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GERMINATION OF WITCHWEED *[Striga hermonthica (Del) Benth.]* SEEDS IN RESPONSE TO STIMULATION BY ROOT EXUDATES OF SOYBEAN *(Glycine max L.)*

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ABSTRACT

Using an adaptation of the Cut-root technique, twenty-one varieties of soybean were screened at 10, 15 and 20 days after planting (DAP) for the stimulation of *S. hermonthica* seed germination. The varieties were TGX1649-11F, TGX1740-7F, TGX1660-15F, TGX1740-2F, TGX1670-3F, TGX1674-3F and SAMSOY-2. Other varieties tested included TGX1681-3F, TGX1479-1 E, TGX923-2 E, TGX1440-1 E, TGX1448-2 E, TGX1660-19F, TGX1519-10F, TGX1019-2EN, TGM-344, TGX1019-EB, TGX1485-1D, TGX536-02D, TGM-351 and TGX849-3B. The strigol analogue, GR-24, was used as the control.. The germination of *S. hermonthica* seeds that was stimulated by GR-24 was significantly higher ($P \leq 0.01$) than that stimulated by all the soybean varieties at all the periods. The most promising varieties were TGX1681-3F, TGX1479-1 E ,TGX1649-11F and SAMSOY-2 with Specific Effectiveness Index (SEI) values of 0.76, 0.75, 0.58 and 0.54, respectively. The other varieties that showed promise include TGX1740-7F , TGX923-2E TGX1440-1 E and TGM344 with SEI values of 0.44, 0.44, 0.45 and 0.44, respectively. There was no relationship between the age of the plant and potency of its root exudates, except for TGX1649-11F, TGM-344 and TGX1681-3F where activity increased with age from 10DAP to 20DAP. These varieties may therefore be used in field crop rotation systems as an option for the management of *S hermonthica*.

Key words : witchweed, soybean, trapcropping, crop rotation, Striga hermonthica

INTRODUCTION

S. hermonthica (Del.) Benth., the giant witchweed is hemiparasitic on sorghum as well as other cereal crops such as maize, millet, rice, teff (M'Boob,1991 ; Ejeta et al.,1992) and barley (Reda et al.,1990). It survives through haustorial connection with the root of the host from which it draws water, nutrients and photosynthates like reducing sugar and amino acids (Okonkwo, 1966; Dogget, 1984). Most of the damage to the host usually occurs before the emergence of *Striga* (Yoshikawa et al., 1978; Press et al., 1991). *S. hermonthica* is known to cause stunting, reduction in vigour and in extreme cases, total collapse and death of the cereal plant. *Striga* introduces toxins into the host plant which alter hormonal balance in the host, causing greater damage than mere removal of nutrients (Ejeta et al., 1992; Frost et al., 1997). Two-thirds of the 73 million hectares of land devoted to cereal crop production in Africa are seriously affected, the greatest damage occuring in the Sahelian and Savanna zones (Lagoke et al., 1991). Lagoke et al., (1994) reported that in Nigeria 94% of the farms in the Savanna zone are infested with *Striga* causing yield losses of between 10% and 100%.. A conservative estimate of total annual value of cereal crop losses due to *Striga* in Africa is US $ 7billion (M'Boob, 1989) and in Nigeria it is

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valued at US $ 250million (Lagoke, 1989).

Germination of *Striga* seeds is usually triggered by chemical stimulants produced in the roots of the host and some non-host plants (Ramaiah and Parker,1982); for example, strigol ; sorgoleones (Netzly et al., 1988) and sorgolactone (Hauck et al., 1992). Analogues of strigol exhibiting growth regulatory (GR) activity have been synthesized (Johnson et al., 1976, 1981) ; some of these GR compounds that are as biologically active as the natural product are GR5, GR7 and GR24 (Boone et al., 1995). Usually only seeds within 1cm of roots exuding stimulant may germinate (Dogget, 1965). The seeds can produce radicle up to 5-10mm length before seed energy reserves are exhausted. The radicle must therefore become attached to a host root within a few days (Ramaiah and Parker, 1982) for the parasite to survive. Poor soils have been associated with the build-up of *Striga* (Lagoke et al., 1991). Thus, improving soil fertility would serve as an alternative means of checking the spread and devastating effects of the parasite and to restore productivity of the land to sustainable levels. Trapcropping and crop rotation have been suggested as the most viable approach to management of *Striga* infestation in farmers' fields. The integration of trap crops into the farming system of a locality is a prerequisite for wide acceptance of this method (Lagoke et al., 1991). Crop legumes are, therefore, the most promising because they are cash crops (Weber et al., 1995), in addition to providing high protein pulses for home consumption. They also improve soil fertility by symbiotic nitrogen fixation.

Alabi et al., 1994. had suggested that laboratory screening can be effectively used to identify soybean varieties that could be useful in *S. hermonthica* control. He reported that variety TGx923-2E gave 25% increase in maize yield in the following maize crop (Alabi et al.,1995). Ariga et al., (1994) have recommended that trap crops be first screened *in-vitro* for high stimulation of germination of *Striga* seeds before being used in rotation systems. Host preferences within a single species of *Striga* which are attributed to differences in strains or races and consequent variation in responses to experimental conditions have been noted (Boone et al., 1995). The objective of this study was therefore to identify varieties of soybean whose root exudates stimulated high germination of *S. hermonthica* seeds obtained from sorghum hosts.

MATERIALS AND METHODS

The Cut-root Technique (van Mele et al.,1992) was adapted at the Weed Science laboratory of the Institute for Agricultural Research, Ahmadu Bello University, Zaria for screening of twenty-one varieties of soybean for stimulation of *S. hermonthica* seed germination. Seeds of the parasite were obtained from sorghum hosts in the Zaria area in the Northern Guinea Savanna of Nigeria.. The screening was carried out in three batches between September and October 1995. The soybean varieties in the first batch were TGX1649-11F, TGX1740-7F, TGX1660-15F, TGX1740-2F, TGX1670-3F, TGX1674-3F and SAMSOY-2. The varieties in the second batch included TGX1681-3F, TGX1479-1 E, TGX923-2 E, TGX1440-1 E, TGX1448-2 E, TGX1660-19F, TGX1519-10F and TGX1019-2EN. The third batch included TGM-344, TGX1019-EB, TGX1485-1D, TGX536-02D, TGM-351 and TGX849-3B. The strigol analogue, GR-24, was used as control in all the three instances.

Procedure

Roots of the above-named grain legumes which were grown for 10, 15 and 20 days repectively in small pots, measuring 10cm x 7cm x 5cm, were washed clean of soil and cut with a pair of scissors into 0.5cm long pieces. A hollow ring was made of aluminium foil and placed centrally on moist filter paper in a petri dish. Discs of glass fibre filter paper made with paper punch and bearing preconditioned (IITA,1993) *S. hermonthica* seeds were arranged radially in four divergent rows of five discs each from the central hollow ring in the petri dish. One gram weight of the cut roots was placed in the central hollow and 1ml of distilled water added. In the control 1ml GR-24 solution (1mgL^{-1}) was applied into the central hollow without the cut roots. The petri dish was covered with a lid. sealed with cellophane, wrapped in aluminium foil and incubated at 33°C for 48 hours. The design adopted was a completely randomised design with three replications.

Germinated and ungerminated seeds of *S. hermonthica* were counted under the low power (x20) of a stereoscopic microscope. A seed was considered germinated when the germ tube became clearly visible. Percentages of the germinated seeds were calculated and the values obtained used for analysis of variance. Means seperation, where the F test indicated significance, was done using the Least Significant Difference *(LSD)*. Specific Effectiveness Index *(SEI)* for each variety of soybean was computed as the ratio of the mean percentage germination stimulated by that variety to that stimulated by the control in each case (Gbehounou,1998).

RESULTS AND DISCUSSION

The results of screening of the first batch of soybean varieties are shown in Table 1. The strigol analogue GR-24 significantly (P≤0.05) stimulated higher percentages of germination of *S. hermonthica* seeds at 10, 15 and 20 DAP when compared to the soybean varieties. Among the grain legume varieties themselves, TGX 1649-11F had germination levels of 26.0%, 29.0% and 30.6% at 10, 15 and 20 DAP, respectively which were significantly higher than those of SAMSOY-2 with 20.7%, 19.7% and 20.7% at the corresponding number of days after planting. The next promising variety after SAMSOY-2 was TGX 1740-7F with 13.3%, 19.3% and 17.3% at similar periods, which values were significantly (P≤0.05) higher than the other remaining varieties. It would appear that while root exudates of some varieties of soybean exhibit change of activity with age of the plant, others do not . This is the case with TGX1649-11F and TGX1740-7F (Table 1) where an increase in germination was observed as the plants grew older. On the other hand, the germination value for SAMSOY-2, to a greater extent, was high at all periods whereas the remaining varieties had values that were

Table 1 : Germination of the first batch of *S. hermonthica* seeds in response to stimulation by root exudates of soybean

Soybean variety	Germination of *Striga* seeds, %			Specific Effectiveness Index (SEI)			Mean SEI
	10 DAP	15 DAP	20 DAP	10DAP	15DAP	20DAP	
TGX 1649-11F	26.0	29.0	30.6	0.64	0.79	0.83	0.75
TGX 1740-7F	13.3	19.3	17.3	0.33	0.52	0.47	0.44
TGX 1660-15F	3.3	2.0	1.7	0.08	0.05	0.05	0.06
TGX 1740-2F	3.0	3.3	3.0	0.07	0.09	0.08	0.08
TGX 1670-3F	3.7	2.3	2.3	0.09	0.06	0.06	0.07
TGX 1674-3F	2.3	1.3	2.3	0.06	0.04	0.06	0.05
SAMSOY-2	20.7	19.7	20.7	0.51	0.54	0.56	0.54
GR-24 (control)	40.3	36.7	36.7	1.00	1.00	1.00	1.00
LSD_{05}	4.0	2.7	2.4				

Table 2 : Germination of the second batch of *S. hermonthica* seeds in response to stimulation by root exudates of soybean.

Soybean variety	Germination of *Striga* seeds. %			Specific Effectiveness Index (SEI)			Mean SEI
	10 DAP	15 DAP	20 DAP	10DAP	15DAP	20DAP	
TGX 1681-3F	13.0	15.7	16.3	0.94	0.65	0.70	0.76
TGX 1479-1E	8.7	13.3	13.0	0.63	0.55	0.56	0.58
TGX 923-2E	10.0	6.3	8.3	0.72	0.26	0.36	0.44
TGX 1440-1E	9.0	8.0	9.0	0.65	0.33	0.39	0.45
TGX 1448-2E	4.7	7.3	6.0	0.34	0.30	0.26	0.30
TGX 1660-19F	4.3	2.7	3.0	0.31	0.11	0.13	0.18
TGX 1519-10F	4.7	3.0	3.0	0.34	0.12	0.13	0.19
TGX 1019-2EN	2.0	2.0	1.7	0.14	0.08	0.07	0.09
GR-24 (control)	13.7	24.0	23.0	1.00	1.00	1.00	1.00
LSD_{05}	5.5	1.8	2.4				

consistently low . These trends are supported by the SEI values, which are quotients, obtained as the mean germination of S. hermonthica seeds stimulated by a soybean variety divided by the germination stimulated by the control (GR 24). TGX1649-11F may have exuded substances that had higher potency with age, whereas TGX1740-7F exudeed less active substances after 15 days of growth and SAMSOY-2 did not show a clearly defined trend.

Table 2 shows the results of the screening of the second batch of soybean varieties. It is shown that at 10 DAP there were no significant differences between levels of germination stimulated by GR24 and the root exudates of TGX1681-3F, TGX1479-1E, TGX1440-1E and TGX923-2E. The remaining varieties did not show much promise at this age. However, at 15 DAP there was a significant difference ($P \leq 0.05$) in germination of *S. hermonthica* seeds between the control and the soybean varieties. It was observed that germination that was stimulated by TGX 1681-3F (15.7%) was significantly higher than that of the other varieties of soybean. This was followed by TGX 1479-1E (13.3%), TGX1440-1E (8.0%), TGX1448-2E (7.3%) and TGX923-2E (6.3%). These varieties differed significantly from the other remaining varieties indicated in Table 2. At 20 DAP, GR 24 stimulated the highest level of germination (23.0%) ; and among the soybean varieties, TGX1681-3F (16.3%) was significantly higher than TGX1479-1E (13.0%). The varieties TGX1440-1E and TGX923-2 E were less promising than the two mentioned previously; though they did show significantly more promise than the remaining varieties in this batch at the periods tested. The SEI values show, more clearly, the differences in activity between the GR 24 (control) and the soybean varieties as well as among the varieties themselves (Table 2). A sharp depression of germination is observed in

Table 3 : Germination of the third batch of *S. hermonthica* seeds in response to stimulation exudates of soybean.

Soybean variety	Germination of Striga seeds, %			Specific Effectiveness Index (SEI)			Mean SEI
	10 DAP	15 DAP	20 DAP	10DAP	15DAP	20DAP	
TGX -344	8.3	10.7	11.7	0.35	0.48	0.51	0.44
TGX 1019-EB	7.7	7.6	7.0	0.33	0.34	0.31	0.32
TGX 1485-1D	6.0	4.3	4.0	0.25	0.19	0.17	0.20
TGX 536-02D	6.0	2.7	6.7	0.25	0.12	0.29	0.22
TGM-351	1.7	1.7	2.3	0.07	0.07	0.10	0.08
TGX 849-3B	2.3	1.7	2.7	0.09	0.07	0.11	0.09
GR-24 (control)	23.3	22.0	22.7	1.00	1.00	1.00	1.00
LSD_{05}	2.0	2.0	2.0				

the activity of all the soybean varieties from 15 DAP. Table 3 shows clearly from the germination at 10, 15 and 20 DAP (8.3%, 10.7% and 11.7% respectively) as well as from the mean SEI (0.44) that TGX 344 is the most promising variety when compared to the others. This is followed by TGX1019-EB with 7.7%, 7.6% and 7.0% at 10, 15 and 20 DAP, respectively. Other varieties in this batch did not show much promise at the periods tested.

Fate et al. (1990) suggested that root exudates of plants contain certain oxidation inhibitors that prevent the reduction of activity of the stimulants. It is therefore possible that the varieties that showed a depression in stimulation of germination may have exuded smaller amounts of oxidation inhibitors by reason of the roots having been severed from the live plant. Parker and Riches (1993) mentioned that different substances are involved in germination stimulation. Where a plant exudes more of one type of germination stimulant than the other ; for example, more sorgoleone than sorgolactone or strigol, the germination response of *S. hermonthica* seeds may vary as their concentration varies in the environment. Furthermore, Hess et al., (1991) found that exudation of sorgoleone is supressed under wet conditions. There may be other biochemical mechanisms through which dormancy of *Striga* seeds were terminated, which also may have contributed to the wide variation in germination response of the *Striga* seeds observed here. Intra-specific variation and host specificity may also contribute to a wider variation in responses to experimental conditions and locality. This may be the reason why these results are not quite consistent with those obtained by Alabi et al., (1994). It is therefore suggested that laboratory screening be done with the strains or races of the parasite obtained from the locality at which the experiments are targeted ; otherwise, inconclusive results may be obtained. The use, field crop rotation systems, of the soybean varieties, which have been identified as stimulating high levels of *Striga* seed germination, remains one of the viable approaches to management of the parasite.

CONCLUSION

The strigol analogue GR 24 stimulated a higher percentage of *Striga* seed germinationin in each of the batches of soybean tested. Among the soybean varieties, the following were the most promising : TGX1649-11F F, •SAMSOY-2 ,TGX1681-3F, TGX 1479-1 E and gave SEI values that were greater than 0.5. Other varieties that also showed promise though to a lesser extent, were TGX1740-7 E , TGX1440-1 E, TGX923-2 E, TGM-344 and TGX1019-EB. Where seed supply of the more effective group is limiting, the less effective ones may be used as viable alternatives in field rotation systems for suicidal germination of *Striga* seeds The concept of SEI is useful in further comparing the activity of the soybean varieties as there may be differences in dormancy and viability of *S. hermonthica* seeds at different testing periods. Finally, this approach of laboratory screening of varieties for high stimulation of indigenous *Striga* seed germination allows for the rapid and effective identification of varieties to be used in rotation systems.

REFERENCES

Alabi, M.O., Berner, D.K. and Olaniyan, G.O.,1994. Characterisation of soybean cultivars for *S.hermonthica* control. *Phytopathology* 84 (10): 1151

Alabi, M.O., Berner, D., Carsky, R. J., Tobe, Sanginga, Dashiell, K., Chude, V. and Kling, J., 1995. *Striga hermonthica* supression by soybean and *Stylosanthes*. *Striga Newsletter* No 5, p 18.

Ariga, E.S., Berner, D.K. and Chweya, J. , 1994. Effects of previous season cotton and cowpea on *Striga hermonthica* parasitism in maize. *Phytopathology* 84 (10):1157

Boone, L.S., Fate, G., Chang, M. and Lynn, D.G., 1995. Seed germination. Pp 14-38 in : Press, M.C. and Graves, J.D. (eds.) *Parasitic Plants*, Chapman and Hall, London.

Dogget, H., 1965. *Striga hermonthica* on Sorghum in East Africa. Journal of Agricultural Science 65:183-194.

Dogget, H., 1984. *Striga*: Its Biology and Control- an Overview. *In Striga: Biology and Control.* Paris, ICSU. Ottawa, Canada. IDRC, pp 27-36.

Ejeta, G.L., Butler, L. and Babiker, A.G.T., 1992. Striga Research at Purdue University. Agricultural Experimentation Station West Lafayette, IND. U.S.A

Fate, G., Chang, M. and Lynn, D.G., 1990. Control of germination of Striga asiatica : chemistry of spatial definition. Plant Physiology 93, 201-207.

Frost, D.C., Gnerney, A.L., Press, M.C. and Scholar, J.D., 1997. Striga hermonthica reduces photosynthesis in sorghum – the importance of stomatal limitations and a potential role for ABA. Plant. Cell and Environment 20 : 483-489.

Gbehounou, A., 1998. Seed ecology of *Striga hermonthica* in the Republic of Benin: host specificity and control potentials. Ph.D. Thesis, Vrije Universiteit, Amsterdam, pp121

Hess, D.E., Ejeta, G. and Butler, L.G., 1991. Research into germination of Striga seed by sorghum root exudates. In : Ransom, J.K., Musselman, L.J., Worsham, A.D. and Parker, C. (eds.) Proceedings, 5th International Symposium on Parasitic Weeds, Nairobi, 1991. CIMMYT, Nairobi, pp 217- 222.

Hauck, C., Muller, S. and Schilknecht, H ., 1992. A germination stimulant for parasitic flowering plants from Sorghum bicolor, a genuine host plant. Journal of Plant Physiology 139, 474-478.

IITA, 1993. *Striga Research Manual.* Ibadan Nigeria. 67pp

Johnson A.W., Rosberry, G. and Parker, C., 1976. A novel approach to *Striga* and *Orobanche* control using synthetic germination stimulants. Weed Research.16: 223 – 227

Johnson, A.W., Gowda, G., Hassanali, A., Knox, J., Monaco, S. and Razawi, Z., 1981. The preparation of synthetic analogues of strigol. Journal of the Chemical Society Perkin Transactions / 6, 1734-1743.

Lagoke S.T.O., 1989. *Striga* in Nigeria PP 68-75 In: T.O.Robson and H.R. Broad (eds.). Striga- Improved Management in Africa. Proceedings of the FAO/OAU All-Africa Government Consultation on Striga control. Maroua, Cameroon. 20-24 October 1988: FAO.

Lagoke, S.T.O., Parkinson, V. and Agunbiade, R. M., 1991. Parasitic weeds and control methods in Africa.pp3-14 In: S.K.Kim (ed.) Combating Striga in Africa. Proceedings of International Workshop by IITA, ICRISAT and IDRC, 22-24 August 1988. IITA Ibadan.

Lagoke S.T.O., Shebayan, J.Y., Weber, G., Olufajo, O., Elemo, K., Adu, J. K., Emechebe, A.M., Singh, B. B., Zaria, A., Awad, A., Ngawa, L., Olaniyan, G.O., Olafare, S.O., Adeoti, A. A. and Odion, C., 1994. Survey of *Striga* problem and evaluation of *Striga* control methods and packages in crops in the Nigerian Savanna. In: Lagoke S.T.O., R. Hoevers, S.S. M'Boob. R. Traboulsi. (eds) Improving Striga Management in Africa, Proceedings of Second General Workshop of PASCON. Nairobi. Accra: FAO. PP 91-120.

M'Boob, S.S., 1989. A regional programme for Striga control in West and Central Africa Pp 190-194 in : Robson, T.O. and Broad, H.R. (eds.) Striga – Improved Management for Africa. Poceedings of FOA/OAU All – Africa Government Consultation on Striga control. 1986. Maroua. Cameroon.

M'Boob S.S., 1991. *Striga* in Africa. pp25-29 In: S.T.O Lagoke,R.Heovers, S.S. M'Boobs, R.Traboulsi (eds.). Improving Striga Management in Africa, Proceedings, Second General Workshop of PASCON Nairobi. Accra: FAO

Netzly, D.H., Riopel, J.L., Ejeta,G. and Butler, L.G., 1988. Germination stimulants of witchweed (*Striga asiatica*) from hydrophobic root exudates of sorghum (*Sorghum bicolor*). Weed Science 36, 441-446.

Okonkwo, S.N.C., 1966. Studies on *Striga senegalensis* Benth. 1. Most of host-parasite union and haustorial structure. *Phytopathology* 16: 453-463.

Parker,C. and Riches, C.R., 1993. Parasitic weeds of the world : biology and control. CAB International, Oxon, UK., 332pp.

Press, M.C., Graves, J. D. and Stewart, G.R., 1991. Physiology of interaction of angiosperm parasites and their higher plant hosts. Plant Cell and Environment 13:91-104

Ramaiah K.V. and Parker, C., 1982. *Striga* and other weeds in sorghum, pp 291-302 In:L.House, L.Mughogho and J. Peacock (eds) Sorghum in the Eighties, Proceedings of the International Symposium on Sorghum vol.1 Patanchern. India: ICRISAT.

Reda, F., Jones, G. and Sherif, A., 1990. New cereal hosts of *Striga hermonthica* in Ethiopia. *Haustorium* - A Parasitic Plants Newsletter, N° 24 October 1990.p2

van Mele P., van Damme, P. and Berner, D., 1992. A new technique to test germination response to *Striga* seed using plant roots. *Meddedeligen Faculteit Landbouwtenschappen*,Universiteit Ghent 57/36;993-999.

Weber, G., Elemo, K., Lagoke, S.T.O., Awad, A. and Oikeh, S., 1995. Population dynamics and determinants of *Striga hermonthica* on maize and sorghum in savanna farming systems. *Crop Protection* 14 (4): 283-290

Yoshikawa, F., Worsham, A.D., Moreland, D.E. and Eplee, R. E., 1978. Biochemical requirements for seed germination and shoot development of witchweed, *Striga asiatica*. North Carolina Agric. Expt. Station, Raleigh, 26: 119-122.