# Screening of cotton lines as trap crops for the induction of abortive germination of *Striga hermonthica* (Del.) Benth in Nigeria

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## ABSTRACT

*Eighty-six cotton genotypes, including advanced northern and eastern zones cotton lines, multi-adversity and long staple cotton lines, were screened in the laboratory for their ability to stimulate* Striga hermonthica *germination using the cut-root technique. Highly significant differences were observed in the ability of the cotton lines to stimulate* Striga *seed germination, which ranged from 13.3 to 50% compared with 47% for the susceptible sorghum variety, CK60B used as a check. The combinations of the stage of growth of the trap crop and the preconditioning period of* Striga *seeds had significant influence on their germination. The wide variability in the cotton lines to stimulate abortive germination of* Striga *seeds is an indication that the trap crop can be improved for this trait. The implications of these results and the use of cotton as a potential trap crop and component of sustainable* Striga *control strategy in maize are discussed.*


## Introduction

*Striga* species constitute major biological constraints to food crop production in west and central Africa savanna, causing serious damage to cereal and grain legume crops on the fields of resource-poor farmers. Of the 23 species of *Striga* identified in Africa, *S. hermonthica* is the most ubiquitous species; causing much of the problems in the Sahelian areas (Pieterse, 1985). In Nigeria, maize is highly susceptible to three *Striga* species, namely *S. asiatica* (L.) Kuntze, *S. hermonthica* (Del.) Benth and *S. aspera* (Willd.) Benth. The problem of *Striga* as a major constraint to maize production in west and central Africa is increasing with the expansion of areas devoted to the crop. The situation is worsening due to intensive cultivation involving continuous monocropping of host crops in an attempt to produce sufficient food for the burgeoning population (Dogget, 1984; Vogt *et al*., 1991; Butler, 1991).

Over 67% of the 73 million hectares of land devoted to cereal crop production in Africa is currently in areas infested by *Striga* (Lagoke *et al*., 1995). Between 10 and 100% yield losses have been attributed to *Striga* in various crops including maize, depending on the intensity of infestation, incidence, distribution, varieties of host crop, location and cultural practices (Lagoke *et al*., 1991). An FAO estimate revealed that annual yield losses on cereals due to *Striga* spp. account for US $7 billion and are detrimental to the lives of over 100 million people (M'Boob, 1986).

There is no known single, effective and economically feasible *Striga* control method available. The control methods include: adequate land preparation, hand pulling and hoe-weeding, as well as the use of trap- and catch-crops, nitrogen fertilizer, seed treatment, herbicide spray, biocontrol agents and host-plant resistance. The use of trap-crops and resistant varieties are the two most feasible, promising and culturally acceptable methods of control in Nigeria. Trap crops are those that induce germination of *Striga* seeds but are not parasitized, and consequently result in abortive germination of *Striga*. Cowpea, pigeon pea, cotton, soyabean and bambara groundnut when grown in rotation with susceptible host or as intercrop have been reported to induce abortive germination of *Striga* seeds with a consequent reduction in infestation (Carson, 1985; Parkinson *et al*., 1986). In surveys conducted in Benin and Togo, it had been reported that the level of *Striga* infestation was always reduced in cereal crops planted after cotton (Parkinson *et al*., 1986).

The objective of this study was to investigate the variability among some cotton germplasm collections in their potential to stimulate abortive germination of *Striga hermonthica* seeds and identify efficient varieties and lines for the characteristic trait.

## Experimental procedure

Eighty-six cotton genotypes including 41 advanced northern and eastern zones cotton lines; 21 multi-adversity lines, three commercial varieties; all of *G. hirsutum* origin and 21 long staple cotton lines of *G. barbadense* were screened in the laboratory for their ability to stimulate the germination of *S. hermonthica* seeds using the cut-root technique developed by Van Mele *et al*. (1992).

The northern and eastern cotton zones are two major cotton growing zones in Nigeria, producing about 60-65 percent and 30-35 percent of the crop, respectively.

*Striga* seeds were collected in 1991 at Hayin Ojo, Kaduna State in the Northern Guinea Savanna. The seeds of each cotton genotype was delinted using sulphuric acid and rinsed several times with distilled water and sun-dried. The seeds were then surface sterilized by soaking in a 1% sodium hypochloride (NaOCl) solution for five minutes and then rinsed several times with distilled water. The seeds were then placed in sterile Petri dishes lined with moistened filter paper. The Petri dishes were wrapped in aluminium foil and incubated at 28 $^{0}$C for 48 hours to germinate. The germinating seeds were planted in sandy soils contained in small plastic pots (625 ml by volume) and arranged in completely randomized design with three repetitions and grown in two sets for 14 and 21 days. Moist glass micro fiber filters, 5.5 mm in diameter, were placed in Petri dishes lined with a double layer moistened Whatman, filter paper of 9 cm in diameter. *Striga* seeds were then spread one-layer thick in most glass micro fiber filter disks, wrapped with aluminium foil and incubated at 28 $^0$C on the same day that the germinating seeds were planted into small plastic pots. The plants were watered on a daily basis. At the end of 14 or 21 days, roots were obtained from the plants, washed free of soil and 1.0 g of root pieces were placed in a cone, made of "cellotape" at the centre of the Petri dishes lined with filter paper in three repetitions. Twenty dishes of glass micro fiber filters with preconditioned *Striga* seeds were placed in a diverging manner from the root core in the Petri-dishes which were then covered and sealed with "cello-tape", wrapped in aluminium foil and incubated at 28 $^0$C for three days, after which germinated and ungerminated *Striga* seeds were counted with the aid of a light microscope. Susceptible sorghum varieties SAR 35, IS 1260 and CK 60B were used as control in the trials.

## Results

Analysis of variance (data not presented) revealed highly significant effect in the stimulation of *Striga* seed germination among the cotton genotypes. Duncan's Multiple Range Test (DMRT) further revealed genotypic differences in the stimulation of *Striga* seed germination (Tables 1 to 4). Generally, higher *Striga* seed germination was recorded with combination of roots obtained from three week old plants and *Striga* seeds preconditioned for the same period than the corresponding two weeks crop growth stage and period (Tables 1 to 4). The mean percent germination among the northern zone cotton lines at two and three weeks ranged from 13.5 to 40.3% and 13.1 to 40% (Table 1). At two weeks, RASA (79) 15d gave the highest stimulation of 40.3%; while at three weeks, ACSA (79) 32f gave 40%. Amongst the commercial varieties, SAMCOT-10 gave the highest stimulation at both two weeks (36.7%) and three weeks (42%). SAMCOT-9, the current commercial variety grown in the northern cotton zone gave very low stimulation both at two and three weeks. The mean percent germination of the susceptible sorghum varieties at both two and three weeks ranged from 15.4 to 41.5% and 13.1 to 42.0%, respectively. CK 60B was the best check and stimulated 42% germination of *Striga* seeds. The performance of SAMCOT-10 and ACSA (79) 32f was comparable to that of the susceptible check CK 60B.

The mean percent stimulation of *Striga* seeds by the eastern zone cotton lines is presented in Table 2. The mean percent stimulation amongst the lines at two weeks ranged from 21.3 to 40.3% while at three weeks it ranged from 14.4 to 45%. SAMCOT-10 gave the highest stimulation at three weeks (49.5), which was comparable to the performance of ASA (79) 29C (45%); RASA (79) 72F (45%) and Y1422 (79) 52C (45%). The check CK 60B stimulated 45% *Striga* seeds as well.

In Table 3, the multi-adversity cotton lines stimulated *Striga* seed germination better than the susceptible checks except CK 60B. TX-CABS-1-83 gave the highest stimulation of 50%. The best susceptible check CK 60B gave 43%. The mean percent stimulation for TAMCOT CAMD-E, TXCDP37HH-1-83, SAMCOT-8 x TAMCOT HQ 95, SAMCOT-10 x TAMCOT HQ95 were comparable to that of CK60B. SAMCOT-10 gave a stimulation percent of 45%.

The mean percent germination at two and three weeks crop stages of the *G. barbadense* lines are presented in Table 4. Bar 14/25(81) 39 gave the highest stimulation of 40%, followed by Bar XL 7(79) 33 and Bar XL 7(79) 36 and Bar 14/25(81) 18 with 39.3%, respectively. The sorghum varieties except CK 60B gave low stimulation germination percent. SAMCOT-10 gave the highest stimulation (50%). Generally, the eastern zone and the exotic (multi-adversity) lines stimulated higher percentage of *Striga* seed germination compared to the northern zone cotton lines.

## Discussion

The significant differences obtained in the mean percent stimulation of *Striga* seeds among the cotton genotypes is an indication of the wide variability among the genotypes in their ability to stimulate *S. hermonthica* seed germination. These results are in agreement with earlier studies by Dejongh *et al*. (1993) in cotton, maize, soybean and cowpea, where variabilities in *Striga* seed germination stimulation was reported. Butler (1995) observed that sorghum genotypes showed wide differences in their capacity to produce germination stimulant.

The mean percent *Striga* germination at three weeks crop growth stage was higher than that obtained at two weeks. This result is consistent with reports of increased sensitivity of *Striga* seeds to germination stimulants with length of preconditioning (Worshen, 1987; Babiker *et al*., 1993).

The three sorghum varieties used as control in this study were selected based on their support of high emergence of *S. hermonthica* in the field, usually at 9 to 12 WAS. CK 60B stimulated a high level of germination of *Striga* seeds in the laboratory while SAR 35 and IS1260 gave low stimulant production at two and three weeks. This result tends to suggest that these two varieties only promote germination and subsequent emergence of *S. hermonthica* at an advanced stage under field conditions.

The cotton genotypes ACSA (79)2F, ASA (79) 65a, RASA (79) 72f, Y1422 (79) 52C, SAMCOT-10, TX-CABS-1-83, TXCDP37HH-1-83, SAMCOT-10 x TAMCOT-CAMD-E and Bar 14/25(81)39 induced high germination of *S. hermonthica*, thus indicating high potential for their use as trap crop genotypes.

The main emphasis in the control of *Striga* is: amelioration of yield reduction of host crop, reduction of *Striga* inoculation in the soil and prevention of seed production. The elimination or depletion of soil seed bank of *S. hermonthica* is the cornerstone of any effective *Striga* control strategy. As such SAMCOT-10, which is the current commercial variety grown in the southern cotton zone in Nigeria, could be recommended for use by farmers, either in rotation or as an intercrop with susceptible host crops in *Striga* endemic areas where cotton can be grown. The depletion rate of the seed bank as a result of rotation may be increased if a trap crop is introduced in the rotation scheme. In practice, the use of cotton alone as a trap crop in rotation or intercrop farming system may not be very efficient. However, cotton in combination with a cereal legume system could be an efficient *Striga* control strategy. An efficient legume helps to improve the low soil fertility by nitrogen fixation of *Rhizobium* or Brady-*Rhizobium* species in the symbiosis with legumes.

At the International Institute of Tropical Agriculture (IITA) Research Farms at Mokwa and Abuja, the maize crop is followed by cotton (SAMCOT-10) and soybean in a 3-year rotation. This system of rotation has been found to be efficient in reducing the soil *Striga* seed bank and significantly enhances the yield of susceptible host varieties.

In conclusion, the stimulations of abortive germination of seeds of *S. hermonthica* by these promising cotton lines and cultivars could be further evaluated both in pots and field trials, and if validated, improved maize productivity could be achieved through intercropping with promising trap crops as a control strategy for the management of *Striga*.

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***Table 1.*** *Germination of* S. hermonthica *seeds induced by advanced northern zone cotton lines at 14 and 21 days growth stages.*

| | Mean % germination* | |
|---|---|---|
| Genotypes | 14 days | 21 days |
| ASA (79) 158a | 28.0b-i | 33.3c-h |
| ASA (79) 29c | 20.0d-k | 37.3b-g |
| ASA (79) 65a | 35.3a-c | 45.0a-b |
| ASA (79) 60b | 26.7c-i | 33.7c-h |
| ASA (79) 28d | 40.3a-b | 29.8e-k |
| ACSA (79) 5f | 31.3a-f | 35.0c-h |
| ACSA (79) 8e | 29.4a-h | 34.3c-h |
| ACSA (79) 22d | 29.0b-h | 14.4l |
| ACSA (79) 90f | 24.8c-k | 33.8c-h |
| ACSA (79) 33b | 30.0a-g | 30.7d-i |
| RSA (79) 4a | 30.0a-g | 31.3d-i |
| RSA (79) 36f | 22.7c-k | 25.0h-k |
| RSA (79) 38c | 31.3a-f | 34.0c-h |
| RASA (79) 14b | 24.3c-k | 34.3c-h |
| RASA (79) 44d | 29.3a-h | 34.3c-h |
| RASA (79) 72f | 25.0c-k | 45.0a-b |
| RASA (79) 85c | 31.4a-f | 35.0c-h |
| Y1422 (79) 20b | 21.3d-k | 20.0j-l |
| Y1422 (79) 52c | 35.3a-c | 45.0a-b |
| SAMCOT-8 } Commercial cotton varieties | 29.3a-h | 32.7c-h |
| SAMCOT-9 } Commercial cotton varieties | 25.4c-k | 34.5c-h |
| SAMCOT-10 | 25.5c-k | 49.5a |
| SAR 35 } Checks | 23.0c-k | 27.0h-k |
| IS12 60 } Checks | 13.0k | 14.8l |
| CK 60B } Checks | 41.0a | 45.0a-b |

*Means followed by the same letter(s) are not significantly different at 0.01 level of probability (DMRT).

*Table 2.* *Germination of* S. hermonthica *seeds induced by advanced eastern zone cotton lines at 14 and 21 days growth stages.*

| | Mean % germination* | |
|---|---|---|
| Genotypes | 14 days | 21 days |
| ASA (79) 158a | 28.0b-i | 33.3c-h |
| ASA (79) 29c | 20.0d-k | 37.3b-g |
| ASA (79) 65a | 35.3a-c | 45.0a-b |
| ASA (79) 60b | 26.7c-i | 33.7c-h |
| ASA (79) 28d | 40.3a-b | 29.8e-k |
| ACSA (79) 5f | 31.3a-f | 35.0c-h |
| ACSA (79) 8e | 29.4a-h | 34.3c-h |
| ACSA (79) 22d | 29.0b-h | 14.4l |
| ACSA (79) 90f | 24.8c-k | 33.8c-h |
| ACSA (79) 33b | 30.0a-g | 30.7d-i |
| RSA (79) 4a | 30.0a-g | 31.3d-i |
| RSA (79) 36f | 22.7c-k | 25.0h-k |
| RSA (79) 38c | 31.3a-f | 34.0c-h |
| RASA (79) 14b | 24.3c-k | 34.3c-h |
| RASA (79) 44d | 29.3a-h | 34.3c-h |
| RASA (79) 72f | 25.0c-k | 45.0a-b |
| RASA (79) 85c | 31.4a-f | 35.0c-h |
| Y1422 (79) 20b | 21.3d-k | 20.0j-l |
| Y1422 (79) 52c | 35.3a-c | 45.0a-b |
| SAMCOT-8 | 29.3a-h | 32.7c-h |
| SAMCOT-9 } Commercial | 25.4c-k | 34.5c-h |
| cotton varieties | | |
| SAMCOT-10 | 25.5c-k | 49.5a |
| SAR 35 | 23.0c-k | 27.0h-k |
| IS12 60 } Checks | 13.0k | 14.8l |
| CK 60B | 41.0a | 45.0a-b |

*Means followed by the same letter(s) are not significantly different at 0.01 level of probability (DMRT).

*Table 3.* *Germination of* S. hermonthica *seeds induced by multi-adversity cotton lines at 14 and 21 days growth stages.*

| Genotypes | | Mean % germination* | |
|---|---|---|---|
| | | 14 days | 21 days |
| TAMCOT CAMD-E | | 23.0c-k | 40.0b-d |
| TAMCOT CAB CS | | 19.3e-k | 39.3b-e |
| TAMCOT Sp 215 | | 30.0a-s | 34.7c-h |
| TX-CABS-1-83 | | 29.7a-h | 50.0a |
| TAMCOT Sp 37 | | 27.0c-i | 29.0f-k |
| FX Cap 37HH-1-83 | | 40.0a-b | 43.2a-c |
| TX CABUCS US-1-83 | | 21.3d-k | 20.0j-l |
| TAMCOT Sphinx | | 19.7e-k | 34.0c-h |
| TAMCOT HQ 95 | | 19.3c-k | 32.0d-h |
| TX LEB CAS-3-85 | | 32.0a-e | 35.0c-h |
| TX CABCUS-2-84 | | 19.7e-k | 32.0d-h |
| TX-CABCHUS-1-84 | | 19.3e-k | 33.7c-h |
| SAMCOT-6 x TAMCOT CAMD-E | | 23.0c-k | 39.3b-c |
| SAMCOT-8 x TAMCOT CAMD-E | | 16.7i-k | 27.8h-k |
| SAMCOT-9 x TAMCOT CAMD-E | | 25.0c-k | 29.0f-k |
| SAMCOT-10 x TAMCOT CAMD-E | | 29.0b-h | 43.0a-c |
| SAMCOT-8 x TAMCOT HQ 95 | | 41.7a | 36.0b-g |
| SAMCOT-9 x TAMCOT HQ 95 | | 27.0c-1 | 34.3c-h |
| SAMCOT-10 x TAMCOT HQ 95 | | 18.0g-k | 43.1a-c |
| SAMCOT-9 x TX CABUCS US-1-83 | | 24.3c-k | 38.3b-f |
| SAMCOT-10 x TX CABUCS US-1-83 | | 20.0d-k | 37.3b-g |
| SAMCOT-8 | Commercial cotton varieties | 29.0a-h | 32.7d-h |
| SAMCOT-9 | Commercial cotton varieties | 21.7d-k | 25.3h-k |
| SAMCOT-10 | Commercial cotton varieties | 35.7a-c | 46.0a-b |
| SAR 35 | Checks | 23.0c-k | 22.0i-l |
| IS12 60 | Checks | 13.0j-k | 14.7l |
| CK 60B | Checks | 40.0a-b | 43.0a-c |

*Means followed by the same letter(s) are not significantly different at 0.01 level of probability (DMRT).

***Table 4.*** *Germination of* S. hermonthica *seeds induced by long staple cotton lines at 14 and 21 days growth stages.*

| Genotypes | | Mean % germination* | |
|---|---|---|---|
| | | 14 days | 21 days |
| Bar x L7 (79) 6 | | 21.3d-k | 25.0h-k |
| Bar x L7 (79) 8 | | 22.7c-k | 29.7e-k |
| Bar x L7 (79) 18 | | 28.1b-i | 33.3c-h |
| Bar x L7 (79) 21 | | 32.7a-e | 31.0d-i |
| Bar x L7 (79) 33 | | 26.3c-j | 39.3b-c |
| Bar x L7 (79) 35 | | 30.0a-g | 30.7d-i |
| Bar x L7 (79) 36 | | 26.3c-j | 39.3b-c |
| Bar 14/25 (81) 1 | | 22.8c-k | 25.0h-k |
| Bar 14/25 (81) 14 | | 31.3a-f | 34.0c-h |
| Bar 14/25 (81) 16 | | 32.0a-e | 35.0c-h |
| Bar 14/25 (81) 18 | | 23.0c-k | 39.3b-e |
| Bar 14/25 (81) 23 | | 24.3c-k | 34.0c-h |
| Bar 14/25 (81) 39 | | 26.3c-j | 40.0b-d |
| Bar 14/25 (81) 43 | | 28.0b-i | 35.0c-h |
| Pima $S_1$ | | 29.3a-h | 34.3c-h |
| Pima $S_2$ | | 24.3c-k | 32.7d-i |
| Pima $S_3$ | | 25.0c-k | 38.3b-f |
| Pima $S_4$ | | 28.7b-i | 37.0b-g |
| Giza 45 | | 19.3e-k | 32.0d-h |
| Giza 68 | | 18.7f-k | 20.7j-l |
| Gize 69 | | 26.0c-j | 28.7f-k |
| SAMCOT-8 | Commercial cotton varieties | 30.0a-g | 35.0c-h |
| SAMCOT-9 | Commercial cotton varieties | 24.7c-k | 34.3c-h |
| SAMCOT-10 | Commercial cotton varieties | 26.3c-j | 50.3a |
| SAR 35 | Checks | 25.0c-k | 29.0f-k |
| IS12 60 | Checks | 16.7i-k | 27.7h-k |
| CK 60B | Checks | 38.2a-c | 40.0b-d |

*Means followed by the same letter(s) are not significantly different at 0.01 level of probability (DMRT).