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Evaluating the Direct and Indirect Effects of Some Growth & Yield Attributes on Grain Yield of Sorghum (*Sorghum bicolor* L. *Moench*) in Nigerian Savanna

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***Abstract**: A field experiment was conducted during the wet seasons of 2013 and 2014 at the Institute for Agricultural Research Farm, Samaru (11 11 N7 38 E; 686 m above sea level) in the Northern Guinea Savanna and experimental Farm of Hassan Usman Katsina Polytechnic, Katsina (12 56 N, 7 36 E; 465 m above sea level) in the Sudan Savanna of Nigeria to determine the effect of integrating nitrogen fertilizer and organic manure on sorghum varieties grown on Striga infested fields. The treatments consisted of two varieties of sorghum (SAMSORG-40 and SAMSORG-41), three levels of nitrogen (0, 40, and 80 kg N /h) and four levels of organic manure (Cassia obtusifolia green manure at 0, 7.5, 15 and cow dung @ 10t / h). The experiment was laid out in split-plot design and replicated three times; with nitrogen assigned to the main plot while factorial combinations of crop variety of sorghum and organic manure were assigned to sub-plots. The experimental sites were inoculated to boost Striga level. The direct and indirect effects by both the growth and yield components on yield were recorded in the two locations and year of study. In both locations, the greatest effect by panicle weight on yield showed that panicle weight greatly influenced yield. The heavier the panicle the more yield will be realized. The direct effects of some growth parameters to yield such as plant height, number of leaves, shoot dry weight, as some of the primary determinants for yield may be attributed to the impact of complementary application of green manure, cow dung and the high rates of N-fertilizer which improved crop growth and eventually led to heavier panicles, 100-grain weight and grain weight that constituted the yield.*

Key words: - *Direct effect, indirect effect*, *Growth, yield attributes, yield, Sorghum*

INTRODUCTION

Sorghum (*Sorghum bicolor (*L.) Moench) is commonly referred to as guinea corn in West Africa, is the fifth most important cereal crop in the world after rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and maize (*Zea mays* L.) (Abunyewa, 2008). Nigeria is the fourth largest producer of sorghum after USA, India and Mexico (CGIAR, 2013). It is unique to environmental conditions, including biotic and abiotic stresses and fits well in the diets of poor people of the semi-arid tropics where drought causes frequent crop failure (Godharle *et al*., 2010). Sorghum 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 (Anon., 2015). The grain and vegetative parts of the crops 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 and used in bakery.

Striga has adverse effect on sorghum, and infestation can result in crop failure. The extent of yield losses is related to the incidence and severity of attack, crop susceptibility to *Striga,* environmental factors (edaphic & climatic) and the management level under which the crop is produced (Esilaba, 2006). Its effect ranges from extraction of nutrients, water, assimilates and mineral salt from the host plant resulting in stunted growth, chlorosis, wilting and consequently death of the plant. It was reported that annual sorghum losses attributed to *Striga* in USA were 22-27% and 25% in Ethiopia and 235% in Nigeria (Anon, 2011). In terms of monetary value, the annual cereal losses due to *Striga* are estimated at US$ 7 billion in USA. In Ethiopia, Mali and Nigeria, the annual losses are estimated at US$ 75 million, US$ 87 million and US$ 12 billion respectively (Anon., 2011). Parasitic weed species of the genus *Striga* establishes preferentially on poor soils and fields which have been exhausted by continuous cropping (Vogt *et al.,*1991), and *Striga* infested areas are characterized by agricultural production systems that witness low crop productivity.

The work reported in this paper aimed at assessing the influence of Crop variety and green manure on the performance of sorghum in a *Striga* infested field at Samaru.

Material and Methods

Two field trials were conducted during each of the wet seasons of 2013 and 2014 to investigate the effects of organic manure, (using *Cassia obtusifolia* L. & Cow dung) on two varieties of sorghum grown on a *Striga*- infested field at the Experimental farm of the Institute for Agricultural Research, Samaru (Lat. 11^0 11 56 “N, 7^0 38” E; 686m above sea level) in Northern Guinea Savanna zone of Nigeria. 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 15t ha^{-1} and cow dung at 10t ha^{-1}). Soils of the experimental Site and the green manure were analyzed for their physical and chemical properties and are presented in Table 1. And Cassia green manure was analyzed for its nitrogen, phosphorus and potassium contents, and is presented in Table 2. The experiment was laid out in a split plot design and 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.

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 ridges 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.

Each experimental site was 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 were uniformly applied by broadcasting immediately after manure application. The inoculation was done to boost the *Striga* level of the infested fields. Dressed seeds of Sorghum was done on June 20th and 15th in 2013 and 2014, respectively at Samaru 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). Paraquat as a Gramazon 270 E.C. was applied on the experimental field prior to land preparation and repeated at two weeks after manure incorporation to control emerged weeds. Hoe weeding was done at 3 and 6 WAS. Subsequent weed control was done by hand pulling as the need arose, avoiding *Striga* plants destruction. Sorghum was harvested when the panicles had attained physiological maturity (Easteen *et al.,* 1973). Data collected included Number of day*s to Striga emergence, Striga* shoot count, crop reaction score and sorghum 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 Multiple Range Test (Duncan, 1955).

Results and Discussions:

The direct and indirect effect of growth and yield components on grain yield in 2013 and 2014 wet seasons in both locations were presentedin Table 1 & 2. At Katsina in 2013, panicle weight plant^{-1} gave the highest direct positive effect (0.969) on grain yield, followed by plant height (0.291) and 100-grain weight (0.103) in the declining order. The highest positive indirect effect on grain yield resulted from grain weight via panicle weight (0.963), while the least positive indirect effect on grain yield was by plant height via number of leaves (0.002). In 2014, plant height had the greatest direct effect on yield (0.492), while the indirect effect was highest with panicle weight via plant height (0.266).

At Samaru across theyears under study, the highest direct effect on grain yield was by panicle weight (0.634) in 2013 and (0.268) in 2014. For the indirect effect, greatest effect was observed on grain yield, by grain weight via panicle weight (0.622) in 2013 and (0.256) in 2014. The greatest effect by panicle weight on yield showed that panicle weight greatly influenced yield. The heavier the panicle the more grain yield would be realized. The direct of some growth parameters to yield such as plant height, shoot dry weight, number of leaves, as some of the primary determinants for yield may be attributed to the impact of complementary application of green manure, cow dung and the high rates of N-fertilizer which improved crop growth and eventually led to heavier panicles, 100-grain weight and grain weight that constituted the yield.

Table 1: Direct and indirect effect of growth and yield attributes to grain yield in 2013 and 2014 wet seasons at Katsina.

	Effect through						
Yield attributes	Plant height	Number of leaves	Shoot dry wt	Panicle wt	Grain wt	100-grain wt	**Total correlation**
				2013			
Plant height	**0.291**	0.002	-0.005	0.479	-0.188	0.034	0.613
No. of leaves	0.036	**0.017**	-0.006	0.274	-0.105	0.017	0.234
Shoot dry wt	0.080	0.006	**-0.018**	0.439	-0.169	0.044	0.381
Panicle wt	0.144	0.005	-0.008	**0.969**	-0.371	0.055	0.794
Grain wt	0.147	0.005	-0.008	0.963	**-0.373**	0.056	0.789
100-grain wt	0.097	0.003	-0.008	0.519	-0.205	**0.103**	0.508
				2014			
Plant height	**0.492**	0.017	0.082	0.039	0.075	-0.013	0.692
No. of leaves	0.084	**0.100**	0.081	0.009	0.018	-0.009	0.283
Shoot dry wt	0.160	0.032	**0.253**	0.030	0.057	-0.013	0.519
Panicle wt	0.266	0.012	0.105	**0.072**	0.139	-0.010	0.584
Grain wt	0.265	0.013	0.104	0.071	**0.139**	-0.027	0.566
100-grain wt	0.230	0.031	0.117	0.025	0.133	**-0.028**	0.508

dwt=dry weight, wt= weight, no= number,

Table 2: Direct and indirect effect of growth and yield attributes to grain yield in 2013 and 2014 wet seasons at Samaru

	Effects Through						
Yield Attributes	Plant Height	No of Leaves	Shoot Dry Wt	Panicle Wt	Grain Wt	100-Grain Wt	**Total Correlation**
			2013				
Plant Height	**0.281**	0.015	0.123	0.369	-0.109	0.001	0.679
No of Leaves	0.094	**0.044**	0.165	0.189	-0.059	0.001	0.433
Shoot Dry Wt	0.125	0.026	**0.278**	0.372	-0.120	0.001	0.680
Panicle wt	0.164	0.013	0.163	**0.634**	-0.193	0.001	0.780
Grain Wt	0.156	0.013	0.170	0.622	**-0.197**	0.001	0.768
100 –Grain wt	0.042	0.011	0.060	0.164	-0.005	**0.006**	0.221
			2014				
Plant Height	**0.186**	0.037	0.002	0.125	0.100	0.122	0.572
No of Leaves	0.078	**0.087**	0.001	0.125	0.121	0.134	0.545
Shoot Dry Wt	0.028	0.004	**0.015**	0.058	0.049	0.062	0.215
Panicle wt	0.087	0.041	0.003	**0.268**	0.222	0.119	0.740
Grain Wt	0.080	0.045	0.003	0.256	**0.232**	0.116	0.733
100 –Grain wt	0.072	0.037	0.003	0.101	0.085	**0.317**	0.614

wt= weight, No= number,

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