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SOIL FERTILITY STATUS AND CROP YIELDS FOLLOWING THE INTRODUCTION OF AN INTENSIVE MULTIPLE CROPPING SYSTEM IN FIVE VILLAGES IN THE UPPER EAST REGION OF GHANA

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ABSTRACT: -

Integrating food and feed crops in the same piece of land could eradicate food and feed shortage, prevent reduce inadequacy of family income and enhance rural livelihoods. A Multiple Cropping Technology (MCT) of mixture of maize + groundnut + Cajanus Cajan in the same piece of field was introduced to farmers in Balungu, Gbane, Gbeogo, Sheaga and Yameriga villages in Upper East Region of Ghana. The Traditional Usual Technology involving sole maize or sole legume was the control. A total of 10 farmers per village formed the group of 50. Ridges were constructed using bullock/ camel attached to locally fabricated plough /ridger. Ridges were approximately 50 cm apart. Two seeds of maize were sown per hole at 50 cm apart, giving a total of 80,000 maize plants/ha. One groundnut seed was planted per hole at 50 cm apart with a total of 40 plants /ha. Cajanus cajan seeds were drilled lightly along at a rate of 25 kg ha-1. Maize was planted in the first ridge, groundnut in the second and Cajanus Cajan in the third ridge. The crops were repeated in the same order to cover the field. Soil samples were collected from farmers' field to a depth of 0 – 40 cm for routine soil laboratory analysis. The soils in the villages are mostly loamy sand, strongly acid to acid in reaction, characterized by moderate organic carbon content with low nitrogen. Available phosphorus moderate with very low to low exchangeable bases, unlike yielded under TUP, yield under MCP increased in the second year. When the second year production in MCT was compared with TUP groundnut was 188 %, 180 %, 142 %, 148 % and 127 %, significantly higher in Gbane, Yameriga, Dbeogo, Balungu and Sheaga respectively. The corresponding values for maize was 402 %, 297 %, 310 %, and 148 5. Cajanus cajan is an additional crop introduced for both livestock and human with the stem used as domestic fuel wood.

KEYWORDS: *Sustainable intensification, multiple cropping technology, resilience, food security.*

INTRODUCTION

The demand and the supply of food for human and feed for animals are a twins' wicked problem facing Africa. FAO (2012a) report puts 23 % or over 200 million people in Africa under hungry class. In another report, FAO (2012b) puts the rise in hunger levels in the continent at 2 % per year. The situation is worrisome as Global Harvest Initiative (2012) estimates that the continent of Africa will only meet 13 % of its food needs by 2050. Toennussen and DeVries (2008) reported that 75 % Sub Saharan Africa (SSA) total land area is highly degraded with farmers losing annually about eight million tons of soil nutrients. Thus the researchers estimated the annual nutrient loss to be worth $4 billion USD. With increasing population in Africa, the demand for human food and animal feed will continue to be a challenge even in the foreseeable future. Massive adoption of mixed or multiple cropping where multiple crops are inter-spaced on the same piece of land in alternate rows will help close yield gaps and increase family income and nutrition security and livelihoods. Care is also taken to arrange crops in the field to mninmize competition for sunlight, water and nutrient. This cropping system will maximize potentials for all crops in mixture to make use of available native and applied nutrient and naturally fixed nitrogen by legumes (Montpellier Panel Report, 2013)

In the Upper East Region of Ghana, Quaye (2008) reported up to 6 – 7 months of food shortage or inadequacy and up to 5 months in Upper West and Northern Regions. Earlier, Bilinsky and Swindale (2007) defined food shortage as the time between food stock depletion and the next new harvest. The food situation in this region is not unconnected with the low rainfall as well as the soils of which according to Gyasi (2002) do not appear particularly productive. Generally, the status of soils in most tropical countries in Africa is particularly bad (Babalola, 2000). The soil of the tropical zone in Africa is inherently fragile and low in native fertility and naturally unable to sustain good and economic yield (Essoka et al., 2008). In addition to soil constraints in the Upper East of Ghana, Gyasi (2002) reports that the dry moisture deficient climate is also a serious additional constraint to cropping and other agricultural activities. The region; from Gyasi's report, receives an erratic rainfall of less than 1000 mm to 1250 mm annually with a prolonged November – April dry season, the desert taking over the once productive farmers' fields in Upper East Ghana.

A general overview of severity of essential plant nutrient for most tropical soils of West Africa is the order "N > P > K". Most essential soil nutrients (NPK) rating for tropical soils reported by Enwezor (1989), Holland et al., (1989) and Udo et al., (2009) places nitrogen in low class when its values are < 1g kg-1, medium between 1 g kg-11.5 g kg-1 and high >1.5 gkg-1. Available phosphorus (AP) is low when laboratory values using the Bray – 1 is < 5 – 10 mg kg-1, rated medium between 10 mg kg-1 – 20 mg kg-1 of soil and high > 20 mg kg-1 of soil. hen Bray – 2 method is used, AP is low when value is < 15 mg-1 of soil medium between 15 – 25 mg kg-1 of soil and high when > 25 mg kg-1 of soil. The nutrient rating for exchangeable potassium is low when K < 0.15 c mol kg-1 of soil medium between 0.15 and 0.25 c mol kg-1 of soil and high > 0.25 c mol kg-1 of soil Quaye (2008) advised that food security programme in the north of Ghana should integrate climate change resilient technologies to enable farmers cope with increasing intensity of droughts. The objective of the study was (1) to introduce to farmers a promising climate resilient cropping technology that meets human food and animal feed security needs using the same land area. (2) Assess crop yields under farmers conventional practice and introduced intensive cropping system.

MATERIALS AND METHODS

The study was carried in Balungu, Gbane, Gbeogo, Sheaga and Yameriga villages in Upper East Region of Ghana. The textures of the soils of this region are predominantly loamy sand and sandy loam on the surface. The soil belongs to varied classes as Entric Plintosol, Endocentric - Stagnic plintosol, Gleyic Arenosol and Eutric Gleysol (Senayah et al., 2006). Rain in the region is erratic with unimodal coming from May /June to September / October with annual average of 800 mm to 1100 mm (MOFA, 2012). The dry season starts in October / November and ends in April or May. November to February is characterized by cool, dry and dusty harmmattan winds with midnight temperature reaching 14o C and midday temperature reaching 40o C. (MOFA 2012). Grasses dry up during the long dry season and become standing hay for roaming livestock. The ecology is semi-arid as a consequence of human activities.

Soil samples were collected randomly to a depth of 0 – 40 cm in all farmers field for routine soil and chemical analysis using standard methods. Particle size distribution was determined by the hydrometer method (Gee and Bauder, 1986), bulk density as described by Blake and Hartge (1986), while porosity was calculated as a function of the total volume not occupied by soil solids, assuming a particle density of 2.65 Mg m3 (Danielson and Sutherland, 1986). Soil pH was determined using 1:2.5 soil water suspension (adequate to wet the electrode) using a pH meter (IITA, 1982). Organic carbon was determined by the wet oxidation method (Nelson and Sommers, 1982). Total nitrogen was determined using the Micro-Kjeldal method (Bremner and Mulvaney, 1982), while available phosphorous was assayed by the Bray P-I method (Olsen and Sommers, 1982) since the soils were not calcareous. Exchangeable bases (Ca, Mg, Na, and K) were extracted with 1 N NH_4OAc buffered at pH 7.0 (Thomas, 1982). Exchangeable acidity (EA) was determined by titration with 0.05 N NaOH, while effective ECEC was taken as the summation of exchangeable bases and total exchangeable acidity (IITA, 1982). Soil variability was estimated using discrete sampling. Variability measures of spread about the mean used the range and coefficient of variation. The range is the difference between the maximum and minimum values. The coefficient of variation (CV) gives a normalized measure of spread about the mean and was estimated using the Equation below

$$CV = 100\ \%\ X\ \frac{S}{Z}$$

where;

S = standard deviation, which is the square root of the sample variance.

Z = is the mean of measured values.

Properties with larger CV values are more variable than those with smaller CV values. Wilding (1985) described a classification scheme for identifying the extent of variability in soil properties based on their CV values, in which CV values of 0 – 15 %, 16 – 35 % and > 36 % indicate low (least), moderate and high variability, respectively

FIELD CULTIVATION

A stakeholder's forum held in the community to introduce the project to the community. Farmers were selected based on gender for equity, willingness to participate and willingness to promote the technological outcome and experience. A total of 10 farmers from each village formed the group in each of the 5 villages. The Farmers Field School held in the farmers' fields within the community, taught and demonstrated the new Multiple Cropping Technique (MCT) and arrangement of crop to the farmers. A total of 10 farmers per village made up the total number of 50 farmers from the 5 villages covered in the project. The Traditional Usual Practice (TUP) in the village is a mono - crop of maize, groundnut, Guinea corn or millet. The MCT introduced is an intensive multiple cropping (maize + groundnut + Cajanua cajan) on the same piece of land. Ridges were constructed as traditionally practiced in the villages. Bullock attached to locally constructed plough /ridger was used as shown in Plate 1A and B Ridges were approximately 50 cm apart. Two seeds of maize were sown per hole at 50 cm apart, giving a total of 80,000 maize plants/ha. One groundnut seed was planted per hole at 50 cm apart with a total of 40,000 plants /ha. Cajanus cajan seeds were drilled lightly along at a rate of 25 kg per ha. Maize was planted to the first ridge, groundnut to the second and Cajanus cajan to the third ridge. The crops were repeated in the same order to cover the field with the crops repeated in the same order to cover the field as laid in the field in Plate 2A and B.

FIELD DATA COLLECTION

Yield data were collected from the farmer's TUP fields and under MCT fields. The five villages represented locations. Ten farmers participated in each of the villages. The ten fields in each village constituted the replicates. Yield data for maize, groundnut, Cajanus cajan and their biomass were analysed as stipulated by Randomized Complete Block Design (RCBD) and means were separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Data on the soil: physical and chemical properties of soil from five villages in Upper East Region of Ghana are shown in Table 1. The soil texture was mostly sandy loam in all the five villages. Sand fraction ranged from 603 g kg-1 in Balungu to 784 g kg-1 in Gbeogo with a mean value of 714 g kg-1. Silt fraction had a mean value of 169 g kg-1 and standard deviation of 33.57. Clay fraction was least with a mean value of 116 g kg-1. The bulk density of the soil ranged from 1.45 to 1.52 g cm-3 with mean values of 1.46 g cm-3. This value is considered adequate as it allows plant roots penetrate the soil for proper growth and performance. The values above the critical level of 1.8 g cm-3 for sandy loam soil (Jones, 1983) limits root penetration severely. Total porosity inferred from bulk density ranged from 43 % to 45 % with a mean of 44 % for tropical soil. According to Kaschinkii (1970), the values put the soils under the five villages into a"satisfactory agricultural soi class (40 % - 45 %). Saturated hydraulic conductivity (SHC) shows the ability of soil to transmit water. It ranged from 28.23 mm hr-1 to 76. 74 mm hr-1. Using Geeve et al., (1995) general guide for rating SHC, soil in Gbane, Gbeogo and Balungu fall under "moderate conductivity class" (20 – 60 mm hr-1). This is indicative that runoff will occur occasionally and also the soil is good for irrigation. With climate change hitting the Upper East Region hardest, irrigation will be the norm for sustainable crop production and climate change adaptation. The soils of Yameriga and Sheaga village fall under "high conductivity class" (60 – 120 mmhr-1). Soils under this class rarely suffer from runoff as the soil transmits down the profile high amount of water per unit time. Such soils are too permeable for irrigation and application of fertilizer should be splited to enable the plant maximized the applied nutrient.

Soil reaction (pH) determined both in water and Kcl is presented in Table 1.The pH in Kcl shows that soil are either strongly acidic (4.1 – 5.2) or acid (5.3 – 6.5) Holland et al., 1989). The pH in Kcl in all the villages studied were lower than the corresponding pH values in water giving a negative delta value i.e. {pH(Kcl) – pH(water)}. The negative delta value means the soil of Balungu, Gbane, Gbeogo, Sheaga and Yemariga have net negative changes. (Kparmwang, 2008). This shows the capacities of the soils for cation retention and exchange. Again With low pH values P will be less available to the plant as P binds together with aluminum and iron compounds under soil acidic condition to become unavailable. With continuous decrease in the values of pH, the concentration of aluminum (Al) and Manganese (Mn) may increase in the soil to the point of toxicity. Excess of Al^{3+} in the soil solution is said to hinder root growth and interrupt functions, in the plant restricting uptake of Ca^{2+} and Mg^{2+} (Kamprath, 1970). For instance activities of Rhizobia species are slowed as well as the breakdown of plant residues and soil organic matters are retarded (Protocol Soil Acidity, 2008).

Soil organic carbon (SOC) could be rated as moderate (15 – 45 g kg-1) in all the villages. Soil organic matter (SOM) content was high (> 30 g kg-1)in Gbane, Balungu and Sheaga villages, whereas it was moderate (20 30 g kg-1) in Gbeogo and Yameriga villages (Holland et al., 1989. The high SOM recorded here could be attributed to effects of organic manure applied by the farmers under the project.. Additionally, high temperature and rainfall regime facilitates rapid decomposition of organic matter in the soil hence resulting in high SOM. However, it is expected that the effect of organic input will reduce with time, therefore requires a continuous supply of organic input to sequester and build back soil resilience. From the report above, microbial activities are also interrupted and slowed.

Total nitrogen (TN) in the soils across the villages was low with values ranging from 0.70 g kg-1 to 0.90 g kg-1 with a mean value of 0.78 g kg-1. The TN values of soil less than 1 g kg-1 is considered as low (Holland et al., 1989). The low TN, but high SOM in the same soil is an indication the applied organic manure is low in nitrogen. This is one case against organic manure; hence the need to be supplemented with inorganic nitrogen. Except in Gbeogo, available phosphorus (AP) was moderate (16 – 30 mg kg-1). The element was low (5 – 15 mg kg-1) in Gbane, Balungu, Sheaga and Yameriga villages. The low and moderate rating for AP in the soils could be attributed to the acidic nature of the soil and reports elsewhere that phosphorus is variably distributed in soils.

Exchangeable basic cations (Ca, Mg, Na and K) Ca and Mg are often the most abundant basic cations in most tropical soils whose preponderance in the soil are very useful in predicting the other chemical fertility parameters in the soil. Ca in the soils ranged from 4.6 c mol kg-1 to 6.20 c mol kg-1 with a mean value of 5.20 c mol kg-1. However Ca was rated as low (5 – 15 c mol kg-1) in the the villages studied and Mg was rated as moderate (1 - 3 c mol kg-1) in all the villages. Sodium (Na) ranged from 0.06 C mol kg-1 to 0.65 c mol kg-1 with a mean of 0.18 c mol kg-1. Sodium (Na) element here was rated very low (< 0.1 c mol kg-1) in Gbane, Gbeogo, Balungu and Yameriga, but Na was classified as low (0.1 -.0.3 c mol kg-1) in Sheaga. Pottassium (K) in the soil was rated as low (0.20 – 0.30 c mol kg-1) in Gbane, Gbeogo, Balungu, Yameriga villages, high (0.60 – 1.2 c mol kg-1) in Sheaga where the highest value for K was recorded. The high value of K in Sheaga, could be attributed to annual burning of bush by small scale miners in search of mineral resources in the village. Although, the disadvantages of bushing outweigh its advantages, the result (ash) of the practice returns K to the soil. The effective cation exchange capacity (ECEC) values put the soils in the five villages in the moderate fertility class (8 – 15 c mol kg-1). (Udo et al., 2009). This indicates that the soil still requires both inorganic and organic inputs to build the fertility to the "high fertility class" to be able to sustain crop production and livelihood.

VARIATION AMONG SOIL PROPERTIES AND SOIL MANAGEMENT

Table 2 groups all measured soil properties in varying classes, namely: High (CV % > 35), Moderate (CV % 16 – 35) and Low (CV % 0 – 15) (Wilding, 1985). Table 2 indicates that soil properties vary in their degree of variability. Most soil properties (chemical and physical) fell within the low and moderate variability class. Similar results had been reported by Oku et al., 2010a, Oku, et al., 2010b about soils in Nigeria. However properties reported or grouped as low in variability in this study were reported to be moderate for temperate soil (Jury 1986; Jury et al., 1987; Baven et al., 1993 and Wollenhaupt et al., 1997). The implication is that uniform soil management practice in analysis for AP, K and Na for the soil could be employed across the five villages namely: Balungu, Gbeogo, Gbane, Sheaga and Yameriga. The use of composite samples could save or reduce cost of analysis. However, composite samples for laboratory analysis should be avoided. Uniform management practice should be discouraged.

CROP YIELD UNDER PROJECT CROPPING TECHNOLOGY (MCT) AND TRADITIONAL USUAL PRACTICE (TUP)

Tables 3, 4 and 5 present crop production under MCT(an intensive mixture of maize, groundnut and cajus cajan on the same piece of land and space) and TUPe (mono or sole cropping on the same piece of land.). The MCT was introduced "late" in the season according to the farmers. Yields of groundnut, maize and cajanus cajan yield in the mixture were significantly different (P = 0.05) in the five villages both in the first and second year. Variability among crop yield in all the villages was moderate (CV 15 % - 35 %). Again, yield in all crops in the mixture under MCT and TUP differed and was significantly higher under MCT when compared with crop yield under TUP. The farmers in Gbeogo, Balungu and Sheaga villages were fast in keying into the MCT and gave it a trial in the first year, despite the "lateness". At the close of the first and the second year of planting, comparative study of yield of groundnut in the second year was 133 %, 68 % and 55% higher in the second than the first year's harvest in Gbeogo, Balungu and Sheaga respectively. The corresponding value for maize is 171 %, 82 % and 91 %. When groundnut yield in the second year under MCT was compared with TUP, it was 188 %, 180 %, 142 %, 148 % and 127 % significantly higher in Gbane, Yameriga, Dbeogo, Balungu and Sheaga respectively. The corresponding values for maize was 402 %, 297 %, 310 %, and 148 %. The MCT creates a multi-story cropping system in the field. When groundnut is properly arranged in the field as under MCT, it plays the role of conservation of soil and water (climate adaptation) in addition to its natural nitrogen fixing function in the farm. Aside native nutrient deficiency of the soil, water is a major limiting factor in crop production in the Upper East Region of Ghana. MCT gave adequate ground cover to enhance water use efficiency (WUE), a critical factor in crop production. Increase crop yield under MCT as presented in Tables 3, 4 and 5 could be attributed to increased water use efficiency in MCT fields. Groundnut and Cajanus cajan are legumes nutrient (nitrogen fixing) enhancement crops, together with fallen leaves from the legumes contributes to increase in crop production under TCP. The traditional usual practice (TUP) leaves unutilized spaces between planted crops, the spaces allow more sunlight to reach the soil surface to increase soil temperature, fasten mineralization, rapid decomposition and lossof organic matter and loss of water through soil evaporation.

Maize, groundnut and cajanus cajan (pigeon pea) biomass showed significant difference among the villages. Whereas Balungu had the highest maize biomass, Yameriga village recorded the highest groundnut vines and pigeon pea biomass (Table 5). Cajanus cajan was introduced to the villages and farmers for the first time. The seeds of pigeon pea were harvested from time to time in the field by the farmers for family consumption; hence the seed yield could be accounted for scientifically. The seeds served both the animals and the family members. The women farmers in the project combined the protein rich pigeon pea with maize to prepare a local delicacy for the family. The leaves and part of the seeds served as feed to animals. Cook (2005) reported other benefits of cajaus cajan to include its use as a shade plant, windbreaker, fuel wood and green manure. Aside using as feed for livestock, the sticks served as fuel wood thereby alleviating the women and girls stress of daily search for fuel wood for domestic cooking.

CONCLUSION

Crop yield under the newly introduced Multiple Cropping Technology (MCT) sustainably increased in the second year unlike the Traditional Usual Practice where yields declined. When the second year production in MCT was compared with TUP, groundnut was 188 %, 180 %, 142 %, 148 % and 127 %, significantly higher in Gbane, Yameriga, Dbeogo, Balungu and Sheaga respectively. The corresponding values for maize was 402 %, 297 %, 310 %, and 148 5. Cajanus cajan (pigeon pea) introduced for both livestock and human feeding and for soil nutrient and resilient improvement also provided fuel wood to women for domestic cooking. The project and study practically demonstrates the profitability of the sustainable intensification agriculture in Upper East Region of Ghana.

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Plate 1A & B. Camels plough a field and farmers learning by doing in a Farmers Filed School.

Plate 2A & B. Showing the crop arrangement in the Multiple cropping Technology (MCT)

Table 1 Physical and chemical properties of soil of five villages in Upper East Region of Ghana

Group	Parameter	units	Villages					Mean	SD	CV %
			Gbane	Gbeogo	Balungu	Yameriga	Sheaga			
Physical	sand	g kg^{-1}	674	784	603	747	762	714	293.86	9.33
	silt	g kg^{-1}	192	123	219	147	166	169.40	33.57	19.82
	clay	g kg^{-1}	134	93	178	106	72	116.60	36.69	31.46
	texture		sl	sl	sl	sl	sl			
	Bulk density	g cm^{-3}	1.45	1.52	1.46	1.45	1.45	1.466	0.02	1.86
	Porosity	%	45	43	44	45	45	44.40	0.80	1.80
	SHC	mm hr^{-1}	56.48	28.23	42.85	75.61	76.74	55.982	18.75	33.50
Chemical	pH (H_20)		6.48	6.30	6.10	6.53	6.42	6.366	0.15	2.41
	pH (Kcl)		5.30	4.66	5	5.22	5.33	5.102	0.24	4.88
	OC	g kg-1	22.70	16.20	19	16	18.70	18.52	2.42	13.10
	OM	g kg^{-1}	39.13	27.93	32.76	27.58	32.23	31.926	4.18	13.10
	TN	g kg	0.90	0.70	0.80	0.70	0.80	0.78	0.074	9.59
	AP	Mg kg^{-1}	11.20	27.10	11	18.30	10.80	15.68	6.37	40.64
	Ca	C mol kg-g^{-1}	4.80	6.20	5.300	5.10	4.60	5.20	0.55	10.67
	Mg	C mol kg-g^{-1}	1.59	2.15	1.69	1.64	1.48	1.71	0.23	13.49
	Na	C mol kg-g^{-1}	0.08	0.07	0.06	0.07	0.65	0.186	0.23	124.77
	K	C mol kg-g^{-1}	0.30	0.20	0.2	0.20	0.90	0.36	0.27	75.76
	ECEC	C mol kg-g^{-1}	8.20	9	8.9	8.20	8.20	8.50	0.36	4.33
	Bsat	C mol kg-g^{-1}	769	824	830	849	883	831	37.20	4.47

Table 2. Fitting chemical and physical properties of five villages in Upper East Ghana into variability classes

Variability class	Physical properties	Chemical properties
High (CV % > 35)	none	Available phosphorus, Sodium, Potassium.
Moderate (CV % 15 – 35)	Silt, Clay, .	Exchangeable Aluminum, Exchangeable acidity.
Low (CV % < 15)	Sand Bulk density, Total porosity Total nitrogen.	Soil acidity, Organic matter, Organic carbon, Total nitrogen, Calcium, Magnesium, Effective cation exchange capacity, Base saturation.

Table 3. Groundnut yield under the Multiple Cropping Technology (MCT) and Traditional Usual Practice (TUP) in five project villages (village mean yield) in Upper East Region of Ghana.

Project Village	First year under MCT t ha^{-1}	Second year under MCT t ha^{-1}	Traditional Usual Practice (TUP) t ha^{-1}
Gbane	nd	1.64	0.57
Yameriga	nd	1.51	0.54
Gbeogo	0.57	1.33	0.55
Balungu	0.77	1.29	0.52
Sheaga	0.76	1.18	0.52
SED	0.127	0.137	
LSD (P < 0.05)	0.294	0.290	
		15.42	4.67

Table 4. Maize yield under the Project Cropping Technology (MCT) and Traditional Usual Practice (TUP) in five project villages in Upper East Region of Ghana.

Project Village	First year under MCT t ha^{-1}	Second year under MCT t ha^{-1}	Traditional Usual Practice (TUP) t ha^{-1}
Gbane	nd	2.41	0.48
Yameriga	nd	2.38	0.60
Gbeogo	0.62	1.68	0.41
Balungu	0.85	1.55	0.52
Sheaga	0.57	1.09	0.44
SED	0.053	0.253	
LSD (P < 0.05)	0.124	0.535	
CV %		35.16	17.62

SED = standard error of difference, LSD + least significant difference

Table 5. Biomass production under Multiple Cropping Technology (MCT) in five project villages) in Upper East Region of Ghana.

Project village	Maize biomass t ha^{-1}	Groundnut vines t ha^{-1}	Cajanus Cajan (pigeon pea) biomass t ha^{-1}
Yameriga	1.52	0.96	6.98
Balungu	1.71	0.64	5.14
Gbane	1.69	0.82	4.17
Gbeogo	1.44	0.64	4.52
Sheaga	1.26	0.43	4.18
SED	0.086	0.077	1.57
LSD (P< 0.05)	0.183	0.164	3.328
CV %	14.32	32.71	26.96

SED = standard error of difference, LSD = least significant difference

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