0014-4754/96/030264-04$1.50 + 0.20 © Birkhäuser Verlag Basel, 1996

The decrease in seed germination of *Striga hermonthica* in Benin in the course of the rainy season is due to a dying-off process

G. Gbèhounou, A. H. Pieterse[a]* and J. A. C. Verkleij[b]

Institut des Recherches Agricoles du Beńin, Laboratoire de Défense des Cultures, B.P. 128, Port Novo (Republic of Benin), and [a]Royal Tropical Institute, Department of Agriculture and Enterprise Development, 63 Mauritskade, NL-1092 Amsterdam, Fax +31 20 5688 444, and [b]Vrije Universiteit, Department of Ecology and Ecotoxicology, De Boelelaan 1987, NL-1087 HV Amsterdam (The Netherlands)
Received 17 March 1995; accepted 27 July 1995

Abstract. Germination rate and viability of *Striga hermonthica* seeds in the field in the Republic of Benin decreased steadily in the course of the rainy season. The percentage of germinating seeds decreased from 82% on April 13, 1993 to 16% on October 13, 1993. The percentage of viable seeds, according to the tetrazolium colour test, decreased in the same period from 90% to 15%. In the subsequent rainy season these values further decreased and it was concluded that the seeds do not enter a stage of secondary dormancy. This implies that if host plants (including wild hosts) are consistently kept away from infested fields for one or two year periods, this will lead to a dramatic decrease in the number of viable *S. hermonthica* seeds in the soil.
Key words. Parasitic weeds, *Striga*; seed viability; germination.

The parasitic weed *Striga hermonthica* (Del.) Benth. poses a serious threat to cereal production in the African savannah regions. This applies in particular to maize (*Zea mais* L.), pearl millet [*Pennisetum typhoides* (Burm. f.) Stapf & Hubbard] and sorghum (*Sorghum vulgare* Pers.). Due to monocropping and limitation or absence of fallow periods this pest has increased alarmingly in both intensity as well as extent of distribution during the last decades.

According to the available literature, *S. hermonthica* seeds remain viable for long periods (at least several years[1]) in the field and may enter stages of secondary dormancy[2,3]. Consequently, decreasing the parasite's seed bank is an essential part of control programmes.

Germination of *Striga* seeds depends on the presence of a germination stimulant exuded by host plant roots. However, roots of some non-host plants, including crops like cowpea [(*Vigna unguiculata* (L.) Walp.] and groundnut (*Arachis hypogea* L.), also produce a germination stimulant. In *Striga* management it is common to use these trap crops to decrease the *Striga* seed bank.

In the present field study in the Republic of Benin (West Africa) it was found that the viability of *S. hermonthica* seeds decreases steadily in the course of the rainy season. This could imply that keeping host plants (including wild hosts) away from infested fields for one or two year periods, is a much more effective means of decreasing the number of viable *S. hermonthica* seeds in the soil than previously assumed.

* Corresponding author.

Materials and methods

S. hermonthica seeds were collected from heavily infested maize fields around Ina Research Station in the Republic of Benin (2° 44′ E and 9° 58′ N, 70 km north of Parakou in the Borgou Department) at the end of the rainy season (on November 3, 1992). The seeds were cleaned of debris and subsequently put in 4 × 9 cm nylon gauze bags (approximately 1000 seeds per bag). They were mixed with coarse sand to limit seed to seed interaction. On November 9, 1992, each bag was buried at a depth of 5 cm in the middle of a 0.5 × 0.5 m plot at Ina Station. The plots were kept weed-free.

On April 8, 1993 the bags were dug up (with the exception of 40 bags which were left in the 0.5 × 0.5 m plot) and buried in an experimental plot using a randomized complete block design (4 replicates). One bag from each replicate was dug up at weekly periods from April 16 until October 13, 1993 to assess seed germination and viability. The viability test was conducted in relation to the germination test, to determine whether non-germinating seeds had entered a state of secondary dormancy or had died. To make the results more conclusive, germination and viability were assessed during the subsequent dry period and rainy season, i.e. on February 17, March 18, June 6 and June 20, 1994. As on October 13, 1993 all bags in the experimental plot had been tested, bags for the 1994 testing were dug up (two bags per testing date) from the 0.5 × 0.5 plot. Although these bags had not been included in the experimental plot, they had been buried in the soil from November 9, 1992 (until April 8, 1993 together with the bags which were transferred to the experimental plot).

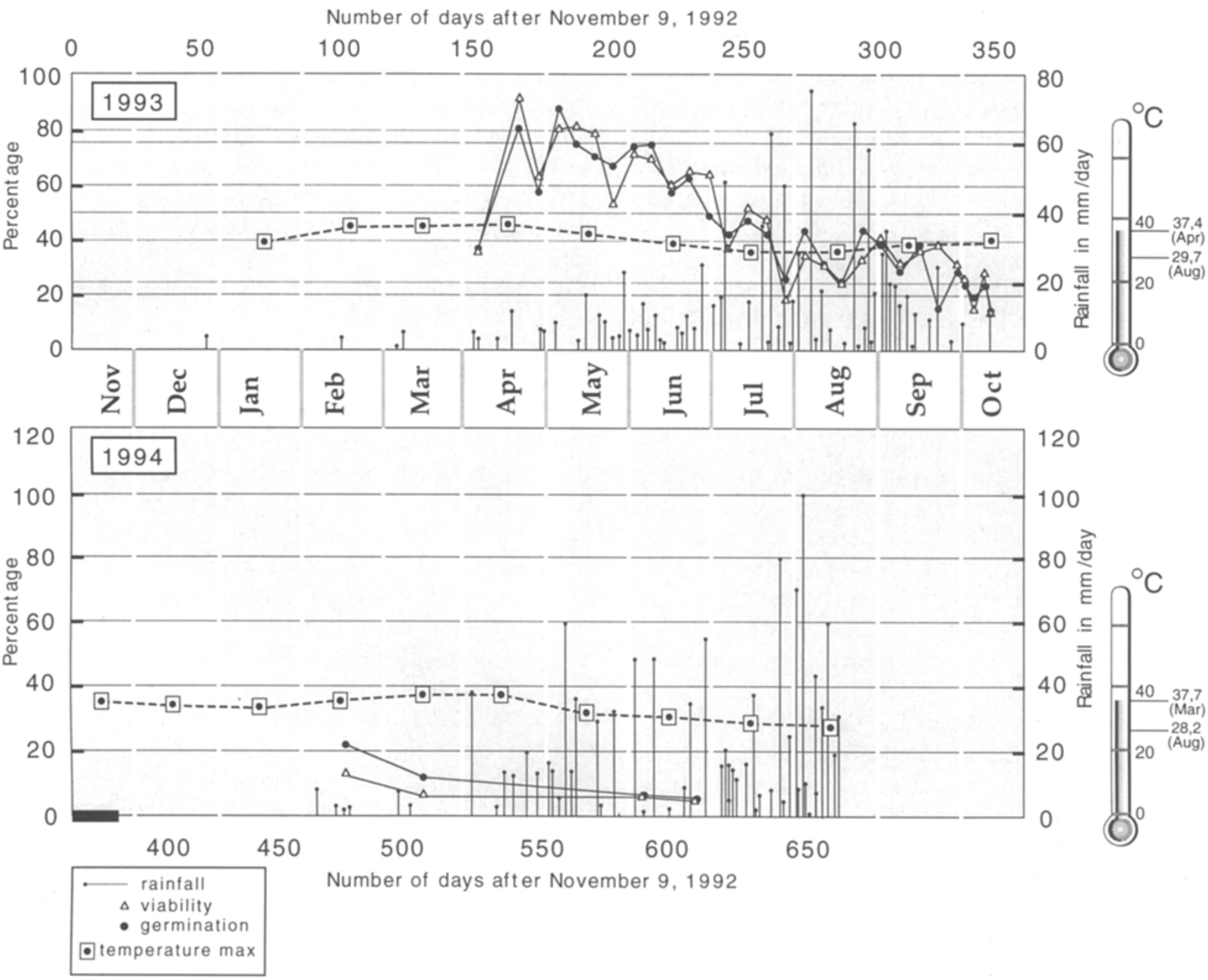

Figure 1. Percentage of germinating seeds and percentage of supposedly viable seeds of *Striga hermonthica* after storage in gauze bags at Ina Station (directly after shedding on November 9 at the end of the 1992 season), as well as rainfall (in mm per day) and temperature data (in °C) at Ina Station. The L.S.D. (0.01) for germination was 10.09%, and for supposed viability (0.01), 6.59% (for data from the 1993 season). The additional data from 1994 (based on the average of two bags) were not included in the statistical test.

Germination and viability of these seeds were assessed after a two-week conditioning period (exposure to moisture) in the laboratory.

After the bags were dug up they were transferred to the laboratory, where the seeds were separated from sand particles. Subsequently, the seeds were spread on a filter paper and surface sterilized for 5 min with a 1% solution of commercial sodium hypochlorite (NaOCl). After thorough rinsing, 100 seeds, split into four groups of 25 seeds, were placed on 47 mm glass-fibre filter paper disks in a petri dish (60 mm diameter). For each bag there were two petri dishes: one was used to test seed germination, the other to test viability by means of the tetrazolium colour test (1.5 ml of a 1% tetrazolium salt solution were added to the seeds[4]). To trigger seed germination, 1.5 ml of a 1 ppm solution of GR24 (a synthetic germination stimulant) was added to each of the petri dishes. The 1 ppm GR24 solution was prepared as follows: 2.5 mg of GR24 were dissolved in 5 ml of 95% ethanol and further diluted to 25 ml with 0.03 mM MES [2(*N*-morpholino) ethane sulphonic acid] buffer. One ml of this solution was diluted with 99 ml of MES buffer. The 1% solution of 2,3,5-triphenyl tetrazolium cloride (TTC) used for viability was prepared by dissolving 1 g of TTC powder in a 100 ml of 0.3 mM MES buffer. Subsequently, the petri dishes were wrapped in aluminium foil and incubated for 48 hours at 30 °C (±5 °C). At the end of the incubation period, the petri dishes were opened, and the germinated seeds were counted under a microscope.

To assess viability the petri dishes were opened after 8 days' incubation at 30 °C (±5 °C), and coloured (pink or red) and non-coloured seeds were counted under a microscope. The coloured seeds were assumed to be viable.

The seeds dug up on February 17, March 18, June 6 and June 20, 1994 were, prior to the germination and viability test, conditioned in the laboratory at 30 °C (±5 °C) on wet filter paper in petri dishes wrapped in aluminium foil for 14 days.

A two-way analysis of variance for randomized complete block design has been performed, after an arcsine square root transformation of the viability and germination percentages recorded in 1993 ($P > 0.01$).

Data on daily rainfall (in mm/day) at Ina Station were obtained from the project PNUD/OMM/BEN/87/010[5].

Results and discussion

The results are presented in figure 1. In the course of the 1993 rainy season the percentage of germinating seeds declined steadily from 82% on April 23 to 16% on October 13. It may be assumed that the increase in germination between April 8 and April 16, which was not statistically significant, is due to insufficient conditioning, as before April 8 only a few scattered showers had been recorded. The percentage of supposedly viable seeds also decreased over the course of the rainy season from the maximum value of around 90% to around 15% on October 13. It is remarkable that between April 8 and April 23 there is, simultaneously with an increase in germination, also an increase in viability according to the TTC test. It seems that conditioning is positively correlated with seed colouring.

The germination percentages recorded during the subsequent dry season, on February 17 and March 18, 1994, after two weeks' conditioning in the laboratory, were 14% and 6%, respectively. These values are not significantly different from the percentage (16%) recorded on October 13. However, on June 6 and June 20, 1994 the percentage of germinating seeds decreased further to 6% and 5%, respectively.

The viabilty was 25% on February 17 and 12% on March 18, 1994. These values are not significantly different from the percentage (15%) recorded on October 13, 1993. On June 6 and June 20, 1994, viability was only 5% (which is significantly lower than on October 13, 1993). Most seeds had shrivelled and exposure to moisture did not lead to swelling, which is commonly observed with viable seeds.

It may be concluded that the *S. hermonthica* seeds die in the course of the rainy season. First of all this may be concluded from the TTC test. However, at least when the seeds are not fully conditioned, this test seems not to be completely reliable. A more definite proof in this respect is the further decrease in germination in the course of the following rainy season. Shrivelling of the seeds, which is not reversed by giving water, also points to a dying-off process.

Apparently, the seeds do not enter a state of secondary dormancy. In 1950 it was reported[3] that under laboratory conditions *S. hermonthica* seeds become dormant after prolonged conditioning. A decrease in germination as a result of prolonged conditioning was confirmed by subsequent researchers[6,7]. However, these researchers could not irrefutably demonstrate whether the seeds became dormant or died. More recently, in vitro studies regarding the effect of prolonged conditioning on *S. hermonthica* seeds from Benin showed a decrease in germination and viability based on the TTC test[8]. This was particularly marked at the higher temperatures tested (30° and higher).

The fact that the germination percentage on February 17 and March 18, 1994 (after two weeks' conditioning) was not significantly different from that in October of the previous year, at the end of the rainy season, could imply that the dying-off process is stopped during the dry season. In this context it may be noted that *Striga* seeds kept under dry conditions in the laboratory remain viable for several years[8]. Consequently, it could be hypothesized that the length of the dry period(s) influences *Striga* survival and that the lack of a dry period in the southern part of Benin (south of 7° 30')[9] where *S. hermonthica* does not occur, is the main limiting factor.

The experiment was conducted under natural conditions in the field. However, to clarify the factor(s) causing the seeds to die, it is recommended that controls kept under aseptic as well under dry conditions should be included in future experiments.

The observed loss of viability of *S. hermonthica* seeds in the course of the rainy season could be of practical importance for control programmes. Apart from the fact that late sowing may result in a decreased infestation, as was already previously reported[11,12,13], rotation with non-host crops for one or two seasons might have a greater impact than previously presumed. Compared to rotation, the effect of suicidal germination of *S. hermonthica* seeds as a result of trap cropping, would be less important. However, trap cropping could enhance the effect of rotation if applied in integrated control schemes.

Acknowledgement. The research was partly financed by the European Union (DG XII, STD 3) in the framework of the project TS3-CT 91-0020.

1 Parker, C., and Riches, C. R., Parasitic Weeds of the World: Biology and Control. CAB International, Wallingford 1993.
2 Vallance, K. B., Ann. Bot. *14* (1950) 347.
3 Pieterse, A. H., and Verkleij, J. A. C., in: Proc. Third Int. Workshop on *Orobanche* and related *Striga* research, Amsterdam, p. 36. Eds A. H. Pieterse, J. A. C. Verkleij and S. J. ter Borg. Royal Tropical Institute, Amsterdam 1994.
4 Eplee, R. E., and Norris, R. S., in: Parasitic Weeds in Agriculture, I. *Striga*. Ed. L. J. Musselman. CRC Press, Boca Raton 1987.
5 PROJET/PNUD/OMM/BEN/87/010. Bulletin agrométéorologique décadaire *325, 326, 328, 329* (1993).
6 Reid, D. C., and Parker, C., in: Proc. Second Int. Symp. Parasitic Weeds, p. 202. Eds L. J. Musselman, A. D. Worsham and R. E. Eplee. North Carolina State University, North Carolina 1979.

7 Pieterse, A. H., Ebbers, A. E. H., and Pesch, C. J., in: Proc. Third Int. Symp. Parasitic Weeds, p. 99. Eds C. Parker, L. J. Musselman, R. M. Polhill and A. K. Wilson. Int. Center for agricult. Res. in Dry Areas (ICARDA), Aleppo 1984.
8 Egbers, W. S., Pieterse, A. H., and Verkleij, J. A. C., in: Proc. Fifth Int. Symp. Parasitic Weeds, Nairobi, p. 407. Eds J. K. Ransom, L. J. Musselman, A. D. Worsham and C. Parker. Centro Int. de Mejoramiento de Maíz y Trigo (CIMMYT), Nairobi 1991.
9 Worsham, A. D., in: Parasitic Weeds in Agriculture, vol. 1 *Striga*. Ed. L. J. Musselman. CRC Press, Boca Raton 1987.
10 Gbèhounou, G., Pieterse, A. H., van der Hulst, P. J., and Verkleij, J. A. C. in: Proc. Third Int. Workshop on *Orobanche* and related *Striga* research, p. 180. Eds A. H. Pieterse, J. A. C. Verkleij and S. J. ter Borg. Royal Tropical Institute, Amsterdam 1994.
11 Andrews, F. W., Ann. Appl. Biol. *32* (1945) 193.
12 Bebawi, F. F., in: Proc. Third Int. Symp. Parasitic Weeds, p. 148. Eds C. Parker, L. J. Musselman, R. M. Polhill and A. K. Wilson. Int. Center for agricult. Res. in Dry Areas (ICARDA), Aleppo 1984.
13 Lagoke, S. T. O., Adeosun, J. O., Ngawa, L., Iwafor, E. N. O., and Nwasike, C., in: Proc. Fifth Int. Symp. Parasitic Weeds, p. 534. Centro Int. de Mejoramiento de Maíz y Trigo (CIMMYT), Nairobi 1991.