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Response of Sorghum (*Sorghum bicolor* L. Moench) Variety to Nitrogen, Cassia Green Manure and Cowdung Rates and on Striga (*Striga hermonthica* Del. Benth) Infested Field at Samaru in Northern Guinea Savanna of 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 to evaluate the effects of integrating nitrogen fertilizer and organic manures on sorghum grown on Striga- infested field. The treatments consisted of four levels of organic manure (Cassia obtusifolia green manure at 0, 7.5 and 15t ha^{-1} and cow dung at 10t ha^{-1}) and three levels of nitrogen (0, 40 and 80kgNha^{-1}). The experiment was laid in a split-plot design and replicated three times; with nitrogen assigned to the main plot, and organic manure were assigned to the sub-plots. The experimental sites was inoculated to boost Striga level. Application of both cow dung and green manure did not influence sorghum stand count, number of leaves, Striga shoot count and Striga infested sorghum stands in 2013. With 10t ha^{-1} cow dung, grain weight was at par when compared to the grain weight by green manure at 15 t ha^{-1} and the untreated control. On the other hand, grain yield was the highest by 15 t ha^{-1} green manure than cow dung at 10 t ha^{-1} across the study periods, but at par with the lowest yield recorded from the untreated control. In contrast, application of 40-80kgNha^{-1} significantly influences Striga shoot count and the number of leaves respectively. Comparable stand count was obtained by the use of 40 and 80kgN ha^{-1} throughout the study periods. In contrast, application of 40-80 kg N ha^{-1} influenced Striga shoot count and infestation only in 2014. Nitrogen application at 80kgN ha^{-1} reduced number of infested sorghum plants with Striga compared to the untreated control. Highest Striga infestation was recorded from the untreated control. Application of 80kgN ha^{-1} gave the highest seed weight and grain yield across the years. On the other hand, grain weight and grain yield were reduced by 40kgN ha^{-1} but at par with the lowest recorded from the untreated control. In conclusion, application of both green manure and cow dung manure showed no any significance influence on establishment count, number of leaves and Striga shoot count. Heaviest grain weight of sorghum was recorded by 10t ha^{-1} cow dung in both years. Application of 15t ha^{-1}green manure increased the grain yield of sorghum with consequent reduction in Striga shoot count. In both seasons, application of 40-80kg Nha^{-1} gave corroborate establishment count and number of leaves. The use of zero (0) kg N ha^{-1} resulted in higher sorghum stands infested with Striga. Application of 80kgN ha^{-1} gave the highest grain weight and yield of sorghum under even Striga infestation.*

Keywords: *Response, Sorghum variety, Nitrogen, Green manure, Striga field.*

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench), the fifth most important cereal crop in the world being surpassed only by rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and maize (*Zea mays* L.) (Abunyewa, 2008). The world sorghum grain production is 55-70 million tones per annum from 40-45 million hectares of land . The world average yield is 1412 kg ha^{-1}(Samuel *et al.*, 2013). In 2010, the USA was the world largest annual producer of the crop, 8.8 metric tones, followed by India with 7.0t, Mexico 6.9t, Nigeria 4.8t and Argentina with 3.6t (CGIAR, 2013). It is unique in adapting to environmental extremes of abiotic and biotic stresses and being essential crop to diets of poor people in the semi-arid tropics where drought causes frequent failure of other crops (Godharle *et al*., 2010). Nigeria is the fourth largest producer of sorghum in the world, with an annual production in excess of 4 million metric tones. In the semi-arid tropics sorghum is used in various ways. Sorghum is primarily used for human consumption as a staple food in the diets of many people in countries of the world, especially in sub – Saharan Africa. (Anon., 2015).It is a principal source of nutrition for millions of people and provides a major source of energy to human diets in Africa and much of Asia. The grains and vegetative parts of the crop are used as animal feed. Sorghum serves as a major raw material in the brewing industry. Some varieties of sorghum can be malted to produce nutritious food stuff for infants as well as making as bakery products.

Despite the importance of sorghum as a food crop and industrial crop the yield on farmers fields is generally low, with 1.5 t ha^{-1}, as compared to the yield of 4.6 t ha^{-1} under improved management system. Continuous cultivation and the use of in organic fertilizers have led to depletion of organic matter and some essential nutrients in the soil as reported by Howard, *et al.* (2001). This is no doubt responsible for the decline in the crop yield. Crop response to applied fertilizer depends on soil organic matter content. Parasitic weed species of the genus *Striga* establishes preferentially on poor soils and fields which have 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 inorganic nitrogen (Mumera and Bello,1993; Pieterse,1996) and organic fertilizer (Ogborn, 1984; Bello,1987) has been reported to reduce *Striga* infestation. Depending on level of infestation, *Striga hermonthica* caused 20-80 % yield reduction in Sorghum yield (Altera and Itoh, 2011). Smaling *et al.* (1992) demonstrated the need for integrated nutrients management, especially in areas of low soil fertility where farmers cannot afford to rely on mineral fertilizer alone. Such integrated approach can reduce the inorganic fertilizer requirement, and at the same time increase the efficiency of the added input (Lee, 2007). Some weed plants have the potential to provide the nutrients. When we compare the available nutrients in synthetic fertilizers and their market values, the use of weeds to improve soil fertility would be cheaper. Exploiting available natural resources is a better way towards utilizing poor and marginal soils productively.

Green manuring is the incorporation of fresh plant material into the soil. The species most commonly used for green manuring are members of the 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 plant nutrients, as well as organic matter are added to the soil, and this also improves soil physical, chemical and biological properties in favour of crop plants (Francis *et al.*, 1986; Hullungale, 1988 and Tejeda *et al.*, 2004). Suryawanshi *et al.*(2011) reported that *Cassia obtusifolia* green manure produced higher total dry matter (1154 kg ha^{-1}) in maize than *Parthenium hytrophorus*. The phosphorus and potassium contents were also higher in *Cassia obtusifolia*. Better results were observed from *Cassia obtusifolia* because it is a legume and contains more nitrogen, phosphorus and potassium as compared to other weeds. However, its assimilation rate was lower compared to the other weeds. The test crop varieties used for this research were SAMSORG-40 and SAMSORG-41. Although research has been conducted on different sorghum varieties, there is limited work on these two varieties of sorghum in the areas of integrating organic and mineral nutrition in the northern Guinea of Nigeria.

OBJECTIVES OF THE STUDY

In view of the above justification, this work was conduct with the following objectives.

a. To evaluate varying rate of *Cassia obtusifolia* green manure on the growth and yield of two sorghum varieties and compare with cow dung at the recommended rates und Striga infestation at Samaru .
b. To evaluate varying rates of nitrogen on the growth and yield of two sorghum varieties under *Striga* infestation at Samaru.

MATERIAL AND METHODS

The two Field trials were conducted during the wet seasons of 2013 and 2014 at Institute for 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 Cassia green manuring on two varieties of sorghum grown on a *Striga*- infested field. Meteorological data in the two locations and seasons were recorded and are presented in Appendices 1&2, while the physical and chemical properties of the soil of the experimental sites are presented in Table 1&2. The N, P and K contents of cassia green manure and cow dung are presented in Table 2&3 respectively. The Experiment consisted of two sorghum varieties (SAMSORG-40 and SAMSORG-41) (Anon, 2015). 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.

The experimental site which was already Striga-infested was further inoculated with *Striga* seeds, a day to sowing. This was done by using 25g of *Striga* seeds per 1kg of fine sand to inoculate each field. The inoculants was uniformly applied by broadcasting n ridges prior to manure application. This was done to boost the *Striga* level of the field.

Dressed seed of Sorghum was sown on June 20th and 15th in 2013 and 2014, respectively, at 4 - 5 seeds per hill at intra-raw spacing of 30cm and seedlings were thinned to two plants per stand at 3 weeks after sowing (WAS).

Nitrogen in the form of Urea (46%N) was applied in two equal doses according to treatment at 3 and 6 W A S by side dressing. Pre-plant (paraquat) and hoe weeding at 3 and 6 W A S were adopted to control weeds.

The crop was harvested when the panicles had attained physiological maturity (Eastin *et al.*, 1973). 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).

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.

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's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

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 (Table 1). The organic carbon, total N, available P in 2013 were very low in contrast, while the CEC which was relatively higher, especially in 2014. The chemical composition of *Cassia obtusifolia* green manure used for this research revealed that total N exchangeable were lower in 2013 in 2014, but the reverses was the case with available P.The chemical composition of cow dung used revealed that total nitrogen, available P and exchangeable K were generally higher in 2014 than 2013 (Table3). Organic manure application at 0-15 t ha^{-1} did not influence stand count, leaves numbers and number of Striga infested sorghum in both years and Striga shoot count. The non significant effect of green manure on the stand count, at that time, rainfall was not adequate to supply moisture for seed germination, even though the soil was rich in N, and this might brought about the differences on the stand count. Similar finding was reported by Theodora *et al.* (2003) who found out that application of farm yard manure did not affect the stand count of sorghum. The non influence of manure on the number of leaves, *Striga* shoot count and *Striga* infestation, may not revealed that necessarily exert influence on these parameters in the first season of application. Sorghum crop and with organic manure application, *Striga* shoots were scarcely recorded when higher dose of the manure and cow dung were used. This might probably be caused by crop growth and reduction of *Striga* shoots. Application of varying rates of organic manure did not show significant influence on *Striga* incidence on sorghum stands at harvest. This might be due to the inadequate amount of available N to suppress the weed. At this stage, organic manures had not completely decomposed, to release N that could reduce *Striga* infestation to crop plants even with higher organic manure levels. The high *Striga* shoot count recorded on the untreated control could be due to the low amount of nitrogen that increased crop susceptivility to *Striga* attack. At higher levels of green manure and the cow dung at 10 t ha^{-1}, crop growth increased and this facilitated its tolerance to *Striga*, under which some *Striga* plants did not survive. The highest sorghum grain yield was resulted by 15 t ha^{-1} green manure over cow dung. This is because nutrients were available and released toward the post-anthesis stage. Thus the nutrients were available to develop the site of photosynthesis, there by aiding yield development of the crop. These results confirmed that the application of manure provide other essential nutrients that are limiting in mineral fertilizer increases grain yield of the host crop even under the *Striga* pressure (Parker and Riches, 1993). Another reason may be that *Cassia* green manure significantly increases yield and yield attributes of sorghum due to improved soil physical and chemical properties. The increased porosity and moisture content should have enhanced root growth, water and nutrient up take, apart from the fact that nutrients released from the green manure has direct effect on growth and yield. The importance of N- in determining sorghum performance has been highlighted by Arunah *et al*. (2006) who found that poultry manure was superior to applied N in determining yield of sorghum.

On the other hand, application of 40-80 kg N ha^{-1} gave significantly comparable and higher than the untreated control in both years of study. This shows that stand loss was reduced, and this could be linked to the suppression of *Striga* infestation impact, which became apparent in 2014, when the number of infected sorghum stands slightly decreased with 40 kgNha^{-1} and significantly decreased with 80 kgNha^{-1} (Table 5). In the same vein, crop foliage significantly improved by N application, fulfilling the role of N in vegetative growth of plants. Zero N rate produced significantly higher sorghum infested stands than the crop treated with 40-80 kg N ha^{-1}. The explanation is nitrogen at the rate of 40-80 kg ha^{-1} markedly reduced *Striga* infestation or attack on plants. Similar report was made by Lagoke *et al*. (1994) that application of nitrogenous fertilizers reduced the severity of *Striga* attack and increase yield of the affected crops. The use of 80 kg N ha^{-1} resulted in the highest grain weight and yield compared to all other rates under study.

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 : 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	2.28
Available P	1.60	1.56
Available K	0.56	0.63

Table 3: N, P and K contents of cow dung manure used for the experiments at Samaru in 2013 and 2014 wet seasons.

Nutrients (%)	Samaru	
	2013	2014
Total N	1.88	2.10
Available P	1.63	2.40
Available K	0.63	0.78

Table: 5 Effects of organic manure and nitrogen on the growth, yield and yield components of sorghum grain yield in 2013, wet season at Samaru.

Treatments	Stand count@ harvest	Number of leaves@ 12WAS	Striga shoot count@ harvest	Striga infested sorghum stands	Grain weight /12.8m^2	Grain yield (kg ha^{-1})
0 t ha^{-1}	71.11	11.9	0.67	0.94	65.8d	1516d
Cow dung at 10 t ha^{-1}	70.3	11.8	0.55	0.28	132a	2120b
***Cassia* at 15 t ha^{-1}**	70.6	12.1	1.17	0.67	112b	2166a
	0.75	0.13	0.53	0.56	4.94	13.7
SE±						
Nitrogen (N).						
0 kg ha^{-1}	66.3b	10.9b	1.46	1.04	81.4b	1753c
40 kg ha^{-1}	72.2a	12.2a	0.33	0.38	104ab	1914b
80 kg ha^{-1}	72.5a	12.8a	1.05	1.00	112a	2046a
SE±	0.82	0.07	0.46	0.42	6.93	6.59
Interactions.						

MxN	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) within a column of each treatment group are not significantly different at 5% level of probability using DMRT.
1.*Cassia* = Green manure.
2.NS Not significant at 5% level of probability.
* = significant at 5% level of probability.

Table: 6 Effects of organic manure and nitrogen on the growth, yield and yield components of sorghum grain yield in 2014, wet season at Samaru.

Treatments	Stand count@ harvest	Number of leaves@ 12WAS	Striga shoot count@ harvest	Striga infested sorghum stands	Grain weight /12.8m^2	Grain yield (kg ha^{-1})
0 t ha^{-1}	71.4	12.9	0.67b	0.44	64.2d	1698d
Cow dung at 10 t ha^{-1}	73.5	12.9	0.34ab	0.22	136a	2233b
***Cassia* at 15 t ha^{-1}**	71.7	12.9	1.33a	0.50	113b	2289a
SE±	1.11	0.11	0.22	0.16	5.66	26.5
Nitrogen (N).						
0 kg ha^{-1}	68.6b	12.2b	1.75	1.00a	84.5b	1868c
40 kg ha^{-1}	74.7a	12.8ab	0.39	0.13ab	96.3b	2113b
80 kg ha^{-1}	75.1a	13.8a	0.21	0.00b	117a	2213a
SE±	1.43	0.17	0.44	0.24	4.73	8.63
Interactions.						
M x N	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) within a column of each treatment group are not significantly different at 5% level of probability using DMRT.
1.*Cassia* = Green manure.
2.NS Not significant at 5% level of probability.
* = significant at 5% level of probability
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CONCLUSION

The use of *Cassia* green manure up to 15 t ha^{-1} is capable of suppressing *Striga* impact and enhancing sorghum grain yield. In the similar trend, nitrogen application showed increasing *Striga* suppressing and sorghum grain yield enhancement with increasing N rate up to 80 kg N ha^{-1} . Therefore, N fertilization is capable of guaranteeing productivity of *Striga* infested land with respect to sorghum production.

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