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Use of Local Plant Aqueous Extracts as Potential Bio-herbicides against *Striga hermonthica* (Del.) Benth. in Burkina Faso

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Abstract: This study was conducted to evaluate the allelopathic properties of endogenous plant species against *Striga hermonthica* (Del.) Benth., a root parasitic weed. In this respect, twenty five water extracts and eight freeze dried water extracts from sixteen plant species were screened in bio-assays to test their ability to induce or inhibit the germination of *S. hermonthica* seeds. *Striga* seeds were conditioned either in 10% water extracts or in 10% diluted lyophilisats to check their inhibition effect on *Striga* seed germination. Three doses, 1, 5 and 10% of water extracts were applied on conditioned *Striga* seeds to test their ability to induce *Striga* germination. Aqueous extracts from four plant species reduced *Striga* seed germination by 95.8 to 99.8% compared to the untreated control. Aqueous extracts from two others also significantly reduced *Striga* germination by 93.1 and 86.3%, respectively. Lyophilisats from four species inhibited *Striga* seeds germination, whereas that of two others reduced *Striga* seeds germination by 93.5 and 99.6%, respectively. Only 1% aqueous extracts of *Ceiba pentandra* and *Eucalyptus camaldulensis* significantly stimulated *Striga* seed germination by 39.2 and 38.9%. These results pointed out that the metabolites produced by some of the local plant species may have the potential to be used as bio-herbicides to control *S. hermonthica* and enhance cereals yield.

Key words: *Striga hermonthica*, control, allelopathy, plant extracts, bio-herbicide, Burkina Faso

INTRODUCTION

Root parasitic weeds of the genus *Striga* (Scrophulariaceae) constitute a major biotic constraint to cereals production in sub-Saharan Africa, particularly for the very important food crops, maize, sorghum and pearl millet. The most devastating to cereal production in West Africa is *Striga hermonthica* (Del.) Benth which causes huge losses ranging from 40-90% (Gressel *et al*., 2004) and up to 75% of its overall damage to the hosts occurred during its subterranean stage of development (Parker and Riches, 1993). A single *S. hermonthica* plant can produce up to 500 000 seeds which can remain viable for more than 14 years (Bebawi *et al*., 1984). This has led to the buildup of a large reserve of *Striga* seeds in contaminated soils.

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Several control methods against *Striga* species have been recommended such as crop rotation, trap and catch cropping, injection of ethylene gas, use of fertilizers and herbicides (Radi, 2007). Unfortunately, techniques targeted at controlling *Striga* are frequently ineffective and rarely adopted by resource-poor African farmers (Hess and Grard, 1999). Indeed, the use of herbicides such as Dicamba and 2,4 D against *S. hermonthica* is effective (Radi, 2007) but the required chemical compounds are expensive for subsistance farmers and ill-fated for human. In addition, their application led sometimes to chemical damage to host crop and environmental pollution.

An alternative control approach against *Striga* would be the use of natural products that would inhibit or induce the germination of *Striga* seeds in order to deplete the *Striga* seedbank in the soil. The effectiveness of plant products to control grasses has been reported. Indeed, the roots of *Callistemon citrinus* produce a toxic substance (Callisto) of which the active compound (mesotrione) inhibits the growth of foliage, roots and seeds germination of numerous weeds (Syngeta, 2004). In bio-assays, about twenty and ten of Chinese medicinal herbs reduced and inhibited, respectively *S. hermonthica* seeds germination (Ma *et al*., 2004). Screenhouse evaluation of *Azadirachta indica* and *Parkia biglobosa* to control *S. hermonthica* revealed that products based on two species were effective to reduce *Striga* emergence (Marley *et al*., 2004). A survey carried out in Eastern Burkina Faso reported traditional uses of endogenous plants to control *Striga* infestation (Traore and Yonli, 2001). Thus, the promotion of plant substances from local species to control *Striga* controlling will contribute to develop new perspectives for crops protection by saving annual yield losses of cereals worth US $ 7 billion (M'Boob, 1988) and decrease the importation of chemicals in Africa. This approach should be based on economically and technically viable technologies without damage to environment.

The effect of extracts from endogenous plants on *S. hermonthica* has not almost been explored in Burkina Faso. This study aimed to evaluate through bio-assays the allelopathic properties of local plants to control *Striga* seed germination. Since, water is presumed to be the most readily available solvent, aqueous extracts were made and assessed for their ability to induce or to inhibit the germination of *Striga* seeds. In this way, we consider to develop a plant-based protection method that would be available for resource-poor farmers.

MATERIALS AND METHODS

S. hermonthica Seeds

Striga hermonthica seeds were harvested in 2006 from a sorghum field located at the Kouaré agricultural research station (11°95'03'' N and 0°30'58''E) in Eastern Burkina Faso, air dried and stored at ambient temperature (30°C). Seeds were surface sterilized with alcohol (70°) and sodium hypochlorite (NaOCl. 1%) amended with Tween 80 respectively for 3 and 5 min before using them in germination tests.

Plant Material

The utilizable parts of sixteen local species were collected from the Sudanian zone of Burkina Faso (Table 1). The plant materials were washed and dried in the dark at room temperature and were separately ground into fine powder (<1 mm) and stored until use.

Plant Aqueous Extracts

Aqueous extracts at 10% concentration were obtained by pickling at room temperature. Ten gram of powdered part of plant were placed in a 250 mL glass beaker with 100 mL of

Table 1: Names and materials of plants tested against *S. hermonthica*

Scientific name	Family	Material used
Accacia gourmaensis A. Chev.	Mimosaceae	Bark, leave
Azadirachta indica A. Juss.	Meliaceae	Leave, root
Balanites aegyptiaca (L.) Del.	Balanitaceae	Roots
Calotropis procera (Ait.) Ait. F.	Asclepiadaceae	Leave
Ceiba pentandra (L.) Gaertn var. *guineensis*	Malvaceae	Bark
Chrysanthellum americanum (Linnaeus) Vatke	Asteraceae	Leave, stalk
Eclipta alba (L.) Hassk.	Asteraceae	Leave, stalk
Eucalyptus camaldulensis Dehnhardt	Myrtaceae	Leave, root
Hyptis spicigera Lamarck	Lamiaceae	Leave, stalk
Jatropha curcas L.	Euphorbiaceae	Leave
Jatropha gossypifolia L.	Euphorbiaceae	Leave
Lannea microcarpa Engl. and K. Krause	Anacardiaceae	Bark, leave
Lantana camara L.	Verbenaceae	Leave, stalk
Parkia biglobosa (Jacq.) Benth.	Mimosaceae	Bark, leave, peel
Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	Leave, root
Thevecia neriifolia A. Juss. Ex Steud.	Apocynaceae	Leave

sterile distilled water. The glass beaker containing suspension was stirred (7/24 h) on an agitator (Edmund Bühler, 7 400 Tübingen, SM 25) at 100 rpm for 24 h and each suspension was then filtered through two tools, the first (nylon cloth) served to move big debris and the second (Whatman® filter paper N°1) to set an homogeneous solution. Eight water extracts were freeze-dried for lyophilisat tests and twenty three were stored at 4°C until use; they were screened for inhibition effect on *Striga* seed germination. Dilutions of 5 and 1% from 10% concentration of sixteen plants were prepared and the three doses were assessed for stimulation effect on germination of water-conditioned *Striga* seeds. For each assay a Completely Randomized Block (CRB) design was used with three replications.

Bio-assays

Inhibition Assay

Thirty to 40 surface sterilized *Striga* seeds were placed on glass microfibre filter paper (GF/A) discs (6 mm ⌀) in Petri dishes (9 cm ⌀) lined with double moistened Wathman No. 1 filter papers (Botanga *et al*., 2003). Eight milliliters of each 10% water extracts or 10% diluted lyophilisats was used to condition *Striga* seeds and treatments were as follows: (1) Seeds conditioned with sterile distilled water (Control); (2) seeds conditioned with water extract or diluted lyophilisat. Sealed Petri dishes were wrapped in aluminum foil and black polyethylene and incubated in darkness at 28°C for 10-12 days. The treatments were replicated three times and arranged as a Completely Randomized Block (CRB) design. After the conditioning, *Striga* seeds were placed on discs and transferred into new Petri dishes (9 cm) lined with double moistened Whatman No. 1 filter papers. Then, a 20 µL of GR24 (0.0001%) was used per dick to check the ability of *Striga* seeds to germinate. Petri dishes were again sealed, wrapped in aluminum foil and black polyethylene and incubated in the darkness at 28°C for 48 h. After 48 h, the effectiveness of each treatment to inhibit *Striga* seeds germination was determined. The experiment was repeated three times.

Stimulation Assay

In this assay, *Striga* seeds were previously conditioned with sterile distilled water as described above. Four discs with *Striga* seeds (30-40) were introduced into new Petri dish (9 cm) lined with double moistened Whatman No. 1 filter papers. For each water extract, a 20 µL was applied on water-conditioned *Striga* seeds per dick in order to stimulate their germination and treatments in comparison were: (1) seeds germination induced with sterile distilled water (Control (-)), (2) seeds germination induced with GR24 (0.0001%) (Control (+)),

(3) seeds germination induced with 1% water extract, (4) seeds germination induced with 5% water extract and (5) seeds germination induced with 10% water extract. Three replications were used per treatment. Sealed Petri dishes were wrapped in aluminum foil and black polyethylene and incubated in the darkness at 28°C for 48 h. After 48 h, the ability of each treatment to stimulate *Striga* seed germination was evaluated by counting the number of germinated seeds. The bio-assay was repeated three times using a Completely Randomized Block (CRB) design.

Statistical Analysis

Germination data of *Striga* seeds were arcsine-transformed (Gomez and Gomez, 1984) before performing ANOVA (SAS Institute. Cary. NC) and then back-transformed. Means were separated using Newman Keuls Multiple Range test and differences between treatments were considered significant at $p<0.01$.

RESULTS AND DISCUSSION

Inhibition of *Striga hermonthica* Seed Germination

No water extract from the 16 plant species completely inhibited *Striga* seed germination. However, they significantly reduced percentage of *Striga* seed germination in comparison to the untreated control. *Striga* seeds germination was strongly inhibited when conditioned with water extracts from *Thevetia neriifolia* (leaves), *Azadirachta indica* (roots), *Parkia biglobosa* (peels), *Balanites aegyptiaca* (roots), *Jatropha gossypifolia* (leaves) and *Eucalyptus camaldulensis* (leaves and roots). Indeed, water extracts from seven species reduced the potential germination rate of *Striga* seeds by more then 76% (Table 2).

Table 2: Inhibition effect of 10% water extracts from local plant species on *Striga hermonthica* seed germination

Plant species	Plant parts	Germination rate* of *Striga hermonthica* (%)
Control (water)	-	1.09a[!] (76.34)[§]
Eclipta alba	Leave + stalk	0.91b (60.75)
Parkia biglobosa	Leave	0.66c (38.27)
Accacia gourmaensis	Bark	0.65c (36.33)
Hyptis spicigera	Leave + stalk	0.58d (30.92)
Azadirachta indica	Leave	0.53de (25.10)
Sclerocarya birrea	Leave	0.51de (24.34)
Parkia biglobosa	Bark	0.51de (23.87)
Sclerocarya birrea	Root	0.49def (22.86)
Accacia gourmaensis	Leave	0.48ef (21.75)
Lantana camara	Leave + stalk	0.48ef (21.61)
Ceiba pentandra	Bark	0.46ef (20.97)
Jatropha curcas	Leave	0.41fg (18.59)
Lannea microcarpa	Leave	0.37g (13.15)
Calotropis procera	Leave	0.37g (14,70)
Lannea microcarpa	Bark	0.36g (13.01)
Chrysanthellum americanum	Leave + stalk	0.35g (14.54)
Eucalyptns camaldulensis	Leave	0.35g (11.96)
Eucalyptns camaldulensis	Root	0.33g (10.44)
Thevecia neriifolia	Leave	0.22h (5.27)
Azadirachta indica	Root	0.19hi (3.20)
Jatropha gossypifolia	Leave	0.14hi (1.69)
Parkia biglobosa	Peels	0.13i (1.29)
Balanites aegyptiaca	Root	0.10i (0.12)
Statistical analysis		
Means		0.4 3 (20.68)
CV%		37,32
SE		0.0087

*Means with the same letter(s) are not significantly different. !Arcsine transformations of percentage of *Striga hermonthica* seeds germination. [§]Means in brackets are back-transformations of percentage of *Striga hermonthica* seeds germination

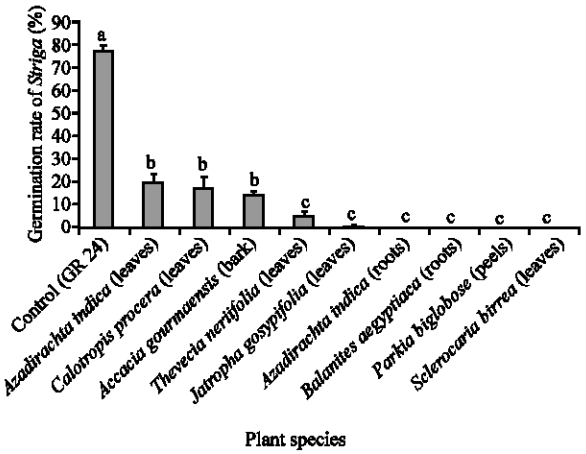

Fig. 1: Inhibition effect of lyophilisats of water extracts from local plant species on *Striga hermonthica* seed germination. Dark gray color indicate standard errors of the means

ANOVA revealed that the lyophilisats of water extracts from nine plant species significantly affected *S. hermonthica* seed germination in comparison to the control (GR 24). Indeed, the rate of *Striga* seed germination from the control was the greatest (77.3%) (Fig. 1). *Striga* seeds germination was 0% when seeds were conditioned with the lyophilisats from *A. indica* (roots), *B. aegyptiaca* (roots), *P. biglobosa* (peels) and *Sclerocarya birrea* (leaves) whereas that recorded with the lyophilisats from *T. neriifolia* (leaves) and *J. gossypifolia* (leaves) were 5.03 and 0.28%, respectively. Among the rates of *Striga* seed germination obtained with the lyophilisats, that of seeds treated with the lyophilisats from *Accacia gourmaensis* (bark), *Calotropis procera* (leaves) and *Azadirachta indica* (leaves) were the highest namely 14.3, 17.5 and 20.2%, respectively (Fig. 1).

Stimulation of *Striga hermonthica* Germination

Striga seeds stimulated with GR24 alone (control +) showed the highest germination rate (about 72%) whereas that treated with sterile distilled water did not germinate. Aqueous extracts from *Ceiba pentandra* (bark) and *Eucalyptus camaldulensis* (leaves) significantly induced *Striga* seed germination. Water extracts (1%) from both species respectively stimulated *Striga* seeds germination by 39.2 and 38.9%, which are the greatest after that of control + (Table 3). Weak germination rates ranging from 1 to 4.3% were recorded when *Striga* seeds were stimulated with 1% water extracts from five other species: *E. camaldulensis* (roots), *Sclerocarya birrea* (roots), *Calotropis procera* (leaves), *Lantana camara* (leaves+stalks) and *Jatropha curcas* (leaves). Considering 5 and 10% water extracts of the different species, only that of *E. camaldulensis* (leaves) induced a *Striga* germination rate more than 10%, while that of *C. pentandra* (bark) showed no effect. Water extracts from *Accacia gourmaensis* (bark) at the dose 5% and from *Chrysanthellum americanum* (leaves+stalks) at the dose 10% weakly stimulated *Striga* germination by 3.2 and 8.3%, respectively.

Water extracts from six local plant species showed significant inhibitory effects on the germination of *Striga hermonthica* seeds. The current study pointed out that plant water extracts may have potential inhibition on *Striga* infestation and widened the list of allelopathic plants to *Striga* germination (Ma *et al*., 2004). Indeed, similar evaluation of water

Table 3: Percentage of *Striga hermonthica* seed germination induced by water extracts from local plant species

		Germination rate* of *Striga hermonthica*		
Plant species	Plant parts	1% aqueous extract	5% aqueous extract	10% aqueous extract
Control + (GR 24)	-	1.14a[I] (72.07)[§]	1.14a[I] (72.07)[§]	1.14a[I] (72.07)[§]
Control – (water)	-	0.32c (0.00)	0.32c (0.00)	0.32b (0.00)
Eucalyptns camaldulensis	Leave	0.78b (38.87)	0.49b (13.24)	0.51b (14.58)
Ceiba pentandra	Bark	0.77b (39.20)	0.32c (0.00)	0.32c (0.00)
Eucalyptns camaldulensis	Root	0.38c (4.27)	0.43bc (7.46)	0.35c (2.07)
Sclerocarya birrea	Root	0.35c (2.10)	0.32c (0.00)	0.35c (1.92)
Calotropis procera	Leave	0.35c (1.92)	0.46b (9.94)	0.32c (0.00)
Lantana camara	Leave+stalk	0.35c (1.67)	0.34c (1.39)	0.32c (0.00)
Jatropha curcas	Leave	0.34c (1.14)	0.32c (0.00)	0.32c (0.00)
Accacia gourmaensis	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Parkia biglobosa	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Chrysanthellum americanum	Leave+stalk	0.32c (0.00)	0.32c (0.00)	0.42c (8.33)
Lannea microcarpa	Bark	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Hyptis spicigera	Leave+stalk	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Sclerocarya birrea	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Jatropha gossypifolia	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Eclipta alba	Leave+stalk	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Azadirachta indica	Root	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Parkia biglobosa	Bark	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Azadirachta indica	Leave	0.32c (0.00)	0.32c (0.00)	0.33c (0.83)
Balanites aegyptiaca	Root	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Accacia gourmaensis	Bark	0.32c (0.00)	0.36c (3.22)	0.32c (0.00)
Parkia biglobosa	Peel	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Lannea microcarpa	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Thevecia neriifolia	Leave	0.32c (0.00)	0.32c (0.00)	0.32c (0.00)
Statistical analysis				
Means		0.42 (8.40)	0.40 (7.08)	0.40 (6.98)
CV%		15.94	13.74	15.10
SE		0.0203	0.0189	0.0200

*Means followed by the same letter(s) are not significantly different. [I]Arcsine transformations of percentage of *Striga hermonthica* germination. [§]Means in brackets are back-transformations of percentage of *Striga hermonthica* germination

extracts from 383 Chinese traditional herbs showed that 27 herbs inhibited *S. hermonthica* seed germination and among them, undiluted extracts from sixteen herbs reduced *Striga* germination by more than 50% (Ma *et al*., 2004). The undiluted extract from *Curcuma longa* L. was found to inhibit completely *S. hermonthica* germination (Ma *et al*., 2004). Present results obtained with *Azadirachta indica* and *Parkia biglobosa* confirmed the observations reported by Marley *et al*. (2004) in Nigeria (West Africa). Their screenhouse evaluation of products based on *A. indica* (seeds, leaves) and *P. biglobosa* (fruits, peels) to *S. hermonthica* control revealed that seeds of *A. indica*, fruits and peels of *P. biglobosa* were effective reducing *Striga* emergence (Marley *et al*., 2004). Other studies reported that *A. indica* (bark and leaves) inhibited germination and growth of three weeds: *Echinochloa crus-galli*, *Monochoria vaginalis* and *Aeschynomene indica* in a bio-assay and in soil (Xuan *et al*., 2004). Previous findings on allelopathic plants suggested that effective compounds can be isolated and characterized to further use for Striga control. Indeed, six phenolic compounds having potential allelopathic activity were isolated from *A. indica* (Xuan *et al*., 2004) while (+)-5-deoxystrigol was isolated from *Lotus japonicus* root culture (Sugimoto and Ueyama, 2008).

The lyophilisats of water extracts from plant species used in this study significantly reduced *S. hermonthica* seed germination. The lyophilisats from *A. indica* (roots), *Balanites aegyptiaca* (roots), *P. biglobosa* (peels) and *Sclerocarya birrea* (leaves) completely inhibited *Striga* seed germination whereas that of *Thevecia neriifolia* (leaves) and *Jatropha gossypifolia* (leaves) reduced *Striga* seed germination by 93.5 and 99.6%,

respectively. Since no significant effect of water extract from *Sclerocarya birrea* (roots) was observed on *Striga* germination, the inhibition effect of its lyophilisat showed that the aqueous extract may contain allelochemicals in low dose. So, the high concentration of compounds in lyophilisat resulted in stronger inhibition activity from *S. birrea* (roots).

In this study, we have targeted seeds as susceptible organ to the extracts of allelopathic plants. In this respect, our results may be additional to that of Salam and Noguchi (2010). These authors evaluated the inhibitory effects of methanol extracts from rice seedlings on shoots and roots elongation of three target weed species.

With regard to the stimulation of *S. hermonthica* seed germination, only 1% water extracts from *Ceiba pentandra* (bark) and *Eucalyptus camaldulensis* (leaves) significantly induced *Striga* seed germination. Present results are similar to that of Ma *et al.* (2004), who used Chinese plants. The evaluation of Chinese traditional herbs revealed that distilled water and methanol extracts of 26 and 22 species, respectively, stimulated the germination of *S. hermonthica* (Ma *et al*., 2004). In this perspective, Tsanuo *et al*. (2003) managed to isolate an isoflavanone (uncinanone B) from *Desmodium uncinatum* (Jacq.) DC. which induced *S. hermonthica* seeds germination. Stimulants of *Striga* germination cannot induce germination at high doses as oppose to low doses (Siame *et al*., 1993; Yasuda *et al*., 2003). The results from this study revealed that the inhibition effect on *Striga* germination of water extracts from some plant species such as *E. camaldulensis* (leaves) is probably due to a high concentration of the applied compounds.

CONCLUSIONS

Ongoing evaluation of acetonic and methanolic extracts from these local plant species will argue the data above and the characterization of the compounds will specify their chemical nature. However, the results from this study have indicated that metabolites produced by some local plant species may have potential to be used as bioherbicides to control *S. hermonthica*. Indeed, they suggest that the prolonged use of non-host plants that produce *S. hermonthica* stimulants or inhibitors may reduce *Striga* seeds bank in the soil. A potential use of local plant species by farmers to control *Striga* infestations in the field could be through crop seed coating with plant metabolites before sowing. So, the use of local plant could be a biological component in the integrated *Striga* management in West Africa.

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