# FALLOW ROTATION WITH THREE WEED SPECIES FOR Striga hermonthica CONTROL AND MAIZE PRODUCTIVITY AT MINNA, NIGERIA



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# FALLOW ROTATION WITH THREE WEED SPECIES FOR *Striga hermonthica* CONTROL AND MAIZE PRODUCTIVITY AT MINNA, NIGERIA

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## ABSTRACT

The potential benefits of planted fallow rotation with weed species: *Hyptis suaveolens* (L.) Poit. (Bush tea), *Desmodium intortum* (Mill.) Urb. (Greenleaf Desmodium) and *Senna obtusifolia* (L.) Irwin & Barneby (Sicklepod) were investigated on-farm for *Striga* control, growth and yield of maize. The treatments were one and two - years *H. suaveolens*, *D. intortum* and *S. obtusifolia* fallows, natural fallows and no fallow cropping plot arranged in a randomized complete block design with three replications. Results show that planted *H. suaveolens* fallow added more organic carbon after one or two years and more available phosphorus after two years. Planted S. *obtusifolia* added more total nitrogen compared to other fallows and no fallow after two years. Delay in *Striga* shoot emergence and reduction in *Striga* shoots density were lowest in *H. suaveolens D. intortum* and *S. obtusifolia* planted fallows after two years. Taller maize plants, bigger and longer cobs, and more grains per cob were significantly ($p<0.05$) associated with *D. intortum* and *S. obtusifolia* planted fallows. Maize grain yield was highest in *S. obtusifolia* planted fallow compared to that in the natural fallow plot after one and two years. Grain yield from *S. obtusifolia* one and two years fallows were 36.8 % and 34.9 % greater than that of natural fallow, respectively. These results suggest that *S. hermonthica* sick land can be fallowed for a minimum of two years with any of the three weed species for increased maize growth and grain yield as part of an integrated management strategy.

**Keywords:** Fallow rotation; weed species; maize; *Striga*

## INTRODUCTION

In many dry Savannas of Sub – Saharan Africa, *Striga hermonthica* (Del.) Benth remains a major biotic constraint to cereal crop production (Ekeleme *et al*., 2011). *Striga* commonly known as “Witchweed”, is a root hemiparasite, which causes significant food crop losses not only in Africa but in Asia as well. In Nigeria, maize (*Zea mays* L.) which is widely adaptable and cultivated in almost all the agro-ecological zones of the country is one major cereal that is severely affected by this parasitic plant (Olakojo and Olaoye, 2007). Furthermore, in Nigeria, grain yield losses in maize due to *Striga* infestation is estimated at 30 – 70 %, which translates into US $7 billion annual revenue (Olakojo and Olaoye, 2007). In West Africa, over 17 million ha of farmlands cultivated with cereal crops have been reported to have a resultant yield loss due to *Striga* infestation that ranges between 10 – 100 %, depending on the crop and cultivar (Ekeleme *et al*., 2011) and degree of infestation.

Management of *Striga* among small-scale farmers remains difficult, such that cereal yield levels have continued to decline even with the use of the numerous control measures (Ekeleme *et al*., 2011). For this reason, an integrated approach, including the use of host plant resistance, cultural practices, chemical and biological treatments have been advocated (Sjogren *et al*., 2010). Unfortunately, these techniques for *Striga* control are rarely adopted by the resource-poor African farmers (Yonli *et al*., 2010). However, interplanting or fallow rotation with leguminous and non-leguminous weed species with cereal crops seems to be a feasible method that can be adopted by the resource-poor farmers for *Striga* control. The seeds of these weeds are readily available at low or no cost. A leguminous weed species like *Desmodium intortum* (Mill.) Urb. (Greenleaf Desmodium) has the ability to fix high amount of N into the soil, preserve soil moisture, produce and release allelochemicals into the soil, stimulates *Striga* suicidal seed germination which in turn depletes its seed bank (Khan *et al*., 2001; Khan *et al*., 2002 and Tsanuo *et al*., 2003). *Hyptis suaveolens* (L.) Poit. (Bush tea) is a non-leguminous aromatic weed species, when incorporated into the soil as green manure can release N and in turn provide an enabling growth environment for a susceptible host crop to tolerate *Striga* infestation effect (Yoganarasimhan, 2000 and Othira *et al*., 2008). *Senna obtusifolia* (L.) Irwin & Barneby (Sickle pod) is a leguminous weed species that contains a non-persistent phytotoxic substance, and has the ability to release N when incorporated into the soil, and inhibit *Striga* seed germination (Kayeke *et al*., 2007; Ismaila *et al*., 2011 and Evans *et al*., 2011). This leguminous weed species, in general, can supplement applied N and be used as trap crops for *Striga* control (Yoganarasimhan, 2000; Khan *et al*., 2001 and Kayeke *et al*., 2007) in maize production.

The study therefore, hypothesize that efficient and sustainable *Striga* control in maize production can be achieved through rotational planted fallow of some leguminous and non-leguminous weed species in the Savanna agro-ecological zone of North Central Nigeria. This study was conducted with the aim of exploring the effect of planted fallow rotation with *H. suaveolens* (L.) Poit., *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby for *Striga* control in maize production. The objectives of the study were to evaluate the effectiveness of *Hyptis suaveolens* (L.) Poit., *Desmodium intortum* (Mill.) Urb. *and Senna obtusifolia* (L.) Irwin & Barneby planted fallow rotation on *Striga* control in maize; and determine the effect of *Hyptis suaveolens* (L.) Poit., *Desmodium intortum* (Mill.) Urb., and *Senna obtusifolia* (L.) Irwin & Barneby planted fallow rotation on growth and yield of maize.

## MATERIALS AND METHODS

### Experimental Site and Soil

The experiment was conducted from 2013 to 2015 growing seasons in a farmer's field highly infested with *Striga* at Gidan Mangoro (9.37ºN; 6.33ºE; 1475 m above sea level), Minna in the southern Guinea Savanna of Nigeria. This location has a monomodal rainfall pattern with an annual rainfall that varies from 1,200 mm to 1,300 mm. Rainy season in this location normally starts in April/May and ends in October, with August as the peak month. The most frequent soils at the site were plinthitic, developed from Minna basement complex arising from geological formation (Ayodele and Omotoso, 2008). The natural vegetation of study site consists of savanna grassland with sparsely growing shrubs and trees. The site chosen has been degraded due to continuous cultivation with arable crops and *Striga* infestation were the major constraints affecting maize production.

**Source of Seeds**

Matured fruits (nutlets) of *H. suaveolens* (L.) Poit., and pods of *S. obtusifolia* (L.) Irwin & Barneby were harvested from the wild, while matured pods of *D. intortum* (Mill.) Urb. were harvested from plants raised in a nursery. The fruits and pods were dried separately, threshed to release the seeds, and then winnowed, air dried and stored in dry bags until when needed. Seeds of popular maize variety (Oba 98 W) were obtained from an agro – seed outlet. The variety was selected as a test crop because it is susceptible to *Striga* infestation, high yield potential and quality protein content and adaptation to the savanna zone of the country.

**Treatments and Experimental Design**

The treatments were, no fallow, natural fallow, *Hyptis suaveolens* (L.) Poit., (Bush tea), *D. intortum* (Mill.) Urb. (Greenleaf Desmodium) and *Senna obtusifolia* (L.) Irwin & Barneby (Sickle pod) planted fallows of one and two years each. In no fallow, maize following maize was planted in the first year, while the one-year and two-year rotation cycles of natural vegetation regrowth fallow, *H. suaveolens* (L.) Poit., *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby planted fallows were on the field for one year and two years. In the one-year rotation, maize was succeeded in the second year. In the two year rotation, maize was succeeded in the third year. The treatments were laid out in a randomized complete block design with three replications. Gross plot size was 4.5 m x 5 m of six ridges each 5 m long. Each plot was separated from the other by an alley of 1 m. The field was naturally infested with a high prevalence of *Striga* and has been under cultivation with sorghum, maize and yam for several years without or little fertilizer application prior to this study.

**Cultural Practices**

The experimental field was manually cleared of existing vegetation in the first year (2013) and the natural and planted fallow sections ploughed and evenly broadcast as per the weed species treatment. For *H. suaveolens* (L.) Poit., 3 kg ha$^{-1}$ (Othira *et al*., 2008) and *D. intortum* (Mill.) Urb., 3.3 kg ha$^{-1}$ (USDA, 2012) seeds were mixed with 20 kg ha$^{-1}$ of sand and broadcast evenly in the first year (2014) of rotation. A seed rate of 25 kg ha$^{-1}$ of *S. obtusifolia* (L.) Irwin & Barneby was also mixed with 25 kg ha$^{-1}$ of sand (Kayeke and Ley, 2005; Kayeke *et al*., 2007) and broadcast evenly in the first year (2013) of the study.

For no fallow, ridges were manually constructed with a hand-held hoe on 6$^{th}$ July 2013, 5$^{th}$ July 2014 and 4$^{th}$ July, 2015 for continuous cropping. At the end of each rotation cycle of one (2014) and two years (2015) natural and planted fallows, the existing vegetation in all the plots was incorporated into the soil manually and ridged at 75 cm apart on 5$^{th}$ and

4th July 2014 and 2015 respectively. Three maize seeds were sown at an intra-row spacing of 50 cm on the ridges and thinned to two seedlings per stand at 2 WAS. Manual weeding was carried out at 3 WAS and hand pulling of weeds other than *S. hermonthica* was carried out at 6, 8 and 10 WAS. Compound fertilizer (NPK-20:10:10) was applied as basal at 3 WAS immediately after hoe weeding at the rate of 60 kg N; 30 kg $P_2O_5$ and 30 kg $K_2O$ $ha^{-1}$ in a single dose since high rates of nitrogen in the soil reduce *S. hermonthica* growth and development. At maturity, maize cobs were harvested from the net plot (3 m x 5 m, consisting of four inner rows). The maize cobs were dehusked, air dried to a constant weight and shelled. At the beginning of the trial, before land preparation, soil samples were taken from the depth of 0-15 cm with an auger of internal diameter of 7.5 cm from ten points each along four diagonal transects across the whole field and each bulked to produce a composite sample for the initial soil characterization of the field. Prior to harvesting, in each year of study and from each plot, soil samples were also taken at 0-15 cm depth between row and in the furrow from three randomly selected locations, bulked to produce a composite sample per plot. The Bouyoucos hydrometer method was used to determine soil particles size distribution (Gee and Or, 2002). Soil pH was determined using the glass electrode pH meter. The Walkley and Black wet oxidation method was used for organic carbon analysis (Anderson and Ingram, 1993). Total nitrogen (N) was determined by the macro Kjeldahl digestion method (Bremner and Mulvaney, 1982). The Olsen method was used to determine available phosphorus, and flame photometry for exchangeable potassium (Okalebo *et al*., 2002).

## Data Collection

From the date of planting, days to first *Striga* shoot emergence was taken from the date plots were sown with maize seeds to the date of first *S. hermonthica* shoot emergence. Number of *S. hermonthica* shoots per maize plant stand was obtained from the net plot (four inner rows), by counting the shoots per maize plant stand and averaged to give the number of *Striga* shoots per maize plant stand at 8, 10 and 12 WAS. Plant height was taken from five randomly selected maize plants within the net plot by measuring each stand from the soil level to the flag leaf with a meter rule at 6, 8, 10 and 12 WAS. Cob length, cob girth and number of grains per cob, were measured from five randomly selected maize cobs from each treatment plot. Grains obtained from the threshed cobs from each net plot were weighed and expressed in kg $ha^{-1}$ to determine the maize grain yield.

## Data Analysis

Prior to data analysis, all *Striga* data were square root transformed ( $\sqrt{X + 0.5}$ ) to improve variance homogeneity. Data collected were subjected to analysis of variance (ANOVA) and the Student Newman Keuls (SNK) test at 5 % level of significance was used to compare the treatment means using Statistical Analysis System (SAS, 2002).

# RESULTS

## Some Soil Nutrient Status

A significant ($P<0.05$) effect of fallow type was observed on soil organic carbon, total nitrogen and available phosphorus in this study (Table 1). *Senna obtusifolia* (L.) Irwin &

Barneby consistently added more organic carbon to the soil even at the end of one year fallow. In contrast, total nitrogen was depleted among all the treatments at the end of one year fallow. However, it increased at the end of two years fallow such that it was highest in *S. obtusifolia* (L.) Irwin & Barneby fallow. Available phosphorus was not significantly ($P<0.05$) affected at the end of one year fallow (Table 1). However, *S. obtusifolia* (L.) Irwin & Barneby contributed more phosphorus to the soil than all other treatments after two years fallow.

Table 1: Effect of fallow type on some soil chemical properties at the end of the cropping season

| | Organic Carbon ($g\ kg^{-1}$) Years of fallow | | Total Nitrogen ($g\ kg^{-1}$) Years of fallow | | Available Phosphorus ($g\ kg^{-1}$) Years of fallow | |
|---|---|---|---|---|---|---|
| Fallow type | One | Two | One | Two | One | Two |
| *H. suaveolens* | 3.32[a] | 4.50[a] | 0.34[d] | 0.70[e] | 2.00[a] | 5.00[a] |
| *D. intortum* | 2.92[b] | 3.75[b] | 0.38[c] | 1.12[c] | 2.00[a] | 2.00[c] |
| *S. obtusifolia* | 2.79[b] | 3.60[bc] | 0.43[b] | 1.82[a] | 2.00[a] | 3.00[b] |
| Natural fallow | 2.12[c] | 2.70[d] | 0.39[c] | 0.98[d] | 2.00[a] | 1.00[d] |
| No fallow | 2.65[b] | 2.55[d] | 0.18[e] | 1.26[b] | 2.00[a] | 2.00[c] |
| Initial | 3.30[a] | 3.30[c] | 0.70[a] | 0.70[e] | 2.43[a] | 2.43[bc] |
| SE± | 0.10 | 0.16 | 0.04 | 0.09 | 0.06 | 0.07 |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

## *Striga* Infestation

Result on days to first *Striga* shoot emergence showed that *D. intortum* (Mill.) Urb., fallow significantly ($P<0.05$) delayed it more than the natural fallow and no fallow after two years only (Table 2).

Table 2: Effect of fallow type on days to first *Striga* shoot emergence in maize

| | Days to first *Striga* shoot emergence Year of fallow | |
|---|---|---|
| Fallow type | One | Two |
| *Hyptis suaveolens* | 64.7[a] | 73.3[ab] |
| *Desmodium intortum* | 64.7[a] | 82.3[a] |
| *Senna obtusifolia* | 64. 3[a] | 74.3[ab] |
| Natural fallow | 60.7[a] | 63.3[b] |
| No fallow | 44.3[a] | 44.3[c] |
| SE± | 5.1 | 3.9 |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

Conversely, *Striga* shoot emergence was earliest in no fallow (continuous cropping) than all other fallow types. Generally, the number of *Striga* shoots per maize plant stand was such that at all the sampling times after one and two years fallow were consistently more in no fallow irrespective of the fallow species (Table 3). However, *D. intortum* (Mill.) Urb., fallow which was similar to *H. suaveolens* and *S. obtusifolia* (L.) Irwin & Barneby planted fallows had the least number of *Striga* shoots at 12 WAS after two years fallow (Table 3).

Table 3: Effect of fallow type on number of *Striga* shoots per maize plant stand

| | Number of *Striga* shoots per maize plant stand | | | | | |
|---|---|---|---|---|---|---|
| | One year fallow | | | Two years fallow | | |
| | Weeks after sowing | | | Weeks after sowing | | |
| Fallow type | 8 | 10 | 12 | 8 | 10 | 12 |
| *Hyptis suaveolens* | 0.8$^{b}$ | 1.1$^{b}$ | 1.6$^{b}$ | 0.0$^{b}$ | 0.4$^{b}$ | 1.0$^{bc}$ |
| *Desmodium intortum* | 0.0$^{b}$ | 1.2$^{b}$ | 1.5$^{b}$ | 0.0$^{b}$ | 0.0$^{b}$ | 0.5$^{c}$ |
| *Senna obtusifolia* | 0.9$^{b}$ | 1.2$^{b}$ | 1.7$^{b}$ | 0.0$^{b}$ | 0.4$^{b}$ | 1.2$^{bc}$ |
| Natural fallow | 1.0$^{b}$ | 1.5$^{b}$ | 1.9$^{b}$ | 0.0$^{b}$ | 0.8$^{b}$ | 1.4$^{b}$ |
| No fallow | 2.1$^{a}$ | 2.6$^{a}$ | 3.0$^{a}$ | 2.3$^{a}$ | 2.9$^{a}$ | 3.1$^{a}$ |
| SE± | 0.1 | 0.2 | 0.2 | 0.0 | 0.3 | 0.1 |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

**Maize plant height**

Maize planted after *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby fallows, and no fallow produced significantly taller plants compared with those in *H. suaveolens* fallow at 6 WAS after one year fallow (Table 4). Also *S. obtusifolia* (L.) Irwin & Barneby fallow had taller plants which were at par with those of *D. intortum* (Mill.) Urb., planted fallow at 10 WAS only, after one year fallow (Table 4). After two years, all fallow types were similar, but only *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby fallow treatments produced significantly taller maize plants than no fallow plot at 6 WAS. At mid-season of 8 WAS, only *D. intortum* (Mill.) Urb., fallow produced significantly taller maize plants than all other fallow types that were in turn similar. During the late season of 10 WAS all planted fallows and natural fallow were similar, but only *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby planted fallows produced taller maize plants than no fallow treatment. The planted and natural fallow treatments had similar maize plant height at 12 WAS, which were significantly ($P<0.05$) taller than those of no fallow (continuously cropped) plot which produced the shortest plants.

Table 4: Effect of fallow type on maize plant height (cm)

| | One year fallow Weeks after sowing | | | | Two years fallow Weeks after sowing | | | |
|---|---|---|---|---|---|---|---|---|
| Fallow Type | 6 | 8 | 10 | 12 | 6 | 8 | 10 | 12 |
| *H. suaveoens* | 40.6$^{b}$ | 91.3$^{a}$ | 135.1$^{b}$ | 155.7$^{a}$ | 58.2$^{ab}$ | 97.3$^{b}$ | 150.3$^{ab}$ | 170.1$^{a}$ |
| *D. intortum* | 51.1$^{a}$ | 90.3$^{a}$ | 158.3$^{ab}$ | 160.6$^{a}$ | 75.7$^{a}$ | 129.2$^{a}$ | 164.4$^{a}$ | 187.2$^{a}$ |
| *S. obtusifolia* | 54.9$^{a}$ | 101.3$^{a}$ | 166.0$^{a}$ | 175.6$^{a}$ | 71.7$^{a}$ | 109.8$^{b}$ | 159.0$^{a}$ | 182.9$^{a}$ |
| Natural fallow | 45.0$^{ab}$ | 85.1$^{a}$ | 138.3$^{b}$ | 158.9$^{a}$ | 65.9$^{ab}$ | 100.8$^{b}$ | 145.7$^{ab}$ | 166.7$^{a}$ |
| No fallow | 53.1$^{a}$ | 90.7$^{a}$ | 143.9$^{b}$ | 158.3$^{a}$ | 51.3$^{b}$ | 92.6$^{b}$ | 128.8$^{b}$ | 140.7$^{b}$ |
| SE± | 2.4 | 5.0 | 5.4 | 5.6 | 4.1 | 5.8 | 6.1 | 5.5 |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

**Maize Cob Girth**

Maize cobs were significantly (P<0.05) bigger in *S. obtusifolia* (L.) Irwin & Barneby fallow treatment but similar to those in natural fallow treatment than those obtained from all other treatments after one year fallow (Table 5). However, after two years fallow, *D. intortum* (Mill.) Urb., and *S. obtusifolia* (L.) Irwin & Barneby planted fallows produced similar bigger maize cobs than *H. suaveolens* fallow and no fallow treatment.

**Maize Cob Length**

Maize cob length was not significantly (P<0.05) different after one year fallow, but it was after two years of fallow (Table 5). In this case, *D. intortum* (Mill.) Urb., planted fallow produced significantly longer maize cobs than all other treatments, except in *S. obtusifolia* (L.) Irwin & Barneby planted fallow. No fallow (continuous cropping) produced the shortest maize cobs.

Table 5: Effect of fallow type on maize cob girth and cob length

| Fallow type | Cob girth (cm) | | Cob length (cm) | |
|---|---|---|---|---|
| | Years of fallow | | Years of fallow | |
| | One | Two | One | Two |
| *Hyptis suaveolens* | 11.5[b] | 11.7[b] | 8.7[a] | 9.6[bc] |
| *Desmodium intortum* | 11.5[b] | 12.8[a] | 9.3[a] | 10.9[a] |
| *Senna obtusifolia* | 12.5[a] | 12.6[a] | 9.4[a] | 10.3[ab] |
| Natural fallow | 12.0[ab] | 12.2[ab] | 8.7[a] | 9.1[c] |
| No fallow | 11.3[b] | 10.9[c] | 8.3[a] | 7.9[d] |
| SE± | 0.1 | 0.1 | | |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

**Maize Grain per Cob**

The number of maize grains per cob after one year fallow in *S. obtusifolia* (L.) Irwin & Barneby was the highest but, similar with those of other planted or natural fallows (Table 6). However, it was significantly higher than that of no fallow (continuously cropped) plot. Furthermore, after two years, *D. intortum* (Mill.) Urb. fallow produced higher number of grains per cob which was in turn similar to all other planted fallows. In contrast, no fallow which was similar with natural fallow treatment produced maize cobs with significantly lower number of grains than the planted fallows.

**Grain Yield**

Maize grain yield was significantly influenced by the number of years of fallows (Table 6). The planted and natural fallows were similar in maize grain yield after one year fallow, but only *S. obtusifolia* (L.) Irwin & Barneby fallow produced higher grain yield than no fallow. Maize grain yield from *D. intortum* (Mill.) Urb. and *S. obtusifolia* (L.) Irwin & Barneby fallows at two years were similar. However, maize grain yield in plots after *S.*

*obtusifolia* (L.) Irwin & Barneby fallow was significantly higher than that obtained from after *H. suaveolens* (L.) Poit., and natural bush fallow plots and from no fallow plots.

Table 6: Effect of fallow type on maize grains per cob and grain yield

| | Number of grains/cob | | Grain yield (kg ha$^{-1}$) | |
|---|---|---|---|---|
| Fallow type | Years of fallow | | Years of fallow | |
| *Hyptis suaveolens* | One | Two | One | Two |
| *Desmodium intortum* | 214.7$^{ab}$ | 222.3$^{ab}$ | 600.0$^{ab}$ | 1133.3$^{bc}$ |
| *Senna obtusifolia* | 211.7$^{ab}$ | 267.0$^{a}$ | 733.3$^{ab}$ | 1318.3$^{ab}$ |
| Natural fallow | 249.3$^{a}$ | 252.0$^{ab}$ | 844.3$^{a}$ | 1466.7$^{a}$ |
| No fallow | 201.0$^{ab}$ | 205.0$^{bc}$ | 533.3$^{ab}$ | 955.3$^{c}$ |
| SE± | 175.0$^{b}$ | 166.3$^{c}$ | 433.3$^{b}$ | 422.3$^{d}$ |
| | 12.5 | 12.1 | 77.5 | 74.0 |

Means followed by the same letter(s) in the same column are not significantly different from each other by Student Newman Keuls (SNK) test at $P \leq 0.05$.

## DISCUSSION

The high organic carbon added to the soil by planted *H. suaveolens* (L.) Poit. fallow was an indication of high leaf litter produced due to its bushy nature and its subsequent decomposition. This finding is in conformity with the report of Osundare (2015) who noted a significant increase in soil organic carbon values under *Panicum maximum*, *Chromolaena odorata* and *Centrosema pubescens* fallows compared to continuous maize cultivation (control). The increase in soil total nitrogen after two years fallow and the highest under *S. obtusifolia* (L.) Irwin & Barneby fallow suggest greater addition of nitrogen through litter decomposition and atmospheric fixation. This finding is in agreement with the works of Arit (2011) and Galeb (2012) who reported the highest total nitrogen value in *C. pubescens* planted fallow relative to *P. maximum* and *C. odorata* planted fallows. The highest addition of available phosphorus by *H. suaveolens* (L.) Poit., after two years fallow could be attributed to the higher soil organic carbon obtained. In previous studies, Osundare (2015) reported that plant nutrients are integrally tied to soil organic matter.

In this study, the planted fallows had the least number of *Striga* shoots, being most pronounced in *D. intortum* (Mill.) Urb., plots after two years fallow. This could be due to the negative impact of the species on *Striga* seed germination and seedling growth (Kayeke *et al*. 2007; Khan *et al*. 2007 and Kifuko-Koech *et al*. 2012). The consistently taller maize plants in the planted fallow plots could be attributed to the delay in *Striga* germination and efficient reduction in shoots which in turn translated into rapid maize growth and development. This result is consistent with the observations of Usman *et al*. (2018) who reported that cultivating maize after a planted fallow like *Aeschynomene histrix* fallow can increase plant height. The *S. obtusifolia* (L.) Irwin & Barneby planted fallow gave bigger cobs than the no fallow, though comparable to *D. intortum* (Mill.) Urb., and natural fallows. This indicates that planted fallow suppressed *Striga* effect on maize, thereby provided conditions for better crop growth and yield attributes production. This finding is in agreement with the findings of Reinhardt and Tesfamichael (2011) who observed that *Desmodium* can supplement applied N and inhibit *Striga* seed germination and in turn improve crop productivity. It was also obvious that *D. intortum* (Mill.) Urb., plot gave longer cobs compared with *S. obtusifolia* (L.)

Irwin & Barneby after two years fallow. Sjogren *et al*. (2010) reported that fodder legumes can effectively reduce *Striga* infestation, and increase growth and yield of the maize plant.

Furthermore, *S. obtusifolia* (L.) Irwin & Barneby and *D. intortum* (Mill.) Urb., gave more grains per cob than no fallow though comparable to other fallow practices. These fallow types gave taller maize plants, bigger and longer cobs, and healthier plants, thereby provided conditions for better maize yield. The highest grain yield of maize from *S. obtusifolia* (L.) Irwin & Barneby plot was compared to other fallow plots after one year, and *D. intortum* (Mill.) Urb., plot after two years fallow. This could be attributed to the effective reduction in *Striga* emergence and seedling growth, production of healthier maize plants which in turn produced higher grain yield. Maize grain yield from *S. obtusifolia* (L.) Irwin & Barneby one and two years fallows were 36.8 % and 34.9 % greater than that of natural fallow, respectively. Our result is similar to the findings of Usman *et al*. (2018) who reported that maize grown after *A. histrix* fallow effectively delayed *Striga* emergence, reduced its virulence on the host and increased grain yield compared to natural fallow.

## CONCLUSION

More organic material and hence organic carbon in addition to available phosphorus were added to the soil by *H. suaveolens* (L.) Poit., fallow, and more total nitrogen by *S. obtusifolia* (L.) Irwin & Barneby fallow. In terms of delay in *Striga* emergence and reduction in *Striga* shoot density, the best treatments were under planted fallows after two years. *Senna obtusifolia* (L.) Irwin & Barneby and *D. intortum* (Mill.) Urb., planted fallows increased maize growth and yield. Maize grain yield was highest in *S. obtusifolia* (L.) Irwin & Barneby planted fallow after one and two years and is therefore recommended for maize production in *Striga* infested farmlands in this agro-ecology of Nigeria.

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