



## **SIMPLE CORRELATION BETWEEN FLAG LEAF AREA AND YIELD CHARACTERS OF SORGHUM UNDER STRIGA INFESTATION DURING THE 2018, 2019 AND 2020 RAINY SEASONS IN BAUCHI, BAUCHI STATE, NIGERIA**

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### **ABSTRACT**

Field experiment was conducted for three (3) years during the rainy seasons of 2018, 2019 and 2020 to study the flag leaf area and yield character relationship as influenced by *Striga* infestation of sorghum in Bauchi state. The research was conducted at Teaching and Research Farm of the Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi (10° 22' N and 9°47' E) in the northern Guinea savanna ecological zone of Nigeria. The treatments consisted of four (4) transplanted age; (2, 3, 4 and 5 weeks after emergence with a control as direct seeded on the field) and five (5) nitrogen levels; (0, 30, 60, 90 and 120 kg N/ha). The treatments were factorially combined and laid out in a Randomized Complete Block Design with three replications. In all the three seasons, sorghum seedlings were first raised in the nursery before being transplanted out to the field. Characters measured were flag leaf area, panicle length, panicle weight, number of spikes per panicle, number of seeds per panicle, spike length, spike weight, number of spikelets per spike, number of seeds per spike, seed weight and seed yield per hectare. Simple correlation between flag leaf area and yield characters of sorghum was carried out to determine the relationship. The results indicated a significant and positive correlations exist between the characters measured throughout the study period. This implies as flag leaf area increase, all yield characters increase with a resultant increase in yield. Based on the result this finding, it can be concluded that net increase in flag leaf area resulted to increase in yield of *Striga* infested sorghum in the study area.

**Keywords:** *Striga*, Sorghum, Transplanting, Correlation, Nitrogen.

### **INTRODUCTION**

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important cereal crop grown for human consumption, surpassed only by rice, wheat, barley and maize. World production of sorghum is between 55 and 70 million times of grains per annum cultivated from between 40 and 45 million hectares, with an average yield of 1412 kg ha (source). In 2010, the USA was the world's largest producer of sorghum (8.8) metric tons annually, followed by India (7.0), Mexico (6.9), Nigeria (4.8) and Argentina (3.6) (source).

Sorghum is one of the leading food crops of Nigeria. The national estimated and expected average crop productivity of sorghum is 2137 kg ha<sup>-1</sup> (Samual *et al.*, 2013). Sorghum is cultivated across the world in the warmer climatic areas. It is unique in its adaptation to environmental extremes of abiotic and biotic stresses and an essential crop to diets of poor people in the semi-arid tropics where droughts have caused frequent failures of other crops (source). Sorghum is produced in virtually all the northern states in Nigeria, though some states



produce more than others. Kano, Kaduna, Sokoto, Gombe, Bauchi, Zamfara, Benue, Kogi, Nasarawa, Taraba and Plateau are major sorghum producing States (source).

In Nigeria, sorghum is used in various ways. The grain is used for human food such as porridge, “Kunu”, “Fura”, “Tuwo”, “Dambu”, infant food, syrup, and local beverage known as “Kunuzaki” and “Burukutu” (source). Also, the stalk is used for animal feed, for construction of houses and fences, and as fuel wood. Its importance is ever increasing as a source of food for rural populace, as animal feed and raw materials, for the industries (source).

Sorghum suffers from a lot of pests among which, the witch weed *Striga* is the most important (source). The genus *Striga* belongs to the family *Scrophulariaceae* and thought to include 35 species. *Striga* is generally native to semi-arid tropical areas of Africa but have been recorded in more than 40 countries (source). *Striga* possibly originates from a region between Semien Mountains of Ethiopia and the Nubian Hills of Sudan. This region is also the birthplace of the domesticated sorghum (source). It has long been recognized as the greatest biological constraint to food production in Africa, where nearly 100 million ha of the African savannah are infested annually with *Striga*. (source) Although these parasites attack several crops, the brunt of the ravage has fallen on the staple crops of the poor in the African savanna, namely maize (*Zea mays*), sorghum (*Sorghum bicolor* (L.), pearl millet (*Pennisetum glaucum* [L.] Gaertn), upland rice (*Oryza sativa*) and cowpeas (*Vigna unguiculata*) (Ejeta and Gressel, 2007).

Most important species of *Striga* are *S. asiatica*, *S. hermonthica* and *S. forbesi* which are mainly found in cereals such as maize, sorghum, pearl millet and rice (source). *S. hermonthica* is thought to be the most important parasitic weed specie worldwide. *Striga* species have become the most common parasitic weeds in sorghum-producing areas or eastern Ethiopia, causing crop losses of 50 to 80% and sometimes of even 100%. *S. hermonthica* is the most common specie, damaging sorghum (*Sorghum bicolor*), maize (*Zea mays*), finger millet (*Pennisetum glaucum*), tef [(*Eragrostis tef* (Zucc.) Trotter], barley (*Hordeum vulgare*) and wheat (*Triticum spp.*) in many parts of the world (source). As a menace to most cereal crops, its seeds mode of dispersal in nature is usually attributed to wind and rain, facilitated by the distinct sculpturing on the seed (Abdul *et al.*, 2012).

*Striga* seeds can remain dormant for several months before they respond to chemicals exuded by the host; this period is referred to as “after ripening”. Conditioning occurs when two environmental factors are present: suitable temperatures in the range of 25-35°C and adequate moisture (Parker, 1991).

Research on *striga* control has been carried out for a long time and a wide range of technologies have been developed such as cultural and mechanical methods which includes hand weeding and sanitation, crop rotation, trap and catch crops, intercropping, soil fertility, ‘push-pull’ technology. Biological control method involves biological control using insects and biological control using pathogens. Chemical control method includes using pre-emergence herbicides, post-emergence herbicides, and host plant resistance. Integrated striga management is another control method that is managed through using two or more different control methods (source).

*Striga hermonthica* could be controlled by using resistant variety, fertilizer on farms which had long been abandoned due to *Striga* infestation, whereas the local cultivars had severe infestation. The application of high nitrogen (N) increases the performance of cereal crops under *Striga* infestation. This is due to the fact that N reduced the severity of *Striga* attack while simultaneously increasing the host performance (Lagoke and Isah, 2010). Also, other advantageous effects of fertilizers include increasing soil N and other nutrients, replenishing the soil organic matter and increasing soil moisture holding capacity (source).



Sorghum productivity in the world in general and in Nigeria in particular is by far below its potential. The major factors that account for this low yield is moisture stress, low soil fertility, pest damage and possibly agronomic practices like use of transplanted seedlings, transplanting. Among the pests, the root parasitic weed *Striga* has long been recognized as the greatest biological constraint to sorghum production (Gebrelibanos and Dereje, 2015). *Striga* spreads rapidly in areas of low fertility and decreasing plant diversity, conditions often experienced by poor farmers in dry land zones. This problem is also common in the semi-arid area which is one of the most sorghum producing areas of the country.

*Striga* has a high fecundity with seed production of 10,000 to 100,000 seed per plant and the seed is asynchronous with seed dormancy of twenty years. This makes the weed difficult to control. It is difficult to control effectively because most of its damages made to the host plant occurs underground before the striga plant emerges. Although the level of striga infestations and damages is increasing, farmers rarely adopt control methods due to limitation and lack of information about available technology options (Hearne, 2008). Application of high dosage of nitrogen fertilizer is generally beneficial in delaying striga emergence and obtaining stronger crop growth (Lagoke and Isah, 2010).

Oswald *et al.* (2001) and Oswald (2005) recommended transplanting as a striga control method. Furthermore, available options when applied individually are not effective. Integration of high urea application and profile agronomic practices like transplanting will further enhance the long-time control of striga. Experiment shows that the best solution in the control of striga is an integrated approach that include a combination of methods that are available and acceptable by farmers (Workneh, 2019).

Controlling *Striga spp.* becomes an enormous task. There is a need to solve the *Striga* problem in order to achieve sustainable food production and N fertilizer is an essential element for reversing this effect. Therefore, adequate application of N fertilizer increases plant vigor and dry matter weight and good plant vigor and high dry matter weight are important criteria for selecting sorghum that are resistant/tolerant to *Striga* threat. This research is therefore conducted to study the relationship that exist between flag leaf area and yield characters of sorghum in a *Striga* infested field.

## **MATERIALS AND METHODS**

Field trial was conducted during the rainy seasons of 2018, 2019 and 2020 at the teaching and research farm of the Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University Bauchi, (10° 22' N and 9° 47' E) in the northern Guinea savanna ecological zone of Nigeria. The site of the research has been known to be endemic to *striga* due to continuous cereal crop monoculture over years. Moreover, aside the endemic nature of the site, the parasite was also inoculated in the field.

The treatments consisted of four transplanted ages 2, 3, 4, 5 weeks after emergence in the nursery and a control (direct seeded in the field) and also, five nitrogen levels of 0, 30, 60, 90 and 120 kgN/ha applied as urea (46%N). Experimental area of 1200 m<sup>2</sup>, the gross plot size was 3m x 4m (12m<sup>2</sup>) with 1m between plots and 2m between replicates to serve as a walk way. Using a spacing of 25cm x 75cm, a population of 120 plants with two per plants stands were obtained from 3m x 4m plot size.

The field was ploughed once and harrowed twice to a fine tilth during the first year using tractor drawn implement. However, manual tillage using hand hoe was carried out in the subsequent years so as to maintain plots and their treatments. The treatments were factorially combined to give 25 treatment combinations which were laid out in randomized complete block



design (RCBD) replicated three times. Spacing of 75cm and 25cm (inter and intra-row) was used.

The experimental land has been known over the years to be endemic to *striga hermonthica* due to continuous cropping of maize and sorghum for over ten years. However, artificial striga inoculation was also carried out, before sowing sorghum (directly seeded treatment plot), holes of 10 cm deep were made at spacing of 75cm by 25 cm. A mixture of 30g of *Striga hermonthica* seed with 2kg of sieved sand (with a 212-micron sieve was used). Sticks were placed on each hole for identification of planting hills for sorghum. The striga seeds were then poured inside the holes using spoon and allowed to be conditioned for two weeks following the procedure of Berner (1997) before sorghum was sown.

Two nurseries were established close to the field. Nursery one with the application of nitrogen constructed to a size of 6m x 3m (18m<sup>2</sup>) and nursery two without nitrogen application of 2m x 3m (6m<sup>2</sup>) size. Seeds were sown in the nursery using broadcast method at the establishment of the rains in each year of the study.

The direct seeded plots were sown on the same day with the seeds in the nursery. Sowing was carried out manually with hand. However, the emerged seedlings were later thinned to two plants per stand, three weeks after emergence.

The first dose of NPK 15:15:15 was applied in nursery by broadcasting at planting and on the direct seeded plot by side placement. Then the second dose of NPK 15:15:15 was applied two weeks after transplanting of each transplanted age and two weeks after the first application on the direct seeded plot. The balance of 30, 60 and 90 kgN/ha were applied to 60, 90 and 120 kgN/ha treatment plot four weeks after the second application using urea (46%N) by side placement. The 0 kgN/ha treatment 0:30:30 was applied using single super phosphate (18% P<sub>2</sub>O<sub>5</sub>) and muriate of potash (60% K<sub>2</sub>O) into two split application halves at planting in nursery two by broadcasting and at direct seeded plot by side placement. The remaining half at two weeks after the first application in the direct seeded plot and two weeks after transplanting of each transplanted age.

No herbicide was applied during the three (3) years trial. Weeding was carried out using hoe at two weeks interval before *striga* emergence. After *striga* emergence, weeds were controlled by hand pulling to prevent the destruction of emerging *striga* plants on the plot. Data was collected on the following parameters:

#### **Flag leaf area**

Flag leaf area was taken by measuring the area of the flag leaf (length x breadth) using measuring tape and multiplied by a factor of 0.723 as suggested by Duncan (1968). The flag leaf area was however, only taken at 14 WAE when the plants were headed.

#### **Panicle Length (cm)**

Panicle length was measured using a measuring tape from the base of the panicle to its tip on the five randomly tagged plants per plot. The mean length was then recorded and averaged on per plant basis.

#### **Panicle Weight (g)**

Panicle weight was measured using Camry high precision electronic weighing scale (model EK 5055) on the five randomly tagged plants per plot. The mean weight was recorded and averaged on per plant basis.

#### **Spike Length (cm)**

Spike length was measured using a measuring tape on the five randomly tagged plants per plot. The mean length recorded and averaged on per plant basis.

#### **Spike Weight (g)**





Measurement of spike weight was carried out using Camry high precision electronic weighing scale (model EK 5055) on the five randomly tagged plants per plot. The mean weight was recorded and averaged on per plant basis.

#### **Number of Spikes per Panicle**

Number of spikes per panicle of each of the tagged plants was counted and the mean taken, recorded and averaged on per plant basis. Spike is the primary branches of the panicle.

#### **Number of Spikelets per Spike**

Number of spikelets per spike of each of the tagged plants was taken and the mean calculated and recorded. These were added together and the total average recorded for each of the five tagged plant per plot. Spikelet is the secondary branches of the panicle.

#### **Number of Seeds per Spike**

The number of seeds per spike of each of the tagged plants was first counted. The mean was then taken and recorded on per plant basis.

#### **Number of Seeds per Panicle**

The number of seeds per panicle of each of the tagged plants was carefully counted. The mean on the five stands was then taken and recorded on per plant basis.

#### **Seed Weight (g)**

After threshing, seeds from the five tagged plants were obtained and from the seed lot, one thousand seeds were randomly taken and counted. Weight of the randomly selected seeds was then weighed using a sensitive electronic balance and the mean recorded for each plot.

#### **Seed Yield (kg/ha)**

The harvested seeds from each plot were first sun dried, threshed, cleaned and weighed. Weight of the seeds was also measured using a sensitive electronic balance and the mean recorded. The results obtained was then expressed in kilogram per hectare.

## **RESULTS AND DISCUSSION**

Table 1 presents simple correlation coefficient between flag leaf area and yield characters of sorghum during the period of the experiment. The results obtained showed that a highly significant ( $P \leq 0.001$ ) and positive relationship exists between flag leaf area with panicle length, panicle weight, spike length, spike weight, number of spikes per panicle, number of seed per panicle, number of spikelets per spike, number of seeds per spike, seed weight and seed yield per hectare.

The positive and highly significant correlation observed between flag leaf area with panicle length, panicle weight, number of spikes per panicle, number of seeds per panicle, spike length, spike weight, number of seeds per spike, seed weight and seed yield per hectare revealed the significance of flag leaf area as a site of light interception for photosynthetic activities. This indicates that, the larger the assimilatory flag leaf area, the higher the amount of light intercepted and the higher the assimilate production and the higher the yield. This research is in agreement with the findings of Rai *et al.* (2016) who reported a significant increase in yield as a result of increase in growth characters. This study agrees with that of Gebrelibanos and Dereje (2015) who reported that nitrogen fertilizer significantly increases the growth and yield characters of sorghum. Zerihun (2016) also reported an increase in growth and yield characters of sorghum with the application of nitrogen fertilizer.

**Table 1:** Simple correlation between flag leaf area and yield characters of sorghum under striga infestation during the 2018, 2019 and 2020 rainy seasons in Bauchi, Bauchi State, Nigeria

Characters	Correlation coefficient ( $\lambda$ )	Mean	Standard Deviation
Flag leaf area	-	-	-
Panicle length	0.194**	34.27	0.22
Panicle weight	0.223**	50.61	1.71
Number of spikelets per panicle	0.279**	57.68	0.27
Number of seeds per panicle	0.361**	2909.40	83.17
Spike length	0.533**	11.78	0.26
Spike weight	0.514**	1.00	0.26
Number of spikelets per spike	0.445**	10.97	0.42
Number of seeds per spike	0.358**	61.35	0.42
Seed weight	0.526**	26.94	0.28
Seed yield	0.587**	1600.95	39.46

\*\* Significant at 1% level of probability

## CONCLUSION AND RECOMMENDATION

It was concluded that significant and positive correlations exist between the characters measured throughout the study period meaning that as flag leaf area increase, all yield characters increase with a resultant increase in yield. Thus, net increase in flag leaf area resulted to increase in yield of *Striga* infested sorghum in the study area. It was recommended that striga infestation in the study area be given priority through adequate pest management strategies in order to enhance crop yields.

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