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Effect of Cassia (Cassia Obtusifolia (L)) Green Manure Rate in Replenishing Lost Nutrients and Sorghum (Sorghum Bicolor (L) Moench) Yield and Yield Components in Northern Guinea Savanna, Nigeria

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Abstract: A field experiment was conducted during the wet seasons of 2013 and 2014 at the Institute of Agricultural Research Farm, Samaru (11 11'N7 38 E; 686m above sea level) in the northern guinea savanna of Nigeria to evaluate the effects of green manures for soil management and sorghum yield. The treatments consisted of two varieties of sorghum (SAMSORG-40 AND SAMSORG-41), three levels of organic manure (Cassia obtusifolia green manure at 0, 7.5 and 15t ha^{-1}). The experiment was laid in a split-plot design and replicated three times; with nitrogen assigned to the main plot while factorial combinations of crop variety and organic manure were assigned to the sub-plots. The highest grain yield of Sorghum was by 15t ha^{-1} green manure across the study periods, but at par with the lowest yield recorded from the untreated control. Soil characteristics measured at the beginning of each experiment showed that there were differences in pH in water, organic carbon, total N and available P. in soils used in both years under study. This might be as a result of seasonal effects and inherent fertility status of the soil of the location. Soil differs in terms of nutrients from one place to another even in the same location from time to time. In Samaru, the soil is loamy indicating more organic matter content and hence better fertility status. Incorporation of 15 t ha^{-1} cassia green manure enriched the soil of the location with high percentage of nitrogen than the 0-7.5 t ha^{-1}. The nutrient content of the non amended soil was low compared to the treated field, this might be due to the effect of green manure to the soil. Generally, the highest N P & K contents of the soil recorded in 2014 compared to 2013 might be due to the residual effect of organic manure applied in 2013. Organic manure is a slow released and it takes time to replenish the soil with nutrients.
Keywords: Cassia, sorghum, yield, replenishment, nutrients.

I. INTRODUCTION

The potential benefits of green manures are many. Apart from increasing soil N (Islam *et al.*,2000), the soil organic matter is maintained and renewed, and the physical and chemical characteristics of soil are improved (Bouldin *et al.*, 1988). Mulangoy et al. (1993) observed that the level of organic matter in soil depends largely on the quality of plant material and water returned to soil. Incorporation of crop residues was beneficial to soil in terms of increased soil organic concentration (SOC) that was not only beneficial to soil in relation to agriculture, but also represents a sequestration of carbon from atmospheric carbon dioxide (Ogunwale et al., 2010). Legumes incorporation is known to result in high soil organic carbon and exchangeable cations and the impacts are mostly felt at the top 0-15 cm soil depth (Cassman, 2003). It was found that legume incorporation at Samaru did not affect soil pH, but further observed difference in C : N ratios of legume treatments.

Tanimu (1999) reported that incorporation of legume after one or two years of growth improved soil pH, soil organic matter, exchangeable cations and cation exchange capacity. Legume straw incorporation has been discovered to increase water infiltration rate by 1.4 times and available water by 2 cm in the 180 cm depth of soil profile. (Suryawanshi, 2011). Incorporation of Crotalaria was reported by Azraf-ul-Haq et al. (2007) to sufficiently reduce soil bulk density to 20 cm depth. It was reported that bulk density of 0-10 cm soil depth was less than that of 10 – 20 cm depth. Lower bulk density implied greater pore spaces and improved aeration, developing a suitable environment for biological activity (Islam and Wall, 2008; Min et al., 2003). In an experiment conducted in Pakistan to assess physical properties of soil as influenced by various green manure legumes, it was observed that leguminous green manure crops on average reduced bulk density by 5%, enhanced total porosity by 8% and macrospores and large mesopores 28% (Sultani et al., 2007). This study further revealed a maximum reduction of 7% in the soil bulk density an increase of 11% in total soil porosity and 17% available water where Sesbania sp. was incorporated.

Incorporation of Lablab, Crotalaria sp and garden pea residues resulted in higher concentration of N and P in the soil through natural fallow control (Lelei et al., 2009). Similarly, Ogunwale et al. (2010) reported that incorporation of residues of Centrosema pascuorum and Parkia biglobosa into the soil increased total soil nitrogen, which they attributed to the quality (i.e nutrient composition) of the incorporated residues. It was further asserted that higher total soil N in most cases means a small C : N ratio which is an indication of the rate of decomposition in the soil. N- studies have shown that a succeeding crop can recover 2-26% of the N-applied through grain legumes residues (Fillery, 2001). However, Rochester et al. (2001) reported that when leguminous crops are grown and used for green manure they provide up to 40% of N available in soils by decomposition of nodules and other biomass of the leguminous green manure crops. Leguminous plants are superior to non-legume green manure because they have an exceptional ability to utilize inaccessible soil phosphorus and potassium thus improving availability of P and K to subsequent crops (Azra-ful-Haq, 2007). Makinde et al. (2001) indicated that manure provides an excellent source of organic matter when added to the soil, and restore some of the depleted nutrients as well as increase in the soil pH, and soil macro and micro nutrients. Ayoola et al. (2006) reported that when green manure crops are ploughed into the soil, their residue help to increase availability of phosphate and trace elements to the succeeding crops due to the lowering of the soil pH, brought about by the carbon dioxide produced during the process of decomposition.

Suryawansh (2011) reported that when C. obtusifolia was used as green manure, a total of 30.7 kg N ha^{-1}, 0.97kg P ha^{-1} and 32.8 kg K ha^{-1} was supplied to the soil. The nitrogen supplied by C. obtusifolia was more than by Parthenium hysterophorus and Achyranthus aspera (Suryawansh, 2011), as in 427 kg N ha^{-1} of C. obtusifolia, 352 kg N ha^{-1} in Parthenium sp and 53 kg N ha^{-1}in Achyranthus aspera. When maize was cultivated with different weed green manure, it showed modification on growth, depending on the age (Suryawansh, 2011). He further reported that percentages of nitrogen, phosphorus and potassium were higher in Cassia obtusifolia than in the other weeds. Yield of fresh vegetable maize on weed green manure was highest 12702 kg ha^{-1}. by C. obtusifolia.

A. Justification of The Study

Continuous cultivation of arable land without nutrients input results in degraded soils, accelerated soil erosion, depletion of soil nutrient reserves, reduced soil organic matter content, loss of soil physical structure and reduced crop productivity (Lee *et al.*, 2007). Continuous removal of biomass from crop land without adequate nutrient replenishment can rapidly jeopardize the sustainability of agricultural production (Stoorvorgel and Smaling, 1990). Parasitic weed species of the genus *Striga* establish preferentially on poor soils and fields which have been exhausted by continuous cropping (Vogt *et al.*,1991). Most *Striga* infested areas are characterized by agricultural production systems that witness low crop productivity.

The use of mineral fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield due to soil acidity and nutrients imbalance (Onjeniyi, 2000 and Adeniyi, 2005). To enhance the quality, and hence the effectiveness of traditional soil fertility maintenance strategy manure application has been suggested (McCown *et al.*, 1992; Probert *et al.*, 1992).

Green manuring is the incorporation of, mostly fresh plants into the soil. The species most commonly used as green manure crops are members of the crop family leguminoseae. The legumes for green manure can be edible, herbaceous or forage legumes. Where the leguminous crops are planted in fallow and are properly managed and incorporated into the soil, substantial amounts of N and other nutrients and organic matter are added to the soil and this also improves soil physical condition (Francis *et al.*, 1986; Hullungale, 1988). If the crop is a legume, considerable N may be added to the soil as a result of its N-fixing ability (Leonard, 1986). Application of organic manure improves soil chemical, physical and biological properties in favour of crop plants. (Makinde *et al.*, 2001). Makinde *et al.* (2001) indicated that manure provides an excellent source of organic matter when added to the soil, and restore some of the depleted nutrients as well as increase in the soil pH, and soil macro and micro nutrients.

Suryawansh (2011) reported that when C. *obtusifolia* was used as green manure, a total of 30.7 kg N ha^{-1}, 0.97 kg P ha^{-1} and 32.8 kg K ha^{-1} was supplied to the soil. The nitrogen supplied by C. *obtusifolia* was more than by *Parthenium hysterophorus* and *Achyranthus aspera* (Suryawansh, 2011), as in 427 kg N ha^{-1} of C. *obtusifolia,* 352 kg N ha^{-1} in *Parthenium* sp and 53 kg N ha^{-1}in *Achyranthus aspera*. When maize was cultivated with different weed green manure, it showed modification on growth, depending

on the age (Suryawansh, 2011). He further reported that percentages of nitrogen, phosphorus and potassium were higher in *Cassia obtusifolia* than in the other weeds. Yield of fresh vegetable maize on weed green manure was highest 12702 kg ha^{-1}. by C. *obtusifolia*.

B. Objectives of The Study

1) To investigate the effect of *Cassia obtusifolia* green manure in replenishing lost nutrients in the soil of the experimental site.
2) To investigate the effect *Cassia obtusifolia* green manure for sorghum grain yield and yield components.

II. MATERIAL AND METHODS

A. Experimental Sites

Two Field trials were conducted during each of the wet seasons of 2013 and 2014 at Institute of Agricultural Research Farm, Samaru (11 11'N7 38 E; 686m above sea level) in the northern guinea savanna of Nigeria to investigate the effects of nitrogen and organic manure, consisting of Cassia obtusifolia L. green manure and cow dung on two varieties of sorghum grown on a Striga- infested field at the Details of meteorological data in the two locations and seasons were recorded and are presented in Appendices 1-4. Prior to land preparation in each season, soil samples were collected randomly from each experimental site at 0-30cm depth using a soil auger. The soil samples were bulked, air dried, ground and sieved using a 2mm wire mesh before being subjected to laboratory analysis for physical and chemical properties using standard procedures as described by Black (1965). The results of analysis are presented in Tables 1 & 2. The chemical properties of Cassia obtusifolia green manure from Katsina in 2013 and 2014 were analysed and determined by the standard procedure and are presented in Appendix 7. Similarly, the chemical properties of cow dung used were also determined by standard procedure and are presented in Table 3.

The Experiment consisted of two sorghum varieties (SAMSORG-40 and SAMSORG-41), four levels of organic manure (*Cassia* green manure at 0, 7.5 and 15 t ha^{-1} and cow dung at 10 t ha^{-1}) and three nitrogen levels (0, 40 and 80 kgN ha^{-1}). The experiment was laid out in a split plot design, with nitrogen levels assigned to main plots and factorial combinations of organic manure levels and variety assigned to the sub-plots. The treatments were replicated thrice. The gross plot size consisted of six ridges,75cm apart, each 3m long giving an area of 13.5 m^2, while the net plot consisted of the two inner ridges, giving an area of 4.5 m^2.

B. Description of Cassia obtusifolia L. (or Cassia tora).

Cassia tora (L.) botanically Senna obtusifolia (L.) Irwin and Barkeby or Cassia obtusifolia L.), belongs to the family Leguminosae, Ceasalpinioidae. It is an erect, branched and bushy annual or perennial dicoyledonous plant, up to 90cm high, that reproduces by seed. The stem is branched, cylindrical, hairless or sparingly hairy. The leaves are alternate, pinnate, 2.5- 7.5cm long. The flower is yellow, 2-3 cm across and borne on pedicel in the leaf axils. The fruit is cylindrical, 10 - 20cm long and 5-6mm wide, curved and beaked. The seed is about 5mm long and 2mm wide, somewhat rhomboid, brown and Smooth. It is a pan-tropic weed of road sides, grass lands and cultivated fields, common near settlements and widespread in West Africa.

C. Variety Description:

1) *SAMSORG- 40 (ICSV 400).* It is non-lodging, drought tolerant, and non-senescent variety with good response to fertilization. Grains have a good food and malting qualities. Morphologically, it is semi-dwarf and semi-compact and seed colour is cream. It is adapted to Sudan and Sahel Savanna Zones. It is an early maturing variety (75 - 80 days). The potential yield of the variety is 1500 – 2000$kgha^{-1}$ and it can grow up to 300 – 350cm. The leaves are brown at maturity. It is tolerant to most leaf diseases and *Striga.*
2) *SAMSORG- 41 (ICSV111).* It is an improved variety, adaptable to both Guinea and Sudan Savanna ecological zones. It is characterized by brown coloured hard grains, which make good local food quality. It is high yielding, draught and Striga tolerant. It matures within 90-110 days. It was developed by International Crops Research Institute for Semi-Arid Tropics (ICRISAT). Its yield potential is 1000-2800$kgha^{1}$.

D. Land Preparation and Manure Incorporation.

In each trial and season, the land was harrowed to a fine tilth and ridged, 75cm apart. The site was marked into plots and replications. Alley path ways of one meter across and one ridge along the ridges were allowed as borders between the plots, while replications were separated by two ridges along and 1m across the ridges. Cassia obtusifolia plants were harvested at five weeks after emergence from nearby fields in both locations. The green manure and crushed cow dung were uniformly applied and incorporated into the soil, two weeks before sorghum seed sowing according to treatments. The incorporation was done by opening the center of each ridge to about 15cm depth, and applying cow dung or burying cassia plants according to treatments, after which, each was covered with soil.

E. Planting

Apron plus was used to dress the seed of each crop variety at the rate of 10g per sachet 3.0kg of seeds. Dressed seeds of sorghum was planted on June 20th and 15th in 2013 and 2014, respectively at Katsina using 4 - 5 seeds per hill at a spacing of 30cm on 75cm ridges. Sorghum seedlings were thinned to two plants per stand at 3 weeks after sowing (WAS).

F. Nitrogen Fertilizer Application

Nitrogen in the form of Urea (46%N) was applied in two equal split doses as per treatment (0, 40 and 80kgNha^{-1}) at 3 and 6 W A S by side dressing.

G. Weed Control

Paraquat as a Gramazon 27 a.i was applied on the experimental field prior to land preparation to control emerged weeds. This was followed by hoe weeding at 3 and 6 WAS. Subsequent weed control was done by hand pulling as the need arose, and *Striga plants* destruction was avoided.

H. Harvesting

Sorghum was harvested when the panicles had attained physiological maturity. This was when there was development of black layer at the placental region of the grain, which marked physiological maturity in sorghum (Eastin *et al*., 1973).

I. Observations and Data Collection

Data was collected on the following growth and yield components of sorghum at various sampling periods. Establishment count, number of leaves, *Striga* count, *Striga* infestation, grain weight and grain yield.

J. Data Analysis

The data collected were subjected to analysis of variance to test the significance of differences between treatment means using the F-test as described by Snedecor and Cochran (1967). The treatment means were compared using the Duncan Multiple Range Test (Duncan, 1955).

III. RESULTS AND DISCUSSION

Table 1. The physical and chemical properties of soil of the experimental site before planting shows that the textural class of the soil was loam, with pH which is slightly acidic. The organic carbon, N, available P was very low in contrast with CEC which was relatively higher. Soil characteristics measured at the beginning of each experiment showed that there were differences in pH in water, organic carbon, total N and available P. in soils used in the experimental field. This might be as a result of seasonal effects and inherent fertility status of the soil of the location. Soil differs in terms of nutrients from one place to another even in the same location from time to time. In Samaru, the soil is loamy indicating more organic matter content and hence better fertility status than the sandy loam which is relatively a marginal soil.

Table 2. Generally, the highest N P & K contents of the soil recorded in 2014 compared to 2013 might be due to the residual effect of organic manure applied in 2013. Organic manure is a slow released and it takes time to replenished the soil with nutrients. The higher nutrient content of the green manure plant material might be related to the fertility of the soil from where the plant was collected. When Green manure was applied into the soil the microbial biomass increase in size across the years of study. Biomass N and P content were higher in 2014 (0.79 % N, 18.72 mg/kg P). Incorporation 15 t ha^{-1} cassia green manure enriched the soil of the location with high percentage of nitrogen than the 0-7.5 t ha^{-1}.

The chemical composition of Cassia obtusifolia green manure used for this research revealed that available K had the lowest value in percentage than the total N and available P in both years. (Table 3).Total nitrogen in 2014 was significantly high (2.78) when compared to the percent value recorded in 2013.

Sorghum grain yield increased with increase in green manure rates (Table 4). This is because nutrients in the manure were possibly released toward the post-an thesis stage. Nutrients such as N and P are important for grain formation and yield development. The application of manure provides other essential nutrients that are limiting in mineral fertilizers, and this could increase grain yield of sorghum even under *Striga* pressure as observed by Parker and Riches (1993). The finding showed that *Cassia* green manure significantly increased yield and yield components of sorghum, probably due to improved soil physical and chemical properties. Organic matter is known to improve porosity and moisture holding capacity of soil and enhances root growth, water and nutrient uptake capability. Apart from the fact that nutrients released from the green manure has direct effect on growth and yield. The importance of N in organic matter in improving sorghum performance has been highlighted by Arunah *et al*. (2006), who found that poultry manure was superior to the applied N in promoting yield of sorghum. With varying rates of organic manures from 0 – 15 t ha^{-1} the panicle weight increases. Enhancement in crop growth obviously improved assimilate production and translocation to the sink, including the reproduction portion which is explained by heavier panicles. When green manure at 15 t ha^{-1} was applied into the soil the microbial biomass increase in size across the locations and years of study. Biomass N and P content were higher in 2014 (0.79 % N, 18.72 mg/kg P). Incorporation of 15 t ha^{-1} *cassia* green manure enriched the soil with high percentage of nitrogen than the 0-7.5 t ha^{-1}. The nutrient content of the non-amended soil was low compared to the treated field, this might be due to the effect of applied green manure to the soil.

IV. CONCLUSION

A. Application of 15 t ha^{-1} Cassia obtusifolia green manure increases the biomass of N & P thus replenishing the lost nutrients from the soil.
B. Sorghum grain yield and yield attribute increased as Green manure rate increases from 0 - 15 t ha^{-1}.
C. Soil that receive no any form of amendment showed low nutritional status and productivity and it continue to deplet as farming activities continue to take place.

Table 1: Physical and chemical characteristic of soil (0-30cm) taken from the experimental site during 2013 and 2014 at Samaru.

Soil properties	2013	2014
Physical properties		
Sand (%)	32.0	30.6
Silt (%)	25.0	27.4
Clay (%)	43.0	42.0
Textural class	Loam	Loam
Chemical properties		
pH in water (1:2.5)	6.30	6.05
pH in 0.1m $Cacl_2$ (1:2.5)	5.61	5.08
Organic carbon (g/kg)	0.80	0.41
Total Nitrogen (g/kg)	0.58	0.50
Available P (mg/kg)	2.10	4.30
Exchangeable Cation (cmol/kg)		
K	1.40	1.20
Mg	1.80	1.50
Ca	4.30	3.03
Na	0.41	0.58
CEC (meq/100g)	2.40	5.27

Table : 2 Physical and chemical analysis of soil sample from the experimental location based on treatments at post harvest in 2013, 2014 wet seasons at Samaru.

Treatments	2013			2014		
	Nitrogen (%)	Available Phosporus. (mg/kg)	Exchangeable Potassium (meq/100g)	Nitrogen (%)	Available Phosporus. (mg/kg)	Exchangeable Potassium (meq/100g)
M_0	0.28	18.23	0.05	0.36	16.12	0.04
M_1	0.38	21.22	0.05	0.50	20.20	0.05
M_2	0.58	18.13	0.05	0.79	18.72	0.07

Source: Soil chemical Laboratory of the Department of Agronomy, Ahmadu Bello University, Zaria.

Table 3 : N, P and K contents of *Cassia* green manure used in the experiments at Samaru in 2013 and 2014 wet seasons.

Nutrients (%)	Samaru	
	2013	2014
Total N	1.75	2.78
Available P	1.60	1.56
Available K	0.56	0.63

Table 4 Effect of Cassia green manure on sorghum yield and yield component at Samaru during 2013 and 2014 wet seasons.

Treatment	2013	2014	2013	2014
	Grain weight		Grain yield	
Green manure ($t\ ha^{-1}$)				
0	65.8d	64.2d	1516d	1698d
7.5	86.3c	86.0c	1815c	2039c
15	112.5b	113.4b	2166a	2289a
SE±	4.94	5.66	13.7	26.5

Means followed by the same letter (s) within a column of each treatment group are not significantly different at 5% level of probability using the DMRT.

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