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Research Article

Screening Exudates from Selected Members of the Asteraceae for Ability to Stimulate Germination of *Striga hermonthica* Seeds

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Abstract

Background and Objective: A preponderance of weedy species that colonize abandoned infested *Striga* plots in Nigeria has been observed to belong to the family Asteraceae. Such weed may assist in ridding plots of its *Striga* inoculums load if they can trigger the suicidal germination of *Striga* seeds. This study investigates the potentials of 20 selected asteraceous weeds to stimulate germination of *Striga* seeds. **Materials and Methods:** Two procedures (cut root and root exudates) were used to obtain stimulants from test plants and compared with a standard synthetic germination stimulant. After 48 h the seeds were examined under a microscope for germination. **Results:** The result revealed that using root cut procedure, *Striga hermonthica* germination ability was highly prevalent, with *Solanecio biafra* and *Eclipta prostrata* supported the highest (64.83%) and lowest (31.83%) percent germination, respectively. While, the root exudates method project *Aspilia africana* and *Syndrella nodiflora* supported the highest (60.50%) and lowest (18.51%) percentage germination, respectively. The positive control check GR-24 had the highest germination percentage value of 65%. **Conclusion:** The differential germination of the *Striga hermonthica* seeds under the cut root and root exudates treatments suggests some members of Asteraceae as a possible trap plant for the suicidal germination of *Striga hermonthica* seeds.

Key words: *Striga*, Asteraceae, suicidal germination, trap crop, GR24

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Striga hermontica (Del.) Benth is the most economically important parasitic plant in the world[1]. It is renowned to be a problematic parasitic weed in agricultural production system in the African savannahs, infecting and causing serious damages to cereals such as maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L), pearl millet (*Pennisetum glaucum* L.), finger millet (*Eleucine coracana*), fonio (*Digitaria exiles*) and upland rice (*Oryza sativa*). According to M'Boob (1989), these susceptible crops are the main staple food for over 300 million people living in sub-Saharan Africa. Although the prevalence of *Striga* parasitism has received some research attention in recent times, *Striga hermonthica* continues to constitute a major biological constraint on food production in sub-Saharan Africa[2-4]. In parts of Africa, *striga* infestation gets so bad that some farmers have had to relocate every few years, incurring further financial burden on these peasant farmers.

In Nigeria, despite international collaborations and programmes aimed at curbing the *Striga* menace, *Striga* has remained a problematic weed especially in the savannah region of the country. Effective management of the devastating effects of *Striga* is being hampered by the ability to produce an enormous amount of seeds (100 000-200 000 seeds/plant)[5] and also the long viability period in the soil which could last up to 14 years[6]. Among several methods of *Striga* control including soil preparation, hand pulling, hoe-weeding, the use of herbicides, trap crops, resistant crop varieties, nitrogen fertilizer, biological control, chemical stimulants and the treatment of crop seeds have been developed[7,8], The suicidal germination of *Striga* seed have been suggested has a more realistic and farmer-friendly way of managing the *Striga* menace[8]. *Striga* as an obligate parasite, requires a host presence to survive. When the seed germinates in the absence of a definite host root, the seedlings die within 3-4 days[9]. Based on this, the use of ethylene gas on *Striga* infected soils as an exogenous stimulant that initiates germination of *Striga* seeds have often been recommended[10]. However, the highly pressurized and flammable nature of ethylene gas which warrants the use of specialized storage and application equipment for soil injection has made its direct use very hazardous and generally unsuitable for small-scale Nigerian farmers.

Preliminary studies reveal that highly infested *Striga* plots in the savanna region of the country are often abandoned and the fallow plots colonized by weedy species some of which belong to the family Asteraceae (personal communication). Such weed may assist in ridding plots of its *Striga* inoculums load if they can trigger the suicidal germination of *Striga* seeds. Hence, the aim of this research was to investigate the potentials of some selected members of Asteraceae to stimulate germination of *Striga hermonthica* seeds as a prerequisite search for a more economic, less laborious and farmer-friendly *Striga* control method. The research questions were (i) Which of the members of Asteraceae produces root exudates that can stimulate germination of *Striga hermonthica* seeds? (ii) Do cut roots as compared with root exudates, from members of Asteraceae produce the right signal that would stimulate germination of *Striga hermothica* seed?

MATERIALS AND METHODS

Study area: This study was conducted in a Laboratory (*in vitro* germination assay) and a screen house (root exudates experiment) at the Department of Plant Biology and Biotechnology Laboratory, University of Benin, Benin City.

***Striga* seeds:** The seeds of *Striga hermonthica* were collected in October 2017, under a pearl millet (*Pennisetum glaucum* L.) farm site at the Agric farm in Bayero University Kano, Kano State (11.9836° N 8.4753° E). The experiments were conducted in 2018. The seeds of *Striga hermonthica* were prepared by first separating them from their floral head using a small-sized mesh net of about 150 micron opening to sieve out the seeds. The seeds were further cleaned by placing them on a clean plain paper sheet and gently tapping it continuously to allow the debris which is bigger and lighter than the seeds to drift down. The clean seeds were then collected and stored in small plastic containers at room temperature under dry storage conditions.

To enable *Striga* seed respond properly to germination stimulants, seeds of *S. hermonthica* were conditioned using the methods of Worsham and Egley[10]. The seeds were surface disinfected for 10 min with 1% of sodium hypochlorite solution to eliminate microbial contaminants on the seed coat. Floating seeds were discarded and the remaining seeds were washed with distilled water. The washed seeds were aseptically allowed to dry and placed on a 2.2 mm-diameter glass fiber filter (Whatman GF/C) disks, which were in turn placed on a moistened 90 mm Whatman filter paper in a 90 mm diameter petri-dish. A forceps was used to dab up small amounts (10-30 seeds) of *Striga* seed on the glass fiber disks in the sterile petri dish. The seeds were incubated under ambient room temperature by putting the petri dish in a dark place for 14 days before introducing them to the cut roots and the root exudates of the 20 Asteraceae sp.

Table 1: Asteraceae sp. screened for *Striga hermonthica* seed germination ability

Species	Common names	Origin	Habit
Acmella uliginosa	Brazil-cress	Native	Herb
Agerathum conyzoides	Billygoat weed	Native	Herb
Aspilia africana	Bush marigold	Exotic	Herb
Chromolaena odorata	Siam weed	Exotic	Shrub
Chrysanthellum indicum	African wild daisy	Exotic	Herb
Conyza sumatrensis	Tall-fleabane	Exotic	Herb
Eclipta alba	False daisy	Exotic	Herb
Eclipta prostrate	Ink plant, Thistle	Exotic	Herb
Emilia coccinea	Emilia, tassel	Native	Herb
Emilia praetermissa	Tassel flower	Native	Herb
Lactuca taraxacifolia	African-lettuce	Native	Herb
Mikania cordata	Climbing hemp.	Native	Vine
Solanecio biafrae	Worowo	Native	Vine
Spilanthes filicaulis	Toothache plant	Native	Herb
Synedrella nodiflora	Cinderella-weed	Exotic	Herb
Tithonia diversifolia	Mexican sunflower	Exotic	Shrub
Tridax procumbens	Coatbottles	Exotic	Herb
Vernonia cinerea	Little iron weed	Native	Herb
Vernonia amygdalina	Better leaf	Native	Shrub
Wedelia trilobata	Creeping daisy	Exotic	Herb

Test plant species: Table 1 shows the members of Asteraceae from which the germination stimulants were extracted and screened. The 20 different Asteraceae spp. seeds were collected from abandoned farmlands in Southern Nigeria and planted in 4 replicates using bottom-perforated nursery bags filled with soil. After growing the plants for about 5 weeks, each species were carefully uprooted and sand washed from the root.

Cut root methods: The root cut assay was carried out as described by Berner *et al*.[9,11]. Each plant root was gently uprooted and washed with distilled water and sectioned into several parts of 1 cm each with the aid of a razor blade. A circular hollow ring out of the aluminum foil diameter approximately 1.5 cm was made. About 1 g of root pieces was weighted and fitted into the well. Two regular moistened filter paper was put in the bottom of standard petri dish, the aluminum foil was placed in the centre of the petri dish, where, the cut root pieces were placed after weighing, the design was done by marking out 3 radii of the glass fibre disk with the condition *Striga* seeds next to the aluminum foil well which radiates out from the central well. The disk closer to the well as was marked as distance 1, the next disk as distance 2 and so on, this placed edge to edge with the first disk touching the edge of the wall, 1-2 drops of sterile deionized water were added to the roots in the centre of the well. For control, 1-2 drops of the stimulant (Strigol analog) on the same amount of cut root pieces of the Asteraceae. After 48 h, treated seeds were viewed with a light microscope and counts of numbers of germinated seeds as well as the total number of seeds of each disk.

Root exudates methods: Root exudates from the 20 selected members of the Asteraceae spp. were used. Water was poured into the perforated nursery bag that contained the plant and allowed percolate into a container, the water was discarded and then refilled with 25 mL of water and leachate was collected into a beaker. Three glass fiber disks containing *Striga hermonthica* seeds were placed in a petri dish that contained a moistened filter paper, following which drops of the leachate from the root exudates were added and placed it in a dark. After 48 h, germination was visualized with the aid of a microscope and counted. The percent ratio of the numbers of germinated seeds out of the total numbers seeds/disk was used to calculate percent germination.

Control: Two control germination stimulants were used. Strigol analog GR-24 was used as the positive control check for germination while the sterile distilled water was used as negative control checks. The experimental petri dishes were laid in a complete randomized block design (RCBD) with $22\times1\times2$ factorial combination, where 22 is the number of Asteraceae spp. (test germination stimulants) and the 2 controls (GR-24 serving as a positive check and sterile distilled water acting as a negative check).

Statistical analysis: Percentage germination of *Striga* seed of the 20 Asteraceae sp. using the 2 treatments (root cut assay and root exudate method) in relation to the control (strigol analog GR24) was tested on Generalized Linear Model (2-way ANOVA) using the SPSS software, version 23.0.

RESULTS

Figure 1a-t reveals that member of Asteraceae shows differential germination potential to *Striga hermonthica* seeds. The germination of *Striga hermonthica* seed using cut root and root exudate compared with the positive check (GR-24) was statistically significant for *Chrysanthellum indicum*, *Emilia coccinea*, *Emilia praetermissa*, *Synedrella nodiflora*, *Tithonia diversifolia*, *Tridax procumbens*, *Vernonia cinerea*, *Vernonia amygdalina* and *Wedelia trilobata.* While for *Ageratum conyzoides*, *Acmella uliginosa*, *Aspilia africana*, *Chromolaena odorata*, *Conyza sumatrensis*, *Eclipta alba*, *Eclipta prostrate*, *Lactuca taraxacifolia*, *Mikania cordata, Spilanthes filicaulis*, *Solanecio biafrae* and *Vernonia cinerea*.

In terms of the efficacy of the use of cut root method in *Striga hermonthica* germination, the highest germination percentage was recorded for *Solanecio biafrae* (64.83%) this was followed by *Aspilia africana* (63%), *Wedelia trilobata* (62.91%), *Mikania cordata* (62%) *Vernonia amygdalina*, *Vernonia cinerea* (59.68%), *Tithonia diversifolia* (59.8), *Acmella uliginosa* (55.1%) and *Chrysanthellum indicum* (55.88%). However, lower germination percentage of *Striga hermonthica* seeds under the cut root treatment were

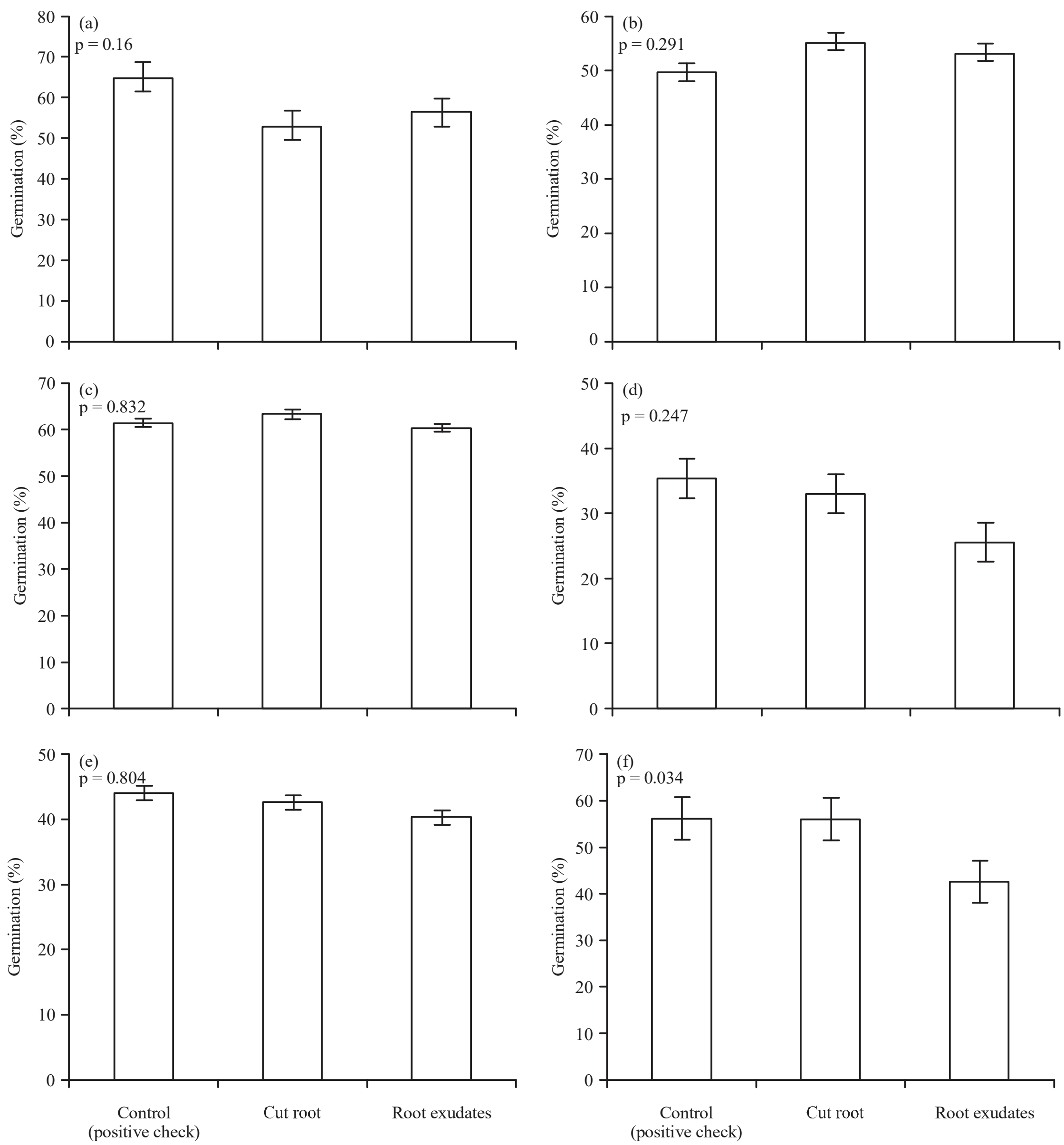
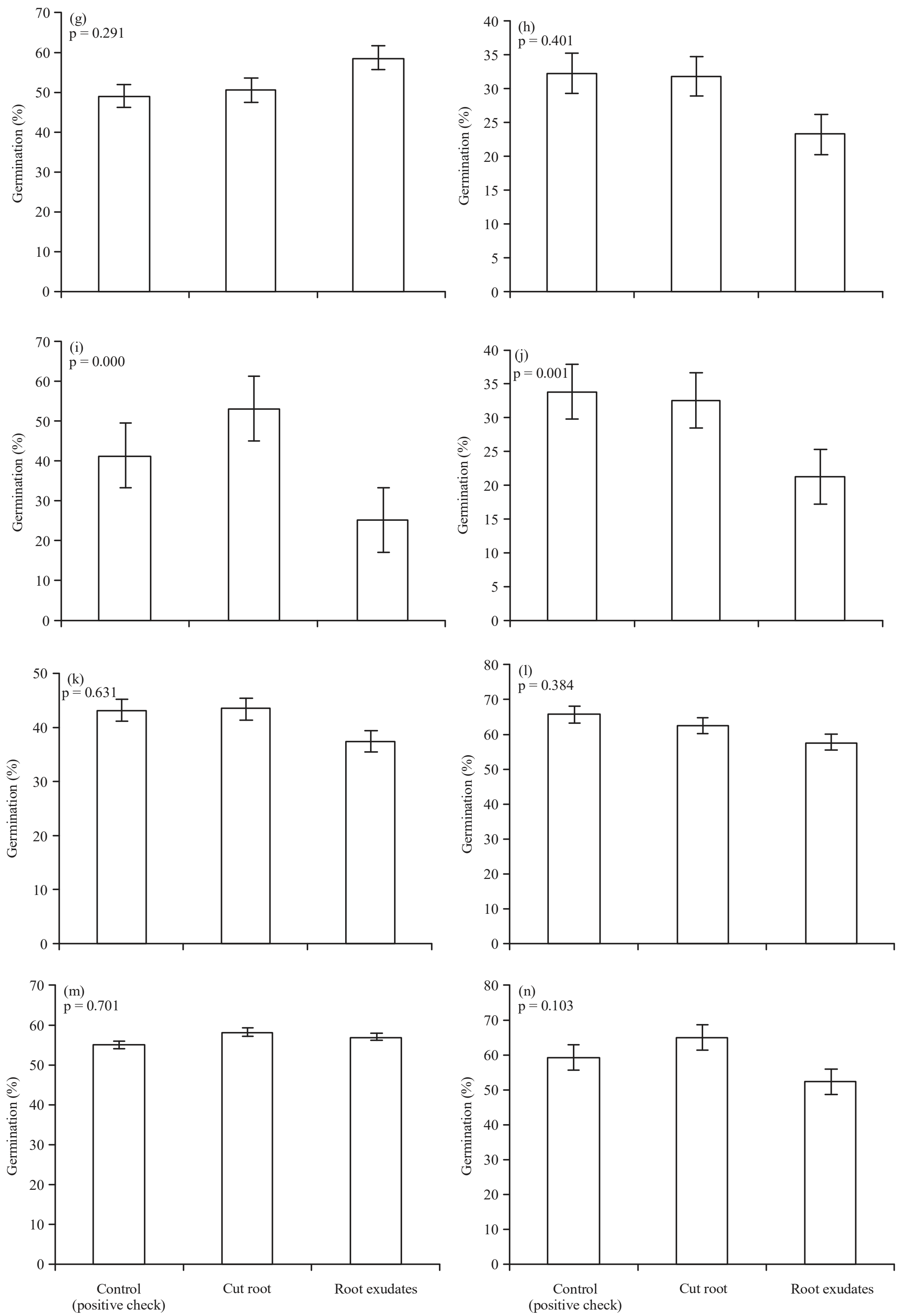


Fig. 1(a-t): Continue



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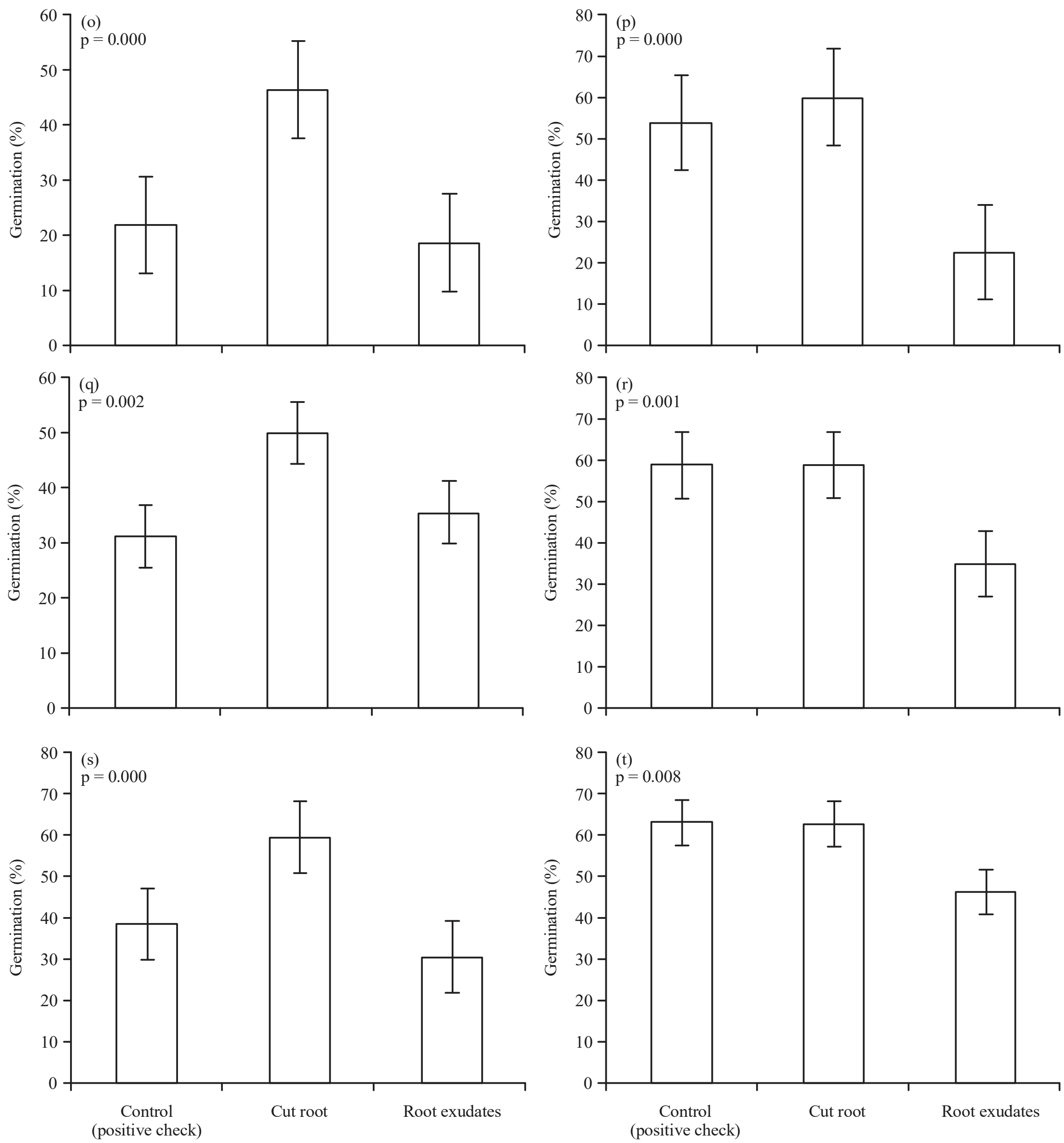

Fig. 1(a-t): Germination percentage of *Striga hermonthica* seeds on different Asteraceae sp. (a) *Ageratum conyzoides*, (b) *Acmella uliginosa*, (c) *Aspilia africana*, (d) *Chromolaena odorata*, (e) *Conyza sumatrensis*, (f) *Chrysanthellum indicum*, (g) *Eclipta alba*, (h) *Eclipta prostrate*, (i) *Emilia coccinea*, (j) *Emilia praetermissa*, (k) *Lactuca taraxacifolia*, (l) *Mikania cordata*, (m) *Spilanthes filicaulis*, (n) *Solanecio biafrae*, (o) *Synedrella nodiflora*, (p) *Tithonia diversifolia*, (q) *Tridax procumbens*, (r) *Vernonia cinerea*, (s) *Vernonia amygdalina* and (t) *Wedelia trilobata*

recorded for *Eclipta prostrate*, having the lowest value at 31.83%, followed by *Emilia praetermissa* (32.50%), *Chromolaena odorata* (32.68%). The positive control check GR-24 had the highest and lowest germination percentage value of 65 and 35%, respectively.

The effects of *Striga hermonthica* seed germination using root exudate (Fig. 1) shows that exudates from *Aspilia africana* had the highest (60.50%) germination potential, followed by *Eclipta alba* (58.91%), *Mikania cordata* (57.50%), *Spilanthes filicaulis* (56.58%) and *Agerathum conyzoides* (56%). Similarly, lower germination of *Striga hermonthica* seeds was evident in seeds exposed root exudates derived from *Emilia praetermissa* (21%), *Tithonia diversifolia* (22.52%), *Eclipta prostrata* (23%), *Chromolaena odorata* (24.75%) and

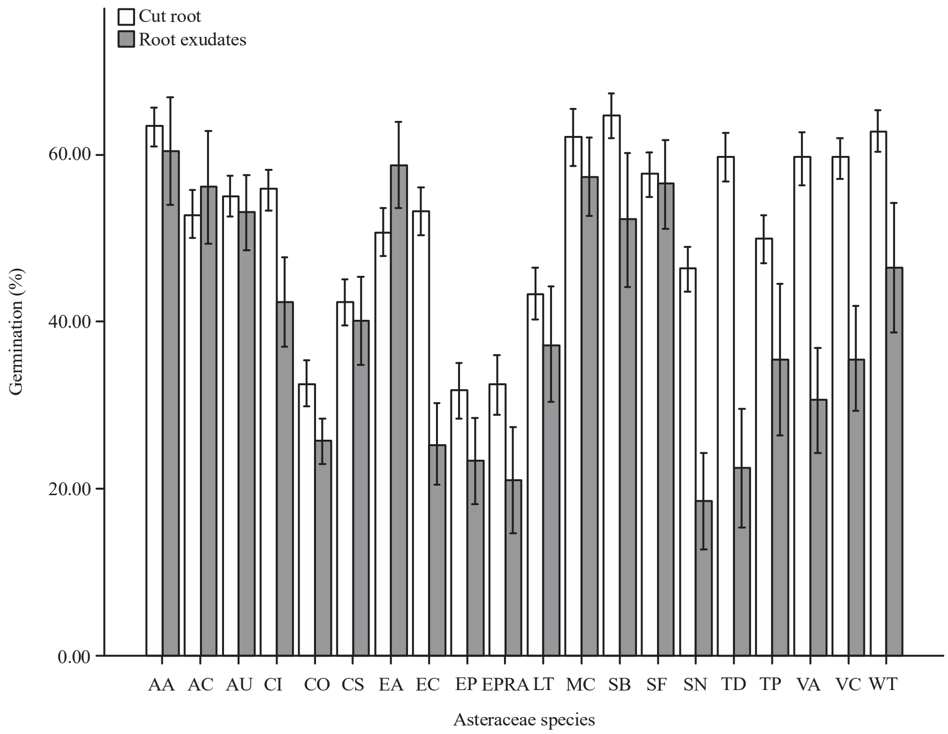

Fig. 2: Germination (%) of *Striga hermonthica* seeds on different Asteraceae species
AC: *Ageratum conyzoides*, AU: *Acmella uliginosa*, AA: *Aspilia africana*, CO: *Chromolaena odorata*, CS: *Conyza sumatrensis*, CI: *Chrysanthellum indicum*, EA: *Eclipta alba*, EP: *Eclipta prostrate*, EC: *Emilia coccinea*, EPRA: *Emilia praetermissa*, LT: *Lactuca taraxacifolia*, MC: *Mikania cordata*, SF: *Spilanthes filicaulis*, SB: *Solanecio biafrae*, SN: *Synedrella nodiflora*, TD: *Tithonia diversifolia*, TP: *Tridax procumbens*, VC: *Vernonia cinerea*, VA: *Vernonia amygdalina*, WT: *Wedelia trilobata*

Synedrella nodiflora (18.51%) recorded the least germination. The positive control check GR-24 had the highest and lowest germination percentage value of 65 and 35%, respectively.

In comparing the effectiveness of methods, cut-root and root exudates, the cut root method gave a better germination percentage than the root exudates method (Fig. 2). Another interesting observation was that the distance of the disk fiber from the well significantly influence germination of *Striga* seeds as disks closer to the well, recorded the higher number of germinated *Striga* seeds, while the disk at the distances away from the root pieces recorded little or no germination of *Striga* seeds.

DISCUSSION

It is quite surprising that despite the dominant occurrence of members of Asteraceae growing on abandoned *Striga* infested farmlands, no report was found in the literature on the potential effects of members of Asteraceae on the germination of *Striga hermonthica* seeds. This study demonstrated that some selected members of the family Asteraceae can initiate the germination of *Striga hermonthica* seeds. Exudates derived from *Solanecio biafrae, Aspilia africana* and *Mikania cordata* significantly stimulated *Striga* germination in both cut-root and root exudate methods. There was however, differential germination stimulation potential for different species and the method of extraction of the germination stimulant. The cut-root method is best suited for *Solanecio biafrae, Aspilia africana*, *Wedelia trilobata*, *Mikania cordata, Vernonia amygdalina*, *Vernonia cinerea, Tithonia diversifolia*, *Acmella uliginosa* and *Chrysanthellum indicum*, while the root-exudates method is appropriate for *Aspilia africana*, *Eclipta alba*, *Mikania cordata*, *Spilanthes filicaulis* and *Agerathum conyzoides*. These species identified to initiate the germination of *Striga* could serve as a trap plant for the reduction of *Striga* inoculum in the soil.

The search for a farmer-friendly and less laborious method of reducing the *Striga* inoculum in the soil remains the focus of most *Striga* researchers. Babiker *et al.*[12] showed that certain soil-borne saprophytic bacteria have the potential to reduce the menace of *Striga hermonthica* by inhibiting seed germination. The drawback in using soil-borne saprophytic bacteria is that the survival of inoculated bacteria is not sustained in the next cropping season. This means that for every cropping season, there is a need for a repeated application resulting high demand of energy and resources. Traore *et al.*[8] suggested a number of cultural practices for controlling *Striga* such as direct hand-pulling of the parasite, land fallowing, crop rotation and crop seed treatment with the powder of *Parkia biglobosa* (African locust bean) peel before planting. However, in adopting a suitable method, one must first consider the eco-friendly nature of such an option. For instance, Land fallowing methods although sounds plausible but will require much deforestation practices which will be highly detrimental to the already dwindling biodiversity. Crop rotation with legumes has also gained considerable advocacy for its effective nature against *Striga hermonthica*[8]. The practical limitation in this control method is that few farmers will be prepared to give up growing their preferred cereals for the number of years that the rotation will last and more so that this method is cultivar dependent and as such the farmer will be faced with the task of choosing cultivars that best effect the suicidal germination of the parasite seeds. The present study spotlights the potentials of selected members of Asteraceae for the possible control of *Striga* in African agriculture. This method is likely to be more promising due to the fact that these species are mostly weeds and ornamentals and as such, they are readily available and comes at no cost whatsoever.

In comparing the effectiveness of both cut-root and root exudate methods based on inference from this study, the cut-root method gave a better germination percentage than the root exudate method. In its practical application, any method of germination stimulant extraction can be adopted by the intended farmers since the difference between both is fairly marginal, with cut root method (64.83%) and root exudates (60.50%).

CONCLUSION

This study provides evidence that common members of the Asteraceae in Nigeria produce aqueous root exudates that are capable of initiating *Striga* seed germination. Based on this evidence, it is hoped that these members of Asteraceae could assist farmers in Nigeria, depopulate the concentration of *Striga* seeds in the soil, hence reducing the attacks on common hosts such as cereals and legumes like maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), Millet (*Pennisetum glaucum* L.) and beans (*Vigna sinensis*).

SIGNIFICANT STATEMENT

The focus of the study was to seek for a more practicable way of managing the devastating effect of *Striga*. This study has successfully screened 20 members of Asteraceae for their ability to stimulate *Striga hermonthica* germination. Exudates derived from *Solanecio biafra*, *Aspilia africana* and *Mikania cordata* significantly stimulated *Striga* germination in both cut-root and root exudate methods. Based on this finding, it is evident that some members of Asteraceae are capable of reducing *Striga* seed load in the soil. Thus, we recommend the use of these selected Asteraceae species for the management of *Striga* infestation in Nigeria, since it is less expensive and ecofriendly compared to other methods of control.

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