

Host plant resistance and anti-transpirant for the control of *Alectra vogelii* in soybean

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Abstract

Striga and related parasitic weed *Alectra vogelii* have become the greatest biological constraints to food production in the dry savannas of West and Central Africa. Yield losses in cereals caused by *Striga* spp. are in the range of 10-70%. Total yield loss in cowpea due to *Alectra* infestation is also common. *Alectra vogelii* is an angiosperm root hemi-parasite attacking C₃ legumes; such as cowpea, groundnut and grams. Soybean, which is relatively free of pests in the dry savanna, is increasingly being threatened by *A. vogelii*. Integrated control methods involving the use of host-plant resistance and cultural practices are often recommended for the management of parasitic weeds in cereals and food legumes. Screenhouse studies were conducted in the northern Guinea savanna of Nigeria to determine the reaction of 5 genotypes of soybean to *Alectra* and its control using anti-transpirants. There were significant differences between the soybean genotypes in the number of emerged *Alectra* shoots and days to first *Alectra* emergence. Two genotypes, TGX 1440-2E and TGX 1519-1D, supported fewer and delayed *Alectra* shoot emergence while three were susceptible. Low emergence of *Alectra* on the resistant genotypes was probably due to low production of *Alectra* germination stimulating root exudates. Application of local anti-transpirants prevented *Alectra* from producing seeds and indicated dramatic change in that within ten days of application, 100% control of *Alectra* was achieved using shea butter and paraffin oils.

Key words: Soybean, parasitic weeds, *Alectra vogelii*, resistance, anti-transpirant.

Introduction

Alectra vogelii (Benth.) is an obligate parasite of grain legumes; particularly cowpea (*Vigna unguiculata* L.), groundnut (*Arachis hypogea*), soybean (*Glycine max* (L.) Merrill), bambara (*Voandzia subterranea* L.) and green gram (*Vigna radiata* (L.) Wilczek)^{15,23}. Cowpea is also attacked by *Striga gesnerioides*, where the two parasites co-exist³. *Alectra* is particularly more destructive in the northern Guinea and Sudan savanna agro-ecological regions where the damage is exacerbated by marginal nutrient status of the soils and unreliable rainfall^{2,27}. The parasite has its greatest impact in low-input subsistence farming systems, where many farmers' fields have been blighted². Serious crop yield losses, caused by *A. vogelii*, have been reported in cowpea and groundnut^{3,22,26,27}. Many cultivated fields have been abandoned because of high soil infestation from *A. vogelii* and related parasitic weeds such as *Striga hermonthica*. *Striga* also causes serious yield losses in cereals in the northern Guinea of West and Central Africa. Field infested by these parasitic weeds are difficult to clean, due to their enormous reproductive capacity (e.g. *S. hermonthica* produces 40,000–60,000 seeds per plant while *A. vogelii* produces 10 times as many) and due to the capacity of their seeds to persist in the soil for several years¹³.

Soybean has become increasingly important in Nigeria and parts of West and Central Africa and has spread to large parts of the Guinea savanna zone, where it is well adapted²⁸. In addition to its use as food and source of vegetable oil, soybean is important because it contributes to soil fertility improvement and reduces the seed bank of *Striga hermonthica* through the stimulation of suicidal germination when grown in rotation with cereals⁴. Soybean contributes to soil N through biological nitrogen fixation,

some of which can be made available to the subsequent maize crop. Nitrogen fertilizer recommendations for maize following soybean may be reduced, making maize production more sustainable from an ecological and economic perspective⁵. The possibility of using soybean as a trap crop for *S. hermonthica* has been mentioned by some workers^{4,6,16} and also suggested crop rotation with efficacious grain legumes as the key to a successful integrated *S. hermonthica* control programme.

Compared to other grain legumes, soybean is faced with few pest problems in the Guinea savanna. However, the threat of the parasitic weed *A. vogelii* to this crop may affect its production if urgent measures are not taken to manage it.

Extensive work has been done in West and Central Africa in breeding for resistance or tolerance of maize to *S. hermonthica*^{1,10-12}. Several authors have reported host plant resistance of cowpea to *A. vogelii*^{3,17,27}. Although differential response of soybean varieties to *A. vogelii* infestation has been reported¹⁵, to our knowledge, there are no known studies in West and Central Africa, on the use of integrated approach involving the combination of crop resistance with other crop management practices for *Alectra* control.

Integrated approach offers probably the best option for the control of parasitic weeds by resource-poor farmers in the West African savanna. For effective management of *S. hermonthica* in the field, Berner et al.⁴ recommended the combined use of host plant resistance, crop rotation with non-host nitrogen fixing legumes, using cultivars selected for their efficacy in stimulating the suicidal germination of *S. hermonthica* seeds and other cultural practices. Chemicals and cultural methods have been

successfully used to manage parasitic weeds and have proved useful in the control of *S. asiatica* (L.) Kuntze in the USA. *Striga* and related parasitic weeds like *Alectra* were reported to have remarkably high rates of transpiration which exceeds those of other annuals in similar environments^{20,22,25}. The stomata remain open when plants are placed in darkness²⁵ and at night²² and are relatively insensitive to water stress²⁰. The high rates of transpiration and the unusual feature of the stomata behaviour exhibited by these parasite can best be interpreted as means of maximizing the flux of resources from the host to the parasite, thus, ensuring supplies of water, inorganic and organic solutes²⁵. The nutritional dependence of parasitic weeds on high transpiration rates suggests the possibility that anti-transpirants might be used to limit the growth of the parasites and thus provide a novel control method. The three principles of parasitic weed control include reduction of seed number in the soil, prevention of new seed production and prevention of movement of seeds from infested to non-infested areas¹⁹. The objectives of this study were therefore to evaluate some widely grown improved soybean genotypes for their reaction to *Alectra* and prevent new seed production by determining the efficacy of some selected anti-transpirants for the control of *A. vogelii*.

Materials and Methods

Two screenhouse trials were conducted during March to May and repeated during August through October, 1998 at Samaru in the northern Guinea savanna zone of Nigeria to study the efficacy of selected anti-transpirants for the control of *A. vogelii* on soybean. The experimental subjects in the first trial were five widely grown soybean cultivars and four abscisic acid (ABA) concentrations (0, 100, 200, 400 ppm), while in the second trial, six locally available materials used as anti-transpirants (shea butter oil, paraffin, gum Arabic, kaoline, vaseline and talc-magnetite) were compared with the control (distilled water) using a susceptible widely grown soybean cultivar, SAMSOY 2. Both trials were arranged in a completely randomized design repeated four times. ABA was chosen in the first trial because it is a known anti-transpirant that affects stomata conductance and transpiration of crops.

About 2,000 *Alectra* seeds were thoroughly mixed with 1000 ml sieved sand to form the inoculum stock. The inoculum stock was

used to inoculate each experimental pot (18 cm in diameter and 2.16 litre in volume) which contained a mixture of sand and soil (1:1 v/v) so that the pot was filled to the brim. The uninoculated control pots were filled to the brim with unsterilized soil-sand mixture (1:1 v/v). After inoculation, the *Alectra* seeds were pre-conditioned for seven days by daily watering the soil in the pots to field capacity. After pre-conditioning of *Alectra* seeds, eight soybean seeds were planted per pot. The experimental pots were subsequently watered to field capacity throughout the period of the trials.

ABA as well as the local materials used as anti-transpirants were applied to *A. vogelii* shoots at 60 days after sowing of the inoculated soybean cultivar(s). Some 15 ml each of the liquid base anti-transpirants (ABA, distilled water, gum Arabic, shea butter oil and paraffin) were applied to *Alectra* plants in each pot using a white-flag sprayer. The paste base materials (kaoline, vaseline, talc-magnetite) were each dissolved in 15 ml of water and applied to *Alectra* plants in each pot using brushes.

Data collected were number of emerged *Alectra* shoots before application of anti-transpirants, number and percentage of dead *Alectra* shoots at 5 and 10 days after application of anti-transpirants. The percentage of *Alectra* shoots that died after application of anti-transpirants was calculated using the formula:

$$\% \text{ Dead shoots} = \frac{\text{Number of dead shoots after application of anti-transpirant}}{\text{Number of live shoots before application of anti-transpirant}} \times \frac{100}{1}$$

The General Linear Model procedure (GLM; Statistical Analysis Systems Package²⁴) was used for data analysis on the parameters and significant differences between treatment means were compared using Duncan's multiple range test.

Results and Discussion

There was a significant cultivar effect on the number of emerged *Alectra* plants (Table 1). The number of emerged *Alectra* plants ranged from 0.3 to 8.4 before and after ABA application, respectively. Soybean cultivars, TGX 1440-2E and TGX1519-1D supported fewer *Alectra* shoot emergence while the rest supported high *Alectra* shoot emergence. *Alectra* emergence occurred earlier in the most susceptible widely grown genotypes, namely, TGX 1019-2EB, TGM 344 and M-351 than in the resistant cultivars. Our result corroborates those of Alonge et al.² who

recently reported differences among cowpea genotypes in their ability to allow *Alectra* shoot emergence. Kureh and Alabi¹⁴ reported that resistant soybean cultivars supported fewer *Alectra* shoots, were less damaged and had more Rhizobium nodulation, shoot dry matter production and plant height than susceptible cultivars. All these results suggest that host plants can respond differently to parasitic weed infestation.

Table 1. Effects of cultivar and abscisic acid concentration on the number of live, dead, percentage of dead *Alectra* shoots and days to first *Alectra* emergence in the screenhouse, Samaru, Nigeria, 1998.

Treatment	No. of <i>Alectra</i> plants at ABA application	Number of dead <i>Alectra</i> plants		Percentage of dead <i>Alectra</i> plants		No. of days to 1 st <i>Alectra</i> emergence
		5 DAA*	10 DAA	5 DAA	10 DAA	
TgX 1019-2EB	8.4a**	0	0	0	0	44b
TGX 1440-2E	0.3c	0	0	0	0	50a
TGM 344	2.3b	0	0	0	0	38c
TGX 1519-1D	0.3c	0	0	0	0	49a
M-351	3.1b	0	0	0	0	46b
Abscisic acid conc. (ppm)						
0	1.6	0	0	0	0	46
100	3.1	0	0	0	0	46
200	3.4	0	0	0	0	45
400	2.3	0	0	0	0	45
Interaction						
V x C	NS	-	-	-	-	NS

* DAA Days after application of anti-transpirant.

** Means followed by the same letter(s) within a column are not statistically different at 5% level of probability according to Duncan's multiple range test (DMRT).

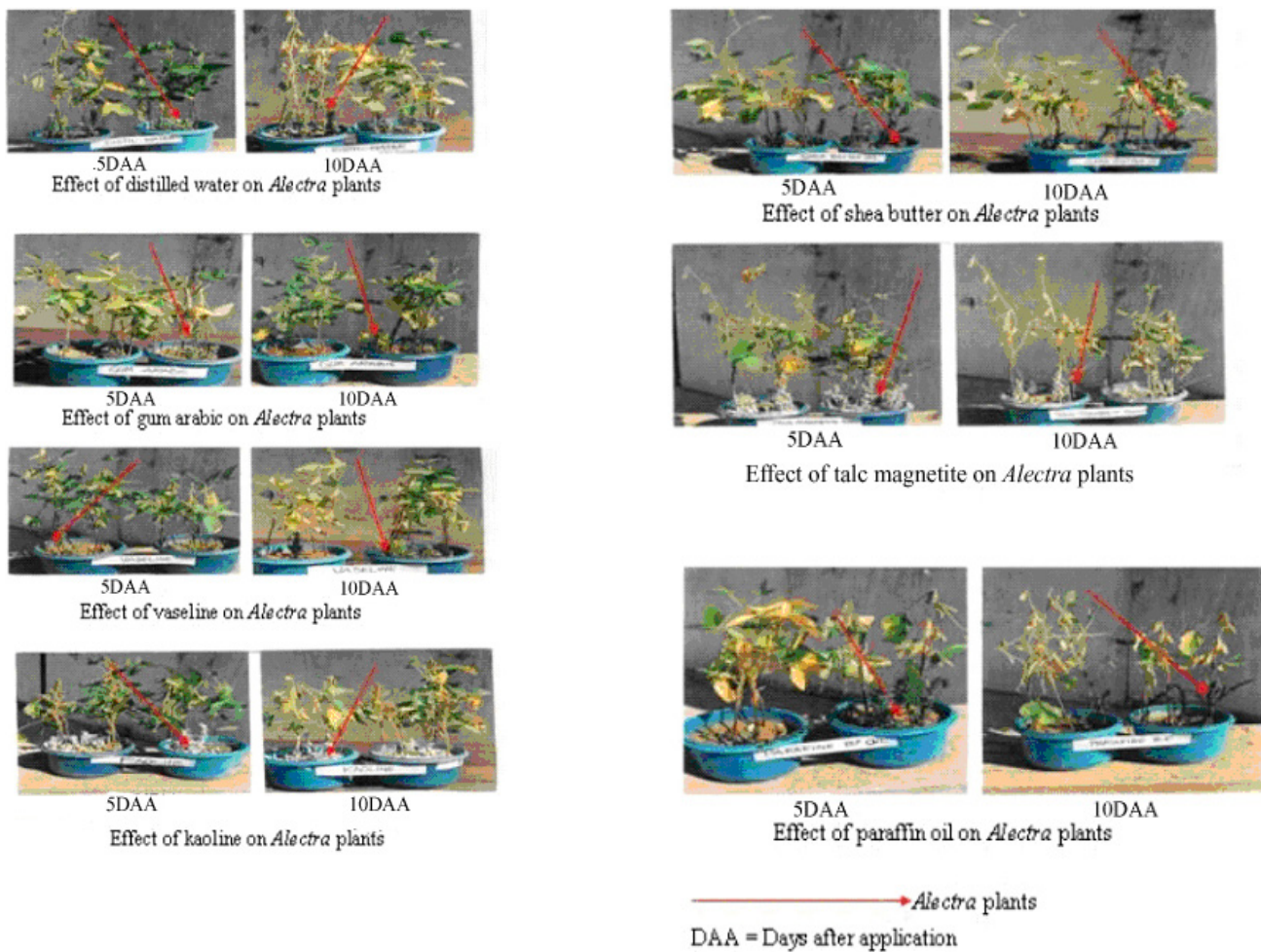


Figure 1. Effect of experimental treatments on *Alectra* plants.

In cowpea, vertical resistance occurs based on single gene that inhibits *Alectra* germination or attachment²⁶. In the present study two different mechanisms of resistance may be responsible. The low emergence may either be due to low germination stimulant production by the genotypes or to host-parasite incompatibility. On the other hand, in the case of *S. hermonthica*, it is known that the ability of host plants to tolerate the parasite involves several different mechanisms^{7, 8, 10-12}. Inhibition of *Striga* germination through low production of germination stimulating host plant root exudate compounds, prevention of haustoria initiation and attachment to host and prevention of attachment and penetration are found to confer resistance in some genotypes of cereals to *Striga*^{8, 9, 30}.

Table 2. Effect of anti-transpirant on number and percentage of dead *Alectra* shoots at five and ten days after application in the screen house, Samaru, Nigeria, 1998.

Anti-transpirant	Number of <i>Alectra</i> plant at application of anti-transpirants	Number of dead <i>Alectra</i> plants		Percentage of dead <i>Alectra</i> plants	
		5 DAA*	10 DAA	5 DAA (%)	10 DAA (%)
Control – distilled water	13.0	0.0c**	0.0b	0.0c	0.0b
Gum Arabic	12.3	7.3abc	11.0ab	68.3ab	84.3a
Kaoline	12.5	7.8abc	10.3ab	66.5ab	91.3a
Vaseline	10.8	3.8bc	5.5ab	59.3ab	68.8a
Shea butter	11.3	10.5ab	11.3ab	90.3a	100.0a
Talc-magnetite	15.5	5.3bc	10.0ab	34.0bc	70.5a
Paraffin	13.8	13.5a	13.8a	98.0a	100.0a

* DAA: Days after application of anti-transpirant.

** Means followed by the same letter(s) within a column are not statistically different at 5% level of probability according to Duncan's multiple range test (DMRT).

Abscisic acid at all concentrations (Table 1) and the control treatment (distilled water) did not affect *Alectra* shoots (Table 2, Fig.1). The stomata remained open throughout the period of the experiment. This tends to suggest that abscisic acid may not be good anti-transpirant for *Alectra* control. This observation confirmed the findings²⁵ that *Striga* stomata are insensitive to abscisic acid. Thus stomata conductance and transpiration were maintained at such a high level to cause substantial evaporative cooling of the leaf and allow the influx of water, metabolites and solutes to the parasitic plant.

However, the application of local anti-transpirants indicated dramatic change and resulted in the death of *Alectra* shoots

(Table 2, Fig. 1). At 5 and 10 days after application, the percentages of *Alectra* plants that died ranged from 34 to 98% and from 69 to 100%, respectively. The leaves of *Alectra* plants began to darken and shrivel after the application of the local anti-transpirants, suggesting an effect over and above that of simply reducing the flux of solutes to the parasite by stomata closure. The anti-transpirants probably caused a significant increase in the heat load of the parasitic plants and thereby induced heat stress in *Alectra*. Nour et al.¹⁸ and Press et al.²¹ reported effective control of *Striga* with the application of an anti-transpirant wilt

pruff S600®. Similarly, Riches²² obtained encouraging results when guar gum solution was applied on *Striga* plants as anti-transpirant. The local materials used in this investigation are cheap and may provide a cheap *Alectra* control option. The choice of these materials would be facilitated by studies of the mechanism of stomata control in *Alectra* as has been earlier suggested for *Striga*²⁹.

Given the devastating effects of parasitic weeds such as *Striga* spp. to both cereals and other legumes in the savanna, the threat of *Alectra* should not be underestimated. Combining several control methods like in the case of the management of *Striga* spp. will prove to be a sustainable option. Our study has confirmed the potential for exploiting host-plant resistance and prevented *Alectra* plants from producing seeds through the use of anti-transpirants as an integrated control option for the management of *Alectra* on soybean. This is because significant variations were established among soybean genotypes and up to 100% control of *Alectra* was achieved by the application of anti-transpirants.

Conclusions

There were significant differences between the soybean genotypes in the number of emerged *Alectra* shoots and days to first *Alectra* emergence. Two genotypes, TGX 1440-2E and TGX 1519-1D, supported fewer and delayed *Alectra* shoot emergence while three were susceptible. Application of local anti-transpirants prevented *Alectra* from producing seeds and indicated dramatic change in that within ten days of application, 100% control of *Alectra* was achieved using shea butter and paraffin oils.

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References

¹Adetimirin, V.O., Kim, S.K. and Aken'Ova, M.E. 2000. Expression of mature plant resistance to *Striga hermonthica* in maize. *Euphytica* **34**: 1-10.

²Alonge, S.O., Lagoke, S.T.O. and Ajakaiye, C.O. 2001. Cowpea reactions to *Alectra vogelii* I: effect on growth. *Crop Protection* **20**: 283-290.

³Atokple, I.D.K., Singh, B.S. and Emechebe, A.M. 1995. Genetics of resistance to *Striga* and *Alectra* in cowpea. *Journal of Heredity* **86**: 45-49.

⁴Berner, D.K., Carsky, R., Dashiell, K., Kling, J. and Manyong, M. 1996. A land management based approach to integrated *Striga hermonthica* management in Africa. *Outlook on Agriculture* **25**: 157-164.

⁵Carsky, R.J., Abaiido, R., Dashiell, K. and Saginga, N. 1997. Effect of soybean on subsequent grain yield in the Guinea savanna zone of West Africa. *African Crop Science Journal* **1**: 33-38.

⁶Carsky, R.J., Berner, D.K., Oyewole, B.D., Dashiell, K. and Schutz, S. 2000. Reduction of *Striga hermonthica* parasitism on maize using soybean rotation. *International Journal of Pest Management* **46**: 115-120.

⁷Efron, Y. 1993. Screening maize for tolerance to *Striga hermonthica*. *Plant Breeding* **112**: 192-200.

⁸Ejeta, G. and Butler, L.G. 1993. Host-parasite interactions throughout the *Striga* life cycle and their contributions to *Striga* resistance.

African Crop Science Journal **1**: 75-80.

⁹Hess, D.E., Ejeta, G. and Butler, L.G. 1992. Selecting sorghum genotypes expressing a quantitative biosynthesis trait that confers resistance to *Striga*. *Phytochemistry* **31**: 493-497.

¹⁰Kim, S.K. 1994. Genetics of tolerance of maize to *Striga hermonthica*. *Crop Science* **34**: 900-907.

¹¹Kim, S.K. 1996. Horizontal resistance. Core to a research break-through to combat *Striga* in Africa. *Integrated Pest Management Review* **1**: 229-246.

¹²Kim, S.K. 1997. Achievements, challenges and future direction of hybrid maize research and production in West and Central Africa. In Badu-Apraku, B., Akoroda, M.O., Ouedraggo, M. and Quin, F.M. (eds.). *Contribution to food sufficiency: Maize Research and Development in West Africa. Proceedings of a Regional Maize Workshop, 29 May – 2 June, 1995, IITA Ibadan, Nigeria.* pp. 42-82.

¹³Kroschel, J. 1998. *Striga* – How will it affect African agriculture in future? An ecological perspective. *Plants* **16**: 137-158.

¹⁴Kureh, I. and Alabi, S. O. 2003. The parasitic angiosperm *Alectra vogelii* (Benth.) can influence the growth and nodulation of host soybean (*Glycine max* (L.) Merrill). *Crop Protection* **22**:361-367.

¹⁵Kureh, I., Katung, M.P. and Orakwue, F.C. 1999. Reaction of soybean varieties to pre-conditioning and concentration of seed inoculum of *Alectra vogelii* (Benth.). *Science Forum: Journal of Pure and Applied Sciences* **2**: 116-124.

¹⁶Kureh, I., Chiezey, U.F. and Tarfa, B.D. 2000. On-station verification of the use of soybean trap crop for the control of striga in maize. *African Crop Science Journal* **8**: 295-300.

¹⁷Lane, J.A., Bailey, J.B. and Terry, P.J. 1991. An *in-vitro* growth system for studying the parasitism of cowpea (*Vigna unguiculata*) by *Striga gesnerioides*. *Weed Research* **31**: 211-217.

¹⁸Nour, J.J., Press, M.C., Bebawi, F.F. and Stewart, G.R. 1988. Anti-transpiration induced heat stress in *Striga* a novel method of control. *Plant Physiology* **86**: 55-60.

¹⁹Obilana, A. T. and Ramiah, K. V. 1992. *Striga* (witchweeds) in sorghum and millet: Knowledge and future research needs. In de Milliano, W.A.J, Frederiksen, R. A. and Bengstown, G. D. (eds). *Sorghum and millet diseases. International Research Institute for the Semi-Arid Tropics. (CP741) Patancheru, AP. 502 323, India.* pp.187-201.

²⁰Press, M.C., Shah, N., Tuohy, J. and Stewart, G.R. 1987. Carbon isotope ratios demonstrated carbon flux from C₄ host to C₃ parasite. *Plant Physiology* **83**: 1143-1145.

²¹Press, M.C., Nour, J.J., Bebawi, F.F. and Stewart, G.R. 1989. Anti-transpirant-induced heat stress in the parasitic plant *Striga hermonthica* a novel method of control. *Journal of Experimental Botany* **40**: 585-591.

²²Riches, C.R. 1990. The biology and control of *Alectra vogelii* Benth (Scrophulariaceae) in Botswana. Ph.D. Thesis, University of Reading, UK, 208 pp.

²³Riches, C.R., Hamilton, K.A. and Parker, C. 1992. Parasitism of grain legumes by *Alectra* species (Scrophulariaceae). *Annals of Applied Botany* **121**: 361-370.

²⁴SAS. 1990. SAS/STAT User's Guide. Version 6, 4th edition. SAS Inc. Cary, North Carolina, USA.

²⁵Shah, N., Smirnoff, N. and Stewart, G.R. 1987. Photosynthesis and stomata characteristics of *Striga hermonthica* in relation to its parasitic habit. *Physiologia Plantarum* **69**: 697-703.

²⁶Singh, B.B. and Emechebe, A.M. 1991. Breeding for resistant to *Striga* and *Alectra* on cowpea. In Ransom, J.K., Musellman, L.J., Warshan, D.A. and Parker, C. (eds). *Proceedings 5th International Symposium on Parasitic Weeds, 24-30 June, 1991, Nairobi, Kenya. CIMMYT, DF, Mexico.* pp. 303-305.

²⁷Singh, B.B., Emechebe, A.M. and Atokple, D.K. 1993. Inheritance of *Striga* resistance in cowpea genotype B301. *Crop Science* **30**: 879-881.

²⁸Smith, J., Woodworth, J.B. and Dashiell, K.E. 1993. Government policy and farm-level technologies. The expansion of soybean in Nigeria.

Agricultural Systems in Africa **3**: 20-32.

- ²⁹Stewart, G.R., Press, M.C. and Graves, J.D. 1991. The physiology and biochemistry of parasitic angiosperm. Annual Review of Plant Physiology and Plant Molecular Biology **41**: 127-151.
- ³⁰Vogler, R.K., Ejeta, G. and Butler, L.G. 1996. Inheritance of low production of *Striga* germination stimulant in sorghum. Crop Science **36**: 1185-1191.