-1}

Table 3: Biomass production by selected legumes

Legume	Biomass(t/ha)
Velvet beans	15.13 a*
Dolichos	12.67 a
Sunhemp	11.75 a
Mean	13.18
Sd	5.01
CV (%)	16.98

**Means in the same column followed by the same letter are not significantly different according to DMRT at $P \leq 0.05$*

Effect of legume residues on particle size distribution and balk density of the soil

The particle size distribution and bulk density of the soil six weeks after residue incorporation are shown in Table 4. The proportions of different soil particles before planting of legumes were 54 % Clay, 1 % Silt and 45 % Sand, but six weeks after incorporation the percentage soil particles where 55 % Clay, 2 % Silt and 43% Sand for velvet beans treated soil, 54% Clay, 3 % Silt and 43 % Sand for dolichos treated soil and 55 % Clay, 3 % Silt and 42% Sand for sunhemp treated soil. These results show that there is tendency of slight increase of clay and silt percent while a slight decrease in sand particles when soil is treated with legume residues. Therefore, use of residues of these legumes can be a good strategy increasing water holding capacity of sand soil due to addition clay particles in the long ran. These results are in agreement with those reports by [22] where they found 3% decrease in sand when velvet beans were incorporated in the soil. Bulk density of the soil before planting legumes was 1.32 g cm^{-3} (Table 6). It was reported by [16] that bulk densities above 1.42 g cm^{-3} hinder root penetration, but the soil under this study had lower bulk density than that stated by London. This indicates that the soil had no hindrance of root penetration. Six weeks after incorporation of legume residues, the bulk density of the soil was decreased from 1.32 g cm^{-3} to 1.02 g cm^{-3}, 1.04 g cm^{-3} and 1.03 g cm^{-3} for velvet beans, dolichos and sunhamp treated soil, respectively. According to [23], the reduction of bulk density of the soil when treated by legume crop residues could be due to increase in the quantity of the lighter fraction and organic matter in the soil. They also reported that, the surface application of plant residues reduces bulk density of surface soil by 0.05 g cm^{-3} but deeper soil layers are not affected. It was also observed by [24] that the physical properties of the soils, such as saturated and unsaturated hydraulic conductivity, water retention capacity, bulk density, total porosity, pore size distribution, soil resistance to penetration, aggregation, and aggregate stability were all improved in plots amended with organic amendments.

Table 4: Effect of legume residues on physical properties of the soil six week after residues incorporation

Soil characteristics	BPL	T1 Treated soil	T2 Treated soil	T3 Treated soil	T4 Treated soil	T5 Treated soil
Clay (%)	54*	54	54	55	54	55
Silt (%)	1	1	2	2	3	3
Sand (%)	45	45	44	43	43	42
BD (g/cm3)	1.32	1.31	1.28	1.02	1.04	1.03
Moisture (%)	1.24	28	27	34	31	30

**Data not subjected to statistical analysis*
BPL= before planting of legumes

Effect of legume residues on soil chemical properties

Chemical properties of soil were positively affected when the soil was treated with legume residues (Table 5). There was a significant difference (P=5%) on the total N content in the soil at 6 weeks after legume incorporation, the highest value being observed on velvet bean treated plots with a mean total N of 0.54% compared to the initial value of 0.3% (Table 5) and the control plots value of 0.27%. This was followed by sunhamp and dolichos that had a means of 0.53% and 0.51%, respectively. Moreover, plots treated by inorganic fertilizer had a total N of 0.28% which was lower compared to residues treated plots that ranged between 0.51% for dolichos to 0.54% for velvet bean. This result implies that the total N in the soil increases when the soil is incorporated by legume residues as a result of addition of N contained in the residues. Therefore, application of legume residues in low N soil is very important for replenishment of the soil nitrogen [25]. Further, the results indicated that there was medium variation of legume residues application that has a variation of (CV) 11.27%. The results also showed that there was no significance difference on the CEC, pH and organic carbon of the soil; though the plots treated with velvet bean had relatively higher CEC followed by sunhamp and dolichos, with 18.1, 17.8 and 17.6 $cmol_c$ kg^{-1}, respectively. The slight increase in CEC of the soil indicates the improvement of the fertility nature of the soil. Organic carbon of the soil also varies, plots treated by legumes residues has slight higher organic carbon which is very important in microbial activity in the soil. Such results have also been documented by [22]. The high variation (CV=37.54%) recorded on the OC variable indicated that the soil organic matter in the plots treated with legumes residues had improved compared to those without residues

Table 5: Effect of legume residues on chemical properties of the soil six week after residues incorporation

Treatments	Total N (%)	CEC(cmol/kg)	OC (%)	pH
Control	0.27b*	16.8a	1.78a	5.14a
Velvet bean	0.54a	18.1a	2.54a	5.12a
Dolichos	0.51a	17.6a	2.57a	5.12a
Sunhemp	0.53a	17.8a	2.55a	5.13a
Urea (46%N)	0.27b	16.8a	1.72a	5.15a
Mean	0.426	17.42	2.23	5.13
Sd	0.14	0.59	0.44	0.01
CV (%)	11.27	4.8	37.54	16.3

**Means in the same column followed by the same letter are not significantly different according to DMRT at $P \leq 0.05$*

Chemical characteristics of incubated legume residues

The chemical characteristics of the legumes residues used are shown in Table 6. The percentage N content of selected residues ranged from 2.42 to 2.77%. Sunhamp had the highest N content of 2.77% followed by velvet bean and dolichos at 2.49 and 2.42%, respectively. Organic carbon of these materials varied from 38.84 to 44.04%, where velvet bean had the highest value of 44.04% followed by sunhamp and dolichos with 43.73% and 38.84% respectively. These results are different from those presented by [26] where he found 2.9, 2.3 and 2.2% N in velvet bean, dolichos and sunhemp residues respectively.

Table 6: Chemical characteristics of incubated legume residues

	%N	%P	%K	%OC	C: N Ration
Velvet bean	2.49*	0.20	2.15	44.04	1:17.71
Dolichos	2.42	0.17	2.12	38.84	1:16.08
Sunhamp	2.77	0.23	2.14	43.73	1:15.82

**These descriptive data were not subjected to statistical analysis*

Nitrogen mineralization and mineralization patterns from incubation study

The nitrogen mineralization patterns of applied treatments were shown in Figure 1. The percentage mineral N released from the applied treatment increased with time and reached the peak at 10 weeks (wks) after onset of the experiment for control and sunhamp with 27.56 and 56.82%, respectively, while inorganic fertilizer N release peaked at 6wks after onset of incubation. This indicates that inorganic fertilizer has higher and fast N releasing ability over legume residues. This may cause N loss through leaching especially in high rainfall areas with sandy soils and, therefore, the need of split application of inorganic fertilizer is very important. Velvet bean and dolichos had similar trend of N releasing ability which shows releasing at decreasing rate throughout the period of incubation with the percentage increment of 51.26% and 47.87%, respectively, at the end of incubation period. Sunhamp had higher N releasing ability compared to velvet bean and dolichosand this is due to its higher N content and relative low C: N ratio as shown in Table 7. The mineralization constant during 16 weeks of incubation (Figure 2 b-d) were 0.1736, 0.1739 and 0.1702 for velvet bean, dolichos and sunhamp, respectively. Control and inorganic N treated samples tended to have lower mineralization constants of about 0.1457 and 0.135, respectively (Figure 2a and 2e). These values imply that the mineralization of these legume residues follows similar pattern though they differed in terms of the total amounts of N that released (Table 8). Similar trend of results was observed by[27] working in Kenya that sunhamp residue tended to have high N content and mineralization rate but relatively lower mineralization constant. However, at the end of the 16-week incubation period all the legumes produced substantial amounts of mineral N which can contribute significantly to the N requirement of a maize crop. Maize crop reach tasseling stage approximately 10 - 12 weeks after planting. This is the stage with the maximum demand for N by the maize crop and coincides with the maximum amount of N released by the decomposing legume residues and can greatly benefit a maize crop.

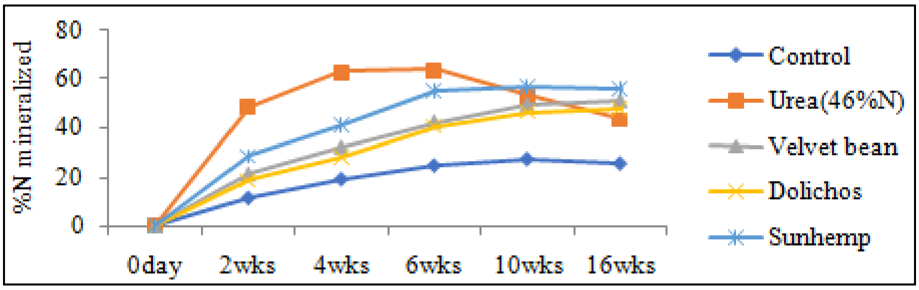
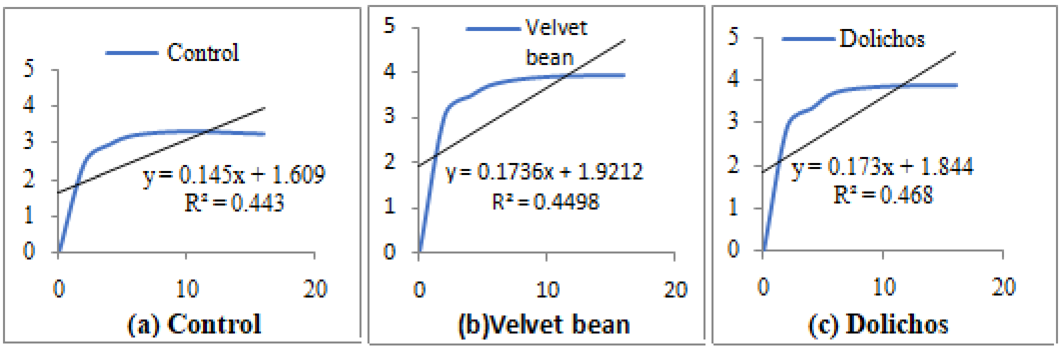


Figure 1: Nitrogen mineralization patterns



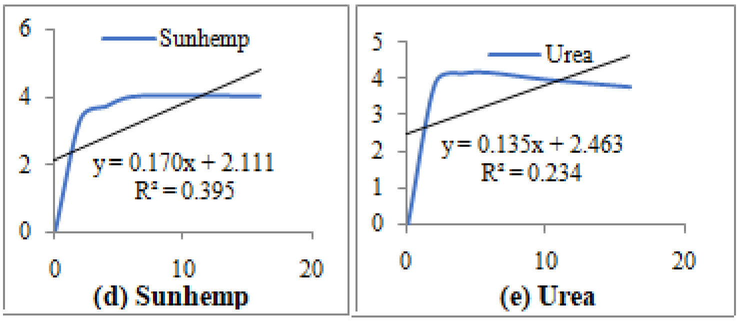


Figure 2: (a-e) Mineralisation constant (*k*) for tested treatments

Effects of legume residues on maize yield components and yield

The effects of treatments applied on maize yield components and grain yield are shown in Table 8. The average cob length from residue-treated and fertilizer (Urea 46%N) plots were greater than those from control plots. The average cob weights were highest and had significant difference ($P \leq 0.05$) in plot applied with residues and fertilizer treated plots than in the control. The average seed weight (g 100 seeds^{-1}) and seed weight (g plant^{-1}) of maize crop were highest (i.e. 44.33 and 98.89 g, respectively) in plots treated with inorganic fertilizers and lowest (i.e. 36.23 and 25.56 g, respectively) in the control treatment. The average maize seed weight did not differ significantly ($P \leq 0.05$) among the legume residue treatments as it ranged from 40.63 to 43.07g. The effects of applied treatments on maize shelling percentage differed significantly ($P \leq 0.05$). Plots treated with Urea resulted into the highest shelling percentage (27.09%) while the lowest value (8.95%) was observed on control plots. Plots treated with legume residues resulted into shelling percentage of 24.28, 24.14 and 23.35% for velvet bean, sunhemp and dolichos respectively. There was a significant difference ($P \leq 0.05$) on maize yield when maize crop treated with these treatments. The average maize yield that resulted from applied treatments was 3.78 t ha^{-1}. The plots treated with Urea fertilizer resulted into the highest maize yield of 3.96 t ha^{-1}) while the lowest yield (1.02 t ha^{-1}) was as expected observed in the control plots. Plots treated with legume residues resulted into 3.69, 3.60, and 3.49 t ha^{-1} when sunhemp, velvet bean and dolichos residues were applied, respectively. The good maize performance and yields in the Urea treatment is due to a continuity of availability of N from the fertilizer. The relatively better performance of the residue treated plots to control plots could have been due to N released as a result of continuous decomposition of legume residues. Moreover, presence of legume residues enhanced the improvement of physical soil characteristics, like water availability, which enhanced good maize performance and yields. Improvement of maize yields due to the use of legume residues has been documented elsewhere. In Tanzania, research results by [28]in Iringa region showed that maize yield improved to 3.6 and 3.4 t ha^{-1} when velvet bean and sunhemp biomass were applied. Yield of 4.56 t ha^{-1} was also recorded in Tanga -Tanzania by[29] from maize plots previously treated by sunhemp. In Kenya, sunhempand velvet beangreen manure improved maize grain yields by 1.5 t ha^{-1}compared to no incorporation [30], while in southern Cameroon, the average maize yields greater than 4 t ha^{-1} were realized after a short-term fallow with velvet bean[26]. Thus, the importance of legume residues in improving yields is evident.

Table 8: Effect of applied legume residues on maize yield components and grain yield

Treatment	Cob length (cm)	Cob weight (g)/plant	Seed weight (g/100seed)	Grain yield (t/ha)	Shelling %
Control	18.25 b*	286.99 b	36.23b	1.02 c	8.95c
Velvet bean	22.67a	371.90 a	40.63ab	3.60 b	24.28ab
Dolichos	21.71a	374.39 a	41.33ab	3.49 b	23.35b
Sunhamp	22.46 a	383.71 a	43.07ab	3.69 b	24.14ab
Urea(46%N)	20.25 ab	365.83 a	44.33a	3.96 a	27.09a
Mean	21.07	356.56	3.15	3.15	78.81
Sd	8.34	17.00	11.95	1.20	3.7
CV (%)	5.37	5.31	8.41	3.78	2.82

** Means in the same column followed by the same letter are not significantly different according to DMRT at $P \leq 0.05$*

4. Conclusion

Legume residues tested produce significant amount of mineral nitrogen (N) in 16 weeks of incubation period. Sunhemp (*Crotolariaocholeuca* G) residues were the best residues in N releasing ability and had best mineralization pattern followed by velvet bean (*Mucunapruensis* L) and dolichos (*Lablab purpureus* L). The maximum N demand period in maize plant was at tasseling stage which ranged from 8 to 10 weeks after planting. The amount of N released from tested residues was higher between 8 and 10 weeks of incubation. These study results indicated that the maximum N demand of maize crop conceded with the maximum N released from legume residues applied. This greatly benefit maize crop in terms of its growth, development and yield. Among tested legume residues, velvet bean appears to be of highest efficiency in biomass production followed by dolichos and sunhemp. However, in term of N content, sunhemp residues had highest N content (2.77%) followed by velvet bean (2.49%) and lastly dolichos (4.42%). The use of any of three legume residues indicated high potential on maize crop performance. The highest maize yield was observed from inorganic fertilizer treated plots (3.96 t ha^{-1}) followed by sunhemp (3.69 t ha^{-1}) >velvet bean (3.60 t ha^{-1})>dolichos (3.49 t ha^{-1}) finally the control (1.02 t ha^{-1}).

5. Recommendations

This study indicated that sunhemp; velvet bean and dolichos residues applied had similar effects of improving maize yield. In case of inadequate amount or lack of inorganic fertilizer such as Urea, the use of the legumes tested can be applied as substitute. This is especially so for poor resource farmers located in the mineral low N soils. Incorporation of sunhemp, velvet bean and dolichos residues should be encouraged in mineral low N soils so as to improve the fertility status of soil especially for poor resource farmers. It is recommended that legumes should be planted during short rains and incorporated at the beginning of long rains in bimodal rainfall pattern areas. This will enhance farmers with low purchasing ability of inorganic nitrogenous fertilizers to improve maize productivity.

References

[1] Suleiman R.A (2015) Current Maize Production, Postharvest Losses and the Risk of Mycotoxins Contamination in Tanzania. Agricultural and Biosystems Engineering at Iowa State University Digital Repository. https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1450&context=abe_eng_conf]14/2/2018
[2] Ministry of Agriculture Food Security and Cooperatives Tanzania (2012). Preliminary food crop forecast. (http://www.agriculture.go.tz/publications/english%20docs/AGSTATS-Prel2012-Executive%20Summary-DNFS-Header Subm%20%282%29.pdf). Site visited on 14/03/2013.
[3] Massawe, B.H.J and Amuri, N.A. (2012). Agronomic Practices Review and Soil Test for Improved Maize Production in Kiteto and Kongwa Districts Tanzania. BACAS, Sokoine University of Agriculture, Morogoro, Tanzania. 120pp
[4] Mkoma, A. (2015) Response of maize to phosphorus in sole maize and maize-pigeon pea cropping system in semi-arid areas of Tanzania. A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in soil science and land management of Sokoine University of Agriculture. Morogoro, Tanzania.[http://www.suaire.sua.ac.tz:8080/xmlui/handle/123456789/707]
[5] Food and Agriculture Organization (2011). FAOSTAT online database, available at link [http://faostat.fao.org] site visited on 12/9/2012
[6] Mtaki, B. (2017) Tanzania corn, wheat and rice report. USDA foreign agricultural services.https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Dar%20es%20Salaam_Tanzania_3-29-2017.pdf] 14/2/2018
[7] Bhattacharyya T., Pal, D.K., Dipak, S. and Wani, S.P. (2013). Climate Change and Agriculture. Stadium Press Ltd., New Delh. 84pp.
[8] Tabi, F. O., Mvondo Ze A. D., Boukong, A., Mvondo, R. J. And Nkoum G. (2013). Changes in soil properties following slash and burn agriculture in the humid forest zone of Cameroon *African Journal of Agricultural Research; 8(18pp)* [http://www.academicjournals.org/article/article1380893580_Tabi%20et%20al.pdf] 16/2/2018
[9] FAO, (2005). Increasing fertilizer use and farmer access in sub-Saharan Africa. A literature reviews. Draft. Agricultural Management, Marketing and Finance Service (AGSF), Agricultural Support Systems Division, Rome
[10] Drechsel, P., Gyiele, L., Kunze, D. and Cofie, O. (2001). Population density, soil nutrient depletion, and economic growth in sub-Saharan Africa. *Journal of Ecological Economics* 38(2):251-258.
[11] Kraaijvanger, R., Veldkamp, T. and Nyssen, J. (2014). Productivity, fertilizer responses and nutrient balances of farming systems in central Tigray, Ethiopia: a multi-perspective view in relation to degradation. *Geophysical Research Abstracts*.783pp.
[12] Tschakert, P., Khouma, M., Sene, M. (2004). Biophysical potential for soil carbon sequestration in agricultural systems of the Old Peanut Basin of Senegal. *Journal of Arid Enviroments* 59: 511-533.
[13] Charles P. W., Amanda J. A., Fred, L. A., Pat, D. K., Stuart, A. W., Donald, D. T., Adam M. T, Kara, L. W, and Kenneth, P. B (2015) Biologically Fixed Nitrogen in Legume Intercropped Systems: Comparison of Nitrogen-Difference and Nitrogen-15 Enrichment Techniques. Agron. J. 107:2419–2430 (2015) doi:10.2134/agronj14.0639[https://dl.sciencesocieties.org/publications/aj/abstracts/107/6/2419]
[14] Kanyeka, E. Kamala, R. and Kasuga, R. (2007) *Improved agricultural technologies recommended in Tanzania*. 1st edition. Published by the Department of Research and Training, Ministry of Agriculture Food Security and Cooperatives, Dar es salaam, Tanzania.
[15] Kuo, S and Sainju, U.M. (1998) Nitrogen mineralization and availability of mixed leguminous and non-leguminous cover crop residues in soil. *Biology and Fertility of Soils* 26: 346-353.
[16] Landon, JR (1991) Booker *tropical soil manual. A handbook of soil survey and agricultural land evaluation in the tropical and subtropical.* Longman. 474 pp.
[17] Shieh, G. (2004). The effectiveness of randomized complete block design. *Statistical Neerlandica*58: 111–124.
[18] Angela, R and Nina, L. B. (2007) Using Organic Amendments to Decrease Bulk Density and Increase Macroporosity in Compacted Soils.[http://www.hort.cornell.edu/uhi/research/articles/auf33 (2).pdf]. Site visited on 19/03/2013.
[19] Belfield, S. and Brown, C. (2008). Field Crop Manual: Maize. A Guide to Upland Production in Cambodia. [http://aciar.gov.au/files/node/8919/maize%20manual%2072dpi.pdf]. Site visited on 30/08/2012.
[20] Ambrosano1*, E., José, C., Heitor Gláucia M.B.A., Ferreira, D., Fábio, L.R., Fabrício T, P., Cesar. O.T.M. (2013) The role of green manure nitrogen uses by corn and sugarcane crops in Brazil. Agricultural Sciences Vol.4, No.12A, 89-108 (2013) http://dx.doi.org/10.4236/as.2013.412A008
[21] Wortmann, C.S., Mclntyre, B.D and Kaizzi, C.K. (2000). Annual soil improving legume: Agronomic effectiveness, nutrients uptake, nitrogen fixation and water use. *Field Crop Research* 68: 75-83.
[22] Avav, T., Shave, P.A., Magani, E.I and Ahom, R.I. (2009). Effects of *Mucuna*Biomass and N-fertilizer on *Striga hermonthica* Del. Benth. Infestation in maize (*Zea mays* L.). *Journal of Animal and Plant Sciences* 42: 320 – 328.
[23] Martınez, E., Fuentes, J.P., Silva, P., Valle, S., Acevedo, E (2008). Soil physical properties and wheat root growth as affected by no-tillage and conventional tillage systems in a Mediterranean environment of Chile. Soil & Tillage Research 99 (2008) 232–244

[24] Rezig, A.M.R., Elhadi, E.A and Mubarak, A.R. (2012) Effect of incorporation of some wastes on a wheat-guar rotation system on soil physical and chemical properties. *International Journal of Recycling of Organic Waste in Agriculture* 1:1-15.
[25] Ghimire, R., Lamichhane, S., Sharma, A., Bharat, B., Prakriti S U. (2017) Tillage, crop residue, and nutrient management effects on soilorganic carbon in rice-based cropping systems: A review *Journal of Integrative Agriculture 2017, 16(1): 1–15*
[26] Odhiambo, J.O. (2011) Potential use of green manure legume cover crops in smallholder maize production systems in Limpopo province, South Africa. *African Journal of Agricultural Research* 6: 107-112.
[27] Odhiambo, J.O. (2010) Decomposition and nitrogen release by green manure legume residues in different soil types. University of Venda, Department of Soil Science, *African Journal of Agricultural Research* 5: 090
[28] Sibuga, K.P., Msaky, J.J., Malima, G., Aloyce, M., Nyallu, L., Mabula, D and Hepelwa, R. (2012) Legume biomass transfer for enhancing productivity of maize in *Striga* infested farmlands: The case of Iringa district, Tanzania. [www.ruforum.org/system/files/file/Biennual%202012/Sibuga.pdf] Site visited on 22/04/2013
[29] Bogale, T., Assenga, R.H., Mmbaga, T.E., Frisen, D.K., Kikafuda, J. and Ramson, J. (2001). Legume fallows for maize based systems in eastern Africa; Contribution of legumes to enhanced maize productivity and reduce nitrogen requirement. [http://books.google.co.tz/books?id=dRoOfAh6VjAC&pg=PA320&lpg=PA320&dq=germination+and+emergence]. Site visited on 23/03/2013]
[30] Ojiem, J.O., Mureithi, J.G., Okwuosa, E.A. (2000). Integrated management of legume green manure, farmyard manure and inorganic nitrogen for soil fertility improvement in western Kenya. In: Mureithi *et al*. (eds) *Participatory Technology Development for Soil Management by Smallholders in Kenya*. Proceedings of the 2nd Scientific Conference of the Soil Management and Legume Research network projects. June 2000, Mombasa, Kenya, pp. 97-102.

Author Profile

Emmanuel Amos Chilagane (Msc Crop Science) is Agricultural Research officer, Ministry of Agriculture, Livestock and Fisheries Agricultural Research Institute Uyole, Box 400, Mbeya- Tanzania.

Professor. Cornel **L Rweyemamu (PhD),** from Sokoine University of Agriculture, Collage of Agriculture, Department of Crop Science and Production Box 3005, Morogoro -Tanzania.

Paul Sabas Saidia is Agricultural Research officer, Ministry of Agriculture, Livestock and Fisheries, Agricultural Research Institute Ukiriguru, Lake Zone Crop Research, P.O Box 1433, Mwanza, Tanzania