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Effects of Sorghum (*Sorghum bicolor* [L.] Moench) Root Exudates and Extracts on Early Developmental Stages of *Strigahermonthica* (Del.) Benth.

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ABSTRACT
Two types of laboratory experiments (*in vitro* and *in vivo*) were undertaken at the Faculty of Agricultural Sciences, University of Gezira, Sudan, to investigate the effects of sorghum (*Sorghum bicolor* [L.] Moench) root exudates and root extracts on early developmental stages of *Strigahermonthica* (Del.) Benth. collected from different locations in Sudan. Collection of seeds was made in *S. hermonthica* endemic areas in Gadarif, Gezira and Kordofan. A total of fifteen *Striga* populations were collected. Twelve *S. hermonthica* populations, one each, were collected from under sorghum and three *S. hermonthica* populations, one each, were collected from under millet. The fifteen *S. hermonthica* populations were arranged in completely randomized design with three replicates. *Striga* seeds and/or germilings were examined under a binocular for germination, haustorium initiation, attachment and penetration 24, 72, 144, 192 hour after initial incubation, respectively. Data were collected and subjected to analysis of variance procedure. Means were separated for significant using Duncan's Multiple Range Test ($P \leq 0.5$). The results revealed that root exudates and extracts of all plants induced seed germination and haustorium initiation in *S. hermonthica*. However, the highest germination, haustorium initiation, attachment and penetration attained by each of *S. hermonthica* population, were on their respective hosts. These findings suggest the existence of both inter-and intra-crop specificity. Moreover, the results confirmed the existence of two strains of *S. hermonthica*, one specific to sorghum and the other, to millet.
Keywords: Witchweed, variability, virulence, specificity, strain, sorghum.

Introduction

Witchweeds (*Striga* spp.), member of the family Orobanchaceae, are obligate root parasitic plants that attack agronomically important cereals and legumes (Anonymous, 1993). *Striga's* complete dependence upon a host for survival requires close coordination of its life cycle with that of the host. *Striga* seeds are minutewith limited stored food reserves and *Striga* germilings survive only for about three days unless attachment to a host root is achieved (Riopel and Baird, 1987). It is not surprising, therefore, that germination of *Striga* seeds is under control of the host through chemical signals exuded from its roots, so that germination usually occurs only when a plant root is available. Subsequent to germination, haustorium initiation occurs in response to a second host-derived signal. The haustorium penetrates the cortex, guided possibly by the internal chemistry of the host root and establishes connection with the vascular system. Following connection with the host xylem, the plumular end comes out of the seed coat and further development occurs. *Striga* is completely dependent on its host for survival, and its life cycle is closely linked with that of the host plant (Haussmann *et al*., 2000).Once connected, the parasite withdraws water, mineral nutrients, carbohydrates, aminoacides and possibly hormones from its host. As a consequence, the parasite causes stunted shoot growth, leaf chlorosis and reduced photosynthesitic capacity of the host (Ejeta and Butler, 2000).

The most promising and culturally acceptable methods for *Striga* management in Africa today are crop rotation with non-host trap crops and planting of tolerant cultivars (Christopher *et al.,* 2002). Resistant cultivars, due to paucity of resistance genes, are limited in number (Ejeta *et al.*, 1992). Furthermore, resistance is temporally and spatially unstable. Instability of resistance is attributed to existence of strains and physiological variants of the parasite. The existence of intercrop-specific strains in *Striga* has been suggested to be based almost entirely on differential response of variants of the species to root exudates from host cultivars (Bebawi and Farah, 1981). However, recent studies showed that differential post-germination development could be a determinant factor in the observed host-specificity (Ali, 2008). Therefore, the present investigation was conducted to investigate the effects of root exudates and root extracts of sorghum on early developmental stages of *Strigahermonthica* (Del.) Benth. populations collected from different locations in Sudan.

Materials and Methods

The experiments were conducted at the phytopathology centre and biology Laboratory, Faculty of Agricultural Sciences, University of Gezira, Sudan.

Collection of *S. hermonthica* seeds

Field surveys were conducted during the rainy season 2009/2010 in *S. hermonthica* endemic areas in Gadarif, Gezira and Kordofan, i.e. Eastern, Central and Western Sudan, respectively.Field surveys were conducted to collect seeds from *Striga* plants growing under their respective hosts (sorghum and millet).A total of fifteen *S. hermonthica* populations were collected. Twelve *S. hermonthica* populations, one each, were collected from under sorghum in Galabat, Sumsum, Gadarif, Butana, El Fau (Gadarif area); Hasaheisa, Abu-Haraz, Hag-Abdalla, Barakat and Wad-Rabia (Gezira area); Um-Rawaba and El-Rahad (Kordofan area).Three *S. hermonthica* populations, one each, were collected from under millet in Kadugli, Khour-Tagat and El Obied (Kordofan area).The seeds were surface sterilized by sodium hypochlorite, (NaOCl) 1% solution, for 3 min with continues agitation. Subsequently the seeds were thoroughly washed with sterilized distilled water for several times. Floating seeds were discarded and the remaining seeds were stored at room temperature till used.

Seed conditioning

In these experiments, the disc technique described by Dafaallah (2006) was used. About 80-100, Glass Fiber Filter Paper (GFFP) (Whatman GF/C) discs (0.5 mm diameter) were placed one layer GFFP in a glass Petri-dish (GPD), 9 cm internal diameter (i.d). *Striga* seeds (25-50) were sprinkled on each disc and the GPDs, moistened with distilled sterilized water (4.5 ml), sealed with Parafilm, covered with black polyethylene bag, were incubated at 30^{0}C in the dark for 12 days.

In vitro experiments

In *vitro*experiments were designed to study the effects of sorghum root exudates and extracts on germination and haustorium initiation of *S. hermonthica*.

Effects of sorghum root exudates collected from under rockwool on germination and haustorium initiation of *S. hermonthica*

Sorghum, cultivar Abu-70, obtained from the Sorghum Programme, Agricultural Research Corporation (ARC), was used in this experiment. Crops seedlings, grown in Petri dishes for 24 hour, were transferred each to rockwool in plastic pots. In each case rockwool was moistened with 200 ml of sterilized distilled water and incubated in a growth chamber for 10 days prior to collection of root exudates under suction using a suction pump. Aliquots of each root exudates (30µl) were applied to each pair of discs containing conditioned *S. hermonthica* seeds placed on glass fiber discs (8 mm i.d.). The Petri dishes were sealed with Para film, placed in black polyethylene bags and incubated at 30°C in the dark. Treatments (fifteen *S. hermonthica* populations) were arrangedin completely randomized design with three replicates. The seeds were examined for germination and haustorium initiation 24 and 72 hour (h) after incubation, respectively.

Effects of sorghum root extract on germination and haustorium initiation of *S. hermonthica*

Sorghum cv. Abu-70 was sown on filter paper rolls placed in plastic pots and watered daily for 6 days. Root samples (1g) each was obtained from crop seedlings and placed in a mortar. Five ml of distilled water were added and the roots were crushed using a mortar and pestle, subsequently centrifuged and the supernatant was collected. Conditioned *S. hermonthica* seeds were treated with aliquots of the root extract (30µl each). Treatments (fifteen *S. hermonthica* populations) were arranged in complete randomized design with three replicates. Seeds were examined for germination and haustorium initiation 24 and 72 h after incubation, respectively. Similarly, conditioned seeds treated with sterilized distilled water, incubated for 24 and 72 h and examined for germination and haustorium initiation were included as control for comparison.

In vivo experiment

In vivo experiments were designed to study the effects of sorghum *in-situ* root exudates on germination, haustorium initiation, attachment and penetration of *S. hermonthica* into host roots.

Effects of sorghum *in-situ* root exudates on developmental stages of *S. hermonthica*

Disposable Petri-dishes (DPD) 9 cm i.d.were filled with Gezira soil that was sterilized in an oven at 105^{0}C for 24 h. Fiber filter paper (Whatman F/C) was placed on top of soil. Soil was moistened with 30 ml distilled sterilized water. Sorghum cv. Abu-70 was raised in paper rolls for 5 days. Crop seedlings (5 days old) were transferred and placed on FFP in the disposable Petri-dishes with a lateral opening to allow for emergence of crop shoot. Conditioned *Striga* seeds placed on glass fiber filter discs (9 mm- di), were placed underneath the roots. Sterilized-distilled water was added to each Petridishas needed. The Petri dishes, covered with a black glass fiber filter paper, sealed with Parafilm and placed in black polyethylene bags, were incubated at room temperature in continuous light. Treatments (fifteen *S. hermonthica* populations) were arranged in complete randomized design with three replicates. *Striga* seeds and/or germilings were then examined under a binocular for germination, haustorium initiation, attachment and penetration 24, 72, 144, 192 h after initial incubation, respectively.

Statistical analysis

Data were collected and subjected to analysis of variance procedure. Means were separated for significance using DMRT at $p \leq 0.05$.

Results

Effects of sorghum root exudates, root extracts and *in-situ* root exudates on seed germination of *S. hermonthica*

S. hermonthica, irrespective of collection site, displayed considerable variations in germination in response to root exudates, root extracts and *in-situ* root exudates of sorghum cv. Abu-70 (Table 1).

Effects of sorghum root exudates on germination

S. hermonthica populations collected from Gadarif area, displayed moderate to high germination (60 -87%) in response to root exudates from sorghum cv. Abu – 70 (81– 84%) (Table1). Seeds collected from Galabat, Sumsum, Gadarif and Butana displayed comparable germination (86 – 87.3%). However, seeds collected from El Fau displayed significantly lower germination (60%). *S. hermonthica* populations collected from Gezira area showed high germination. Seeds collected from Hasaheisa, Abu-Haraz, Hag-Abdalla and Barakat displayed high and comparable germination (83 – 84%). In among all seeds collected from Gadarif area, those obtained from Wad-Rabia showed the lowest germination (81.7%). *S. hermonthica* seeds collected from Kordofan area displayed differential response to sorghum root exudates. *Striga* seeds collected from Um-Rawaba showed the highest germination (87.3%), followed by El-Rahad population (81%). Seeds collected from under millet at El-Obied, Khour-Tagat and Kadugli displayed moderate germination (53 - 55.3%) (Table1).

Effects of sorghum root extracts on germination *S. hermonthica* populations collected from Gadarif area displayed moderate response to root extracts from sorghum cv. Abu – 70 (Table 1). Seeds collected from Galabat, Sumsum and Gadarif displayed significantly the highest germination (71 – 72.7%). Seeds collected from Butana displayed significantly lower response. Seeds collected from El Fau showed the lowest response to the stimulant (60% germination). *S. hermonthica* populations collected from Gadarif area showed moderate germination. *Striga* seeds collected from Hasaheisa and Hag-Abdalla showed the higher germination (67.3 - 69.3%). Seed population from Abu-Haraz displayed significantly lower germination. Seeds collected from Barakat and Wad-Rabia displayed a significant further decline in response to the root extract (60 – 62.3% germination), respectively. *S.*

hermonthica populations collected from response to sorghum root extracts. *Striga* seeds collected from Um-Rawaba and El-Rahad showed moderate and comparable germination (70.3-71%). *S. hermonthica* populations collected from under millet at El-Obied, Khour-Tagat and Kadugli displayed low (37.7 – 39%) and comparable germination (Table 1).

Effects of sorghum *in-situ* root exudates on germination

S. hermonthica collected from Gadarif area, placed in close proximity to roots of sorghum cv. Abu-70, displayed moderate to high germination (68 - 83%) (Table 1). Seeds collected from Gadarif showed the highest and most significant germination (83%) in comparison to populations from other sites in Gadarif area. Seeds collected from Sumsum showed a significantly lower response (78.7% germination).Seeds collected from Galabat and those from El Fau were significantly less responsive than those obtained from Sumsum. Among all seed populations collected from Gadarif area those obtained from Butana showed the lowest germination (68%). *S. hermonthica* populations collected from Gadarif area displayed moderate germination. *Striga* seeds collected from Abu-Haraz showed the highest germination (79%). On the other hand, seeds collected from Hasaheisa were significantly less responsive to the exudates. Seed populations from Hag-Abdalla were significantly less responsive than those from Hasaheisa and displayed 70.3% germination. Seeds collected from Barakat and Wad-Rabia displayed a further significant reduction in response to the exudates. *S. hermonthica* populations collected from Kordofan area and placed in the vicinity of sorghum roots displayed differential response. *Striga* seeds collected from El-Rahad and Um-Rawaba showed the highest germination (78 and 79%). *S.* Kordofan area displayed differential *hermonthica* populations collected from under millet at El-Obied, Kadugli and Khour-Tagat displayed low and comparable germination (30.3 - 32.7%). Among all seeds population collected from Kordofan area germination was lowest (30.3%) for those collected from Khour-Tagat (Table 1).

Effects of sorghum root exudates, root extracts and *in-situ* root exudates on haustorium initiation of *S. hermonthica*

Haustorium initiation in response to root exudates, root extracts and *in-situ* root exudates of sorghum cv. Abu-70 showed considerable variations (Table 2).

Effects of sorghum root exudates on haustorium initiation

S. hermonthica populations collected from Gadarif area displayed moderate haustorium initiation in response to root exudates from sorghum cv. Abu – 70 (Table 2). Seeds collected from Gadarif, Galabat and Sumsum showed the highest haustorium initiation (54 - 56%). Seeds collected from Butana and El Fau displayed the lowest haustorium initiation (53 – 53.7%). *S. hermonthica* seed populations collected from Gadarif area showed moderate haustorium initiation. *Striga* seeds collected from Hag-Abdalla and Wad-Rabia showed the highest haustorium initiation (53.7 - 55%). On the other hand, seeds collected from Hasaheisa, Abu-Haraz and Barakat displayed significantly low haustorium initiation in response to root exudates (50 – 51.7%). Haustorium initiation in *S. hermonthica* populations collected from Kordofan area displayed differential response to sorghum root exudates. *Striga* germilings obtained from seeds collected from Um-Rawaba showed the highest haustorium initiation (57%). *Striga* germilings arising from seeds collected from El-Rahad were less responsive to the haustorium factor in the root exudates as only 50% of the germilings developed haustoria. *S. hermonthica* germilings obtained from seeds collected from under millet at Kadugli, Khour-Tagat and El Obied showed the lowest response (16 – 18%) (Table2).

Effects of sorghum root extracts on haustorium initiation

Root extracts from sorghum cv. Abu – 70 induced moderate haustorium initiation in *S. hermonthica* germilings resulting from seeds collected from Gadarif area (Table 2). *Striga* germilings from seeds collected from Gadarif, Galabat and Sumsum showed the highest haustorium initiation (55 - 55.3%). Germilings from seeds collected from Butana and El Fau displayed significantly lower haustorium initiation. *S. hermonthica* germilings from seed populations collected from Gadarif area displayed moderate haustorium initiation (47 – 51.3%) (Table2). *Striga* population collected from Hasaheisa and Abu-Haraz showed the highest haustorium initiation (50 – 51.3%). On the other hand, *Striga* germilings collected from Hag-Abdalla, Barakat and Wad-Rabia displayed significantly less haustorium initiation in response to sorghum root extracts. Populations from Kordofan area displayed differential response to sorghum root extracts. *Striga* germilings from populations collected from under sorghum at Um-Rawaba and El-Rahad, showed the highest haustorium initiation (53.3 – 54%). Germilings from populations collected from, under millet, at Kadugli, El-Obied and Khour-Tagat displayed low and comparable haustorium initiation (15 – 17.3%) (Table2).

Effects of *in-situ* root exudates on haustorium initiation

Germilings from *Striga* seeds placed in close proximity to roots of sorghum cv. Abu-70 displayed differential haustorium initiation (Table 2). Populations from Gadarif area showed significantly high haustorium initiation (70.3 - 84%). Germilings from *Striga* seeds collected from Galabat and Gadarif showed the highest haustorium initiation (84%). Population from Sumsum displayed a significantly lower haustorium initiation. Germilings fromseeds population from Butana showed a significant decrease in haustorium initiation in comparison to population from Sumsum. A further significant decline in haustorium initiation was displayed by germilings from El-Fau seed population. *Striga* germilings frompopulations collected from Gadarif area displayed high haustorium initiation. *Striga* population collected from Abu-Haraz showed the highest haustorium initiation (84%). Germilings fromseeds collected from Hasaheisa and Hag-Abdalla displayed significantly lower haustorium initiation. Germilings from populations collected from Wad-Rabia and Barakat displayed a further significant decline in haustorium initiation. *Striga* germilings frompopulations collected from Kordofan area displayed differential response to the haustorium factor from sorghum. Germilings from seeds collected from El-Rahad showed the highest haustorium initiation (81.7%). *Striga* germilings from seed populations collected from under millet at El-Obied, Kadugli and Khour-Tagat displayed moderate to high haustorium initiation (72-78%). *Striga* germilings from seeds collected atUm-Rawaba displayed comparatively lowest haustorium initiation (69.7%) (Table2).

Effects of *in-situ* root exudates on attachment and penetration of sorghum roots

S. hermonthica, irrespective of collection site, displayed considerable variations in attachment and penetration of sorghum roots (Table 3).

Effects of *in-situ* root exudates on attachment to sorghum roots

Striga germilings from population collected from Gadarif, Gadarif area, displayed the highest attachment (46%) to sorghum cv. Abu-70 roots. Germilings from seeds collected from Galabat, Sumsum and El Fau displayed significantly less attachment (40- 41.3%). Among all *Striga* populations germilings from seeds collected from Butana displayed the lowest attachment (35%). *Striga* germilings from populations collected from Hasaheisa and Hag-Abdalla, Gadarif area, displayed about 40% attachment (Table 3 and Plate 1). However, germilings from seeds collected from Abu-Haraz displayed significantly lower attachment (36%). A further significant decline in attachment was displayed by germilings from seeds collected from Barakat and Wad-Rabia (33.7 and 34%, respectively). *Striga* germilings from populations collected from Um-Rawaba and El-Rahad displayed identical attachment (40%) to sorghum root. However, germilings from populations collected from Kadugli, Khour-Tagat and El-Obied displayed significantly lower attachment (35 -37%) (Table3).

Effects of *in-situ* root exudates on penetration of sorghum roots

Striga germilings from different populations showed differential penetration into sorghum roots (Table 3). Population collected from Sumsum and Gadarif, Gadarif area, displayed comparable penetration into roots of sorghum (35 and 39.3%). However, population collected from Galabat displayed a significantly lower penetration. A further significant decrease in penetration was displayed by populations collected from F Fau and Butana. Among *S. hermonthica* populations from Gadarif area, population from Butana displayed the lowest penetration (20%). *S. hermonthica* populations collected from Hasaheisa, Abu-Haraz and Hag-Abdalla, Gadarif area, displayed comparable penetration (29 - 30%) into sorghum roots. However, populations from Barakat and Wad-Rabia displayed, significantly, less penetration (18.3 and 18.7%). Among seeds collected from Kordofan area, populationfrom Um-Rawaba showed the highest penetration (28%). Population from El-Rahad showed significantly lower penetration. A further decline in penetration was observedby populations from Kadugli, El-Obied and Khour-Tagat (Table 3).

Discussion

*S. hermonthica*is a noxious weed and is well adapted to its host and the environment comprising agro-ecosystems and climates (Mohamed *et al.*, 2007). The adaptation includes readiness to germinate, the potential of attachment to a suitable host and probability of successfully producing seeds for the next generation (Zhongkui *et al.*, 2007). The close association between the parasite and its host, the complexity of the life cycle of the parasite, copious seed production, germination requirements, variability between *S. hermonthica* populations and existence of host specific populations and physiological variants make the parasite a difficult weed to control (Babiker, 2007).

The present study revealed that, *S. hermonthica* millet strain is less responsive to sorghum root exudates and extract than sorghum strain. These findings taken in conjunction with the differential germination response of the two strains to root exudates, root extracts and *in-situ* root exudates suggest the possibility of differential structural requirements and/or deficiency in penetration or accumulation of the stimulant at the site of action.

The observed differential response of the two *Striga* strains to haustorium inducing factor(s) from sorghum may indicate specificity of the haustorium factors. Such specificity may be related to differences in quality, identity and/or quantity of the haustorium factor. The observed differential response is consistent with a previous report by Astatt and Hansen (1978) who reported that the potential number of haustoria is a product of the concentration and/or quality of haustoria inducing factor and the parasite individual ability to respond.

The findings of this study are in agreement with those of Ali (2008) who reported that, root extracts and exudates from all plants tested were able to induce germination and haustorium initiation. However, the magnitude of germination and haustorium initiation varied with the parasite population and the host in question. Thus the findings reported in this study taken in conjunction with those reported by Ali (2008) indicate clearly that induction of germination, haustorium initiation, attachment, penetration and establishment of connection with the host xylem in *S. hermonthica* were influenced by the respective host and parasite. The highest attachment and penetration attained by each of the *S. hermonthica* population were on their respective hosts. The results also corporate the observation made by Rao (1982) who suggested that the earlier stages of parasite establishment may have greater importance in determining host specificity. Also, the results are consistent with observation made by Wilson-Jones (1955) that two strains of *S. hermonthica* exist in Sudan, one prevailing in Eastern and Central Sudan and only attacks sorghum while in Western Sudan, both millet and sorghum were attacked. Furthermore, the strain on millet did not attack sorghum and vice versa. Sorghum was usually heavily attacked by *S. hermonthica* in the clay soils of Central Sudan whereas millet was particularly immune, but the reverse was true on sandy soils.

The close association between *Striga*, its host and the environment together with the copious seed production and ease of dissemination may maximize the risk of spread of the parasite by the ongoing climate changes (Mohamed *et al.*, 2007). It is noteworthy that *S. hermonthica* collected from under millet at Kordofan area, responded to root exudates, root extracts and *in-situ* root exudates from sorghum. This behaviour is intriguing and at the same time is an indicator of a serious problem. In Central and Eastern Sudan, sorghum predominates and millet is rarely grown. However, in Western Sudan both crops are cultivated often in the same field. Accordingly, hybridization between the two strains may result in a progeny capable of attacking both crops.

Conclusions and Suggestions

- This study showed that host specificity is a function of a multitude of factors including germination, haustorium initiation, attachment, penetration and growth.
- The study suggests two levels of physiological specialization in *S. hermonthica* in Sudan: intercrop specialization and intra-crop specialization. Furthermore, the results confirmed the existence of two host-specific strains.
- The study indicates the need for in depth research on variability and host specificity in *S. hermonthica* at the molecular level. Such studies are needed to facilitate development of stable and durable resistance.

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Table 1: Effects of sorghum root exudates, root extracts and *in-situ* root exudates on seed germination of *S. hermonthica*

S. hermonthica population		Germination (%)		
		Sorghum cv.Abu-70		
Area	Location	Root exudates	Root extracts	*In-situ* root exudates
Gadarif (Eastern Sudan)	Galabat*	87.0 a	72.0 ab	71.3 cd
	Sumsum*	86.0 ab	71.0 abc	78.7 b
	Gadarif*	86.7 a	72.7 a	83.0 a
	Butana*	87.3 a	67.7 d	68.0 e
	El Fau*	60.0 f	60.0 g	70.3 d
Gezira (Central Sudan)	Hasaheisa*	84.0 bc	69.3 cd	73.0 c
	Abu-Haraz*	83.0 cd	64.7 e	79.0 b
	Hag-Abdalla*	83.3 cd	67.3 d	70.3 d
	Barakat*	83.0 cd	60.0 g	65.0 f
	Wad-Rabia*	81.7 de	62.3 f	63.7 f
Kordofan (Western Sudan)	Um-Rawaba*	87.3 a	71.0 abc	78.0 b
	El-Rahad*	80.0 e	70.3 bc	79.0 b
	Kadugli**	55.3 g	39.0 h	32.7 g
	Khour-Tagat**	53.7 gh	39.0 h	30.3 h
	El Obied**	53.0 h	37.7 h	31.7 gh
SE ±		0.7124	0.7088	0.7137
CV %		4.17	5.18	5.10

*, **= *Striga* populations collected from under sorghum and millet, respectively.

Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P ≤ 0.05).

Table 2: Effects of sorghum root exudates, root extracts and *in-situ* root exudates on haustorium initiation of *S. hermonthica*

S. hermonthica population		Haustorium initiation (%)		
		Sorghum cv.Abu-70		
Area	Location	Root exudates	Root extracts	*In-situ* root exudates
Gadarif (Eastern Sudan)	Galabat*	55.0 abc	55.0 a	84.0 a
	Sumsum*	54.0 bc	55.0 a	80.3 bc
	Gadarif*	56.0 ab	55.3 a	84.0 a
	Butana*	53.0 cde	50.0 bc	77.0 ef
	El Fau*	53.7 cd	49.0 cd	70.3 gh
Gezira (Central Sudan)	Hasaheisa*	51.0 ef	51.3 b	80.0 bcd
	Abu-Haraz*	50.0 f	50.0 bc	84.0 a
	Hag-Abdalla*	55.0 abc	48.0 df	78.7 cde
	Barakat*	51.7 def	47.7 df	76.0 f
	Wad-Rabia*	53.7 cd	47.0 e	76.7 ef
Kordofan (Western Sudan)	Um-Rawaba*	57.0 a	54.0 abc	69.7 h
	El-Rahad*	50.0 f	53.3 a	81.7 b
	Kadugli**	18.0 g	17.3 f	76.0 f
	Khour-Tagat**	17.3 g	16.3 fg	72.0 g
	El Obied**	16.0 g	15.0 g	78.0 def
SE ±		0.7031	0.6518	0.7280
CV %		4.70	5.24	4.20

*, **= *Striga* populations collected from under sorghum and millet, respectively.

Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test (P ≤ 0.05).

Table 3: Effects of *in-situ* root exudates on attachment and penetration of sorghum roots

S. hermonthica population		Sorghum cv.Abu-70	
Area	Location	Attachment (%)	Penetration (%)
Gadarif (Eastern Sudan)	Galabat*	40.0 b	30.0 c
	Sumsum*	41.0 b	39.3 a
	Gadarif*	46.0 a	35.0 a
	Butana*	35.0 de	20.0 e
	El Fau*	41.3 b	23.0 d
Gezira (Central Sudan)	Hasaheisa*	40.3 b	29.0 c
	Abu-Haraz*	36.0 cd	30.0 c
	Hag-Abdalla*	40.0 b	30.0 c
	Barakat*	33.7 e	18.7 ef
	Wad-Rabia*	34.0 e	18.3 ef
Kordofan (Western Sudan)	Um-Rawaba*	40.0 b	28.0 c
	El-Rahad*	40.0 b	20.0 e
	Kadugli**	37.0 c	19.7 e
	Khour-Tagat**	36.0 cd	17.7 f
	El Obied**	35.0 de	17.0 f
SE ±		0.5034	0.7831
CV %		4.69	20.82

*, **= *Striga* populations collected from under sorghum and millet, respectively.

Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

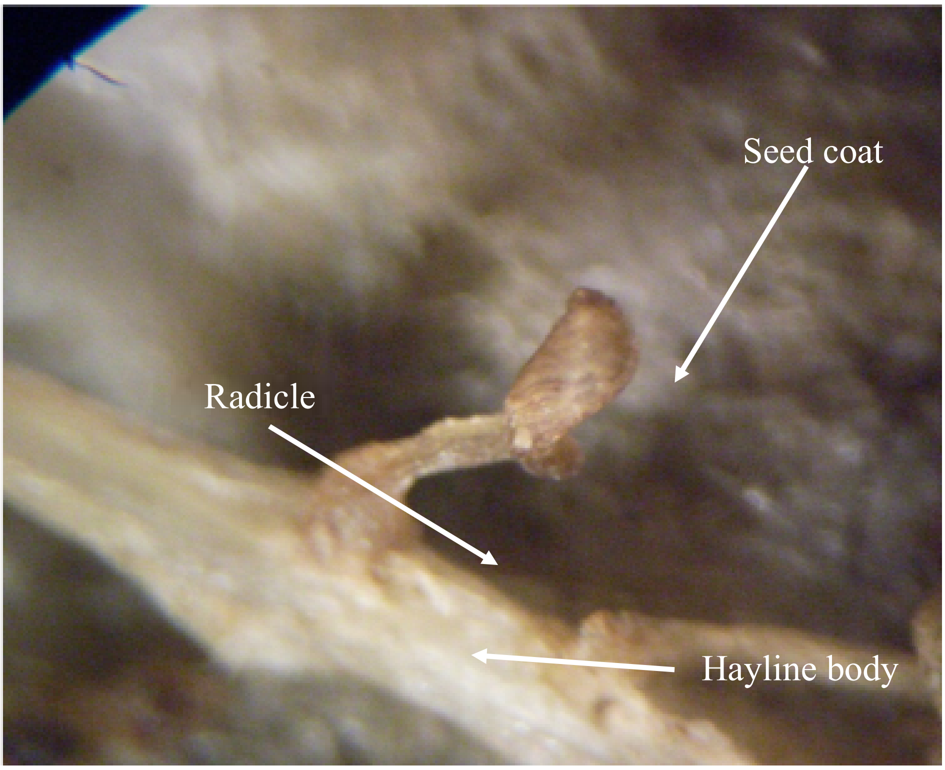

Plate 1. Attachment and penetration of *S. hermonthica* from Hag-Abdalla, sorghum population, to seedling root of sorghum cv. Abu-70

تأثير إفرازات ومستخلصات جذور الذرة (*Sorghum bicolor* [L.] Moench) على المراحل المبكرة لتطور البُودا (*Strigahermonthica* (Del.) Benth.)

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المستخلص:

أُجري نوعان من التجارب المعملية (*in vitro* و*in vivo*) بكلية العلوم الزراعية، جامعة الجزيرة، السودان، لبحث تأثير إفرازات ومستخلصات جذور الذرة (*Sorghum bicolor* [L.] Moench)على المراحل المبكرة لتطور طفيل البُودا (*Strigahermonthica* (Del.) Benth.) التي جمعت من مواقع مختلفة في السودان. تم جمع البذور من المناطق الموبوءة بالطفيل في القضارف والجزيرة وكردفان. تم جمع ما حاصله خمسة عشر عشيرة للبُودا. جمعت اثني عشر عشيرة للبُودا، واحدة لكل، من تحت الذرة، وجمعت ثلاث عشائر من تحت الدخن، واحدة لكل. وُضعت الخمسة عشر عشيرة للبُودا في تصميم عشوائي كامل بثلاث تكرارات. تم فحص بذور و/أو نابتات الطفيل بواسطة المجهر بغرض الإنبات، نشوء المماص، الالتصاق والاختراق عند 24، 72، 144 و192 ساعة بعد التحضين الابتدائي. جمعت البيانات وأخضعت لتحليل التباين. تمت مقارنة المتوسطات بواسطة اختبار دنكن، عندما كان الاختبار معنويا ($at\ p \leq 0.5$). أوضحت النتائج أن إفرازات ومستخلصات الجذور لكل النباتات المختبرة حثت الإنبات ونشوء مماص طفيل البودا. ومع ذلك، أُحرزت أعلى نسب للإنبات ونشوء المماصوالالتصاق والاختراق لكل عشيرة من البُودا على عائلها الخاص. يقترِح هذا البحث وجود كل من التخصصية بين وداخل نوع المحصول. أضف إلي ذلك، تأكد النتائج وجود سلالتان للبُودا واحدة متخصصة في الذُرة والأخرى في الدُخن.