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Germination, Attachment and Development of *Striga hermonthica* (Del.) Benth Induced by Host and Non-host Crops

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Abstract: *Striga hermonthica* (Del) Benth is a semi-parasitic weed that reduces yields of sorghum, maize, pearl millet, sugarcane and rice in the semi-arid tropics. Germination of striga seed is induced by stimulants exuded by roots of host and non-host plants. The objectives of this study were to compare the ability of some host and non-host crops to induce striga seed germination and haustoria formation as well as to confirm the susceptibility of wheat and barley to infestation. *S. hermonthica* seeds were collected from Abu Haraz, Gezira State, Sudan, in 2004/2005, and their germination on some host and non-host crops was investigated using root chambers that allow observation of striga underground stages. Striga seeds germinated with all tested crops. Besides sorghum varieties and maize, *S. hermonthica* germinated, attached and developed to complete striga plants with barley and two cultivars of wheat from Sudan. This is the first report of *S. hermonthica* parasitizing wheat and barley in Sudan. Use of root chambers proved that some leguminous crops were susceptible to *S. hermonthica*. Chick pea (*Cicer arietinum* L.), phillipesera (*Vigna trilobata* L.), brown seed cowpea *[Vigna unguiculata* (L.) Walp.], hyacinth bean (*Lablab purpureus* L.), peas (*Pisum sativum* L.) pigeon pea (*Cajanus cajan* L.), faba bean and mung bean induced seed germination, attachment and development of complete green striga plants. Soybean, roselle, safflower and sunflower supported germination and attachment of *S. hermonthica*, but there was no further development of the semi-parasitic weed. A natural brownish colouration around the

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contact area between the parasite haustoria and the host roots was seen. These findings confirm that *S. hermonthica* could infect a large number of hosts including leguminous crops.

Key words: *Striga hermonthica*; germination; attachment; host range; leguminous crops

INTRODUCTION

Striga species (witch weeds) are noxious semi-parasitic weeds that attack the roots of cereals and legumes, resulting in a major threat to the staple food crops of over 100 million people in Africa. They are endemic to Africa; in addition, *Striga* spp. occur in over 40 countries worldwide, ranging from Asia to North America. In Sub-Saharan Africa, the impact of striga has increased and has been described as one of the most biological constraints to food production (Sauerborn 1991). The same author estimated the area severely infested with striga in Sub-Saharan Africa to be more than two-thirds of the 73 million hectares of land used for cereal cultivation.

Striga hermonthica is the most economically important species among the 11 *Striga* spp. that infect crops; it attacks all the major African cereals, including sorghum {*Sorghum bicolor* (L.) Moench}, maize (*Zea mays* L.), and pearl millet {*Pennisetum glaucum* (L.) R. Br.} (Parker and Riches 1993). Furthermore, *Striga* spp. attack upland rice (*Oryzae sativa* L.), sugarcane (*Saccharum officinarum* L.), and cowpea {*Vigna unguiculata* (L.) Walp}. Recently, Vasey *et al*. (2005) found that wheat is highly susceptible to *S. hermonthica,* causing 24% decrease in plant height and 33% in biomass accumulation in severely infected plants.

Upon striga seed germination, the radicle subsequently grows and when approaching the host root cells undergoes haustoriogensis giving rise to the functional attachment organ through which parasitism is initiated. Seeds of *Striga* spp. germinate in the vicinity of their host plants in response to specific chemical signals, of which the sorgoleone (Humphery and Beale 2006) and strigolacones (López-Ràez *et al*. 2008) are typical. Germination of *S. hermonthica* is stimulated by exudates from the roots of both host and non-host plants. Trap crops (non-host) are those crops that induce germination of striga seeds but are not parasitized, and consequently result in suicidal germination. Striga seedlings must attach to a host root within 3 to 5 days after germination or they die (Worsham 1987).

The objectives of the present study were (i) to compare the ability of host and non-host crops to induce striga seed germination (ii), to assess if non-host crops possess the chemical signals required for attachment, formation of haustoria and development of *S. hermonthica* plants and (iii) to confirm the susceptibility of wheat and barley to *S. hermonthica* from Sudan.

MATERIALS AND METHODS

Catch and trap crops were screened for their ability to induce germination, attachment and development of *S. hermonthica* by means of root chambers. The experiments were conducted at the University of Hohenheim, Stuttgart, Germany in 2009.

Plant material

Striga hermonthica seeds were collected from an infected sorghum field in the Faculty of Agriculture and Natural Resources - Abu Haraz, University of Gezira, Wad Medani, Sudan, in 2004. All crop seeds tested for their ability to germinate striga were collected from Sudan except sunflower and barley seeds which were obtained from the Institute of Crop Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart, Germany (Table 1).

Striga and crop seeds were surface sterilized by soaking in 1% (v/v) sodium hypochloride (NaOCl) for 2 to 5 minutes and then rinsed three times in distilled sterilized water and allowed to dry at room temperature.

Screening techniques

Root chambers were used as described by Linke and Vogt (1987). The use of the root chambers, beside germination, facilitates observation of attachment and other developmental stages of striga. The chamber had back and sides made of hard plastic, while the front was closed with clean transparent plexiglass .The dimensions of the root chamber were 20 x 6 x

1 cm (length, width, and depth). Non-preconditioned sterilized striga seed were sprinkled by hand on the surface of microfiber glass-filter paper (Whatman GF/A) (26 x 6 cm) and placed on the front side of the root chamber. The chambers were filled with sterilized sand soil. Three seeds of the host and non-host plants were sown in each chamber between the filter paper and the lid. To prevent light penetration, the chambers were wrapped in black plastic and placed at angle so that crop roots had to grow near the surface of the plexiglass plate. The experiment was conducted in a growth chamber at temperature of 25°C day and night and photoperiod of 12 hours. After germination, the plants were thinned to 2 plants/chamber. Evaluation was done with the aid of a binocular microscope at 7 days interval for 5 weeks by counting the total number of germinated striga seeds, number of striga attached to the roots and number of developed complete striga shoots. The experiment was repeated twice, using four replicates. Data were analysed using SPSS software version 14. Means were compared using protected LSD at 5% probability level.

RESULTS

Germination

The 25 plant species tested stimulated germination of *S. hermonthica* seeds (Figure 1). The germination mean ranged from 23% to 72%. Among the tested crops, sorghum variety Mayo was the highest stimulant producer; it gave 72.3% germination of striga seeds. It was followed by the sorghum variety Abu Sabein (62%), Sudan grass (*Sorghum sudanense*) (60.5%) and sorghum variety Wad Ahmed (60%). The non-host plant species stimulated striga seed germination with no significant difference from the above mentioned host species; chick pea gave 61.5%, cotton 60.4%, faba bean 55% and white seed cowpea 52.5%.

Another group of host and non-host species moderately stimulated striga seed germination. These were sorghum varieties: Safra (49.9%), and Dabar (49.4%), barley (46.3%), wheat var. Dibeira (42.6%) and maize var. Mug 45 (40.3%). They were not significantly different from each other and from the non-host species, e.g. mung bean (44.1%), lablab bean (43.9%), pigeon pea (42%), phillipesara (41.6%), peas (41.0%), brown seed cowpea (40.0%), sunflower (33.8%) and roselle (32.3%).

The lowest germination stimulant producers were pearl millet var. Ashana (7.4%) and safflower (2.3%).

Table 1. List of host and non-host crops (collected from Sudan) tested for their ability to induce germination, attachment and development of striga

Crop	Scientific name	Family
Sorghum (variety Wad Ahmed)	*Sorghum bicolor* (L.) Moench	Poacae
Sorghum (variety Mayo)	"	"
Sorghum (variety Safra)	"	"
Sorghum (variety Fatareeta)	"	"
Sorghum (variety Dabbar)	"	"
Sorghum (variety Abu Sabein)	"	"
Sudan grass (Garawia)	*Sorghum sudanense* L.	"
Pearl millet (variety Ashana)	*Pennisetum glaucum* (L.) R. Br.	"
Maize (variety Mug 45)	*Zea mays* L.	"
Maize (local variety from Ghana)	*Zea mays* L.	"
Barley	*Hordeum vulgare* L.	"
Phillipesara	*Vigna trilobata* L.	Fabacae
Cowpea (white seed)	*Vigna unguiculata* (L.) Walp	"
Cowpea (brown seed)	*Vigna unguiculata* (L.) Walp	"
Faba bean	*Vicia faba* L.	"
Chick pea	*Cicer arietinum* L.	"
Mung bean	*Vigna radiata* (L.) R. Wilczek	"
Peas	*Pisum sativum* L.	"
Pigeon pea	*Cajanus cajan* L.	"
Soybean	*Glycine max* L.	"
Hyacinth bean	*Lablab purpureus* L.	"
Cotton	*Gossypium barbadense* L.	Malvaceae
Roselle	*Hibiscus sabdariffa* L.	"
Safflower	*Carthamus tinctorius* L.	Asteraceae
Sunflower	*Helianthus annuus* L.	"

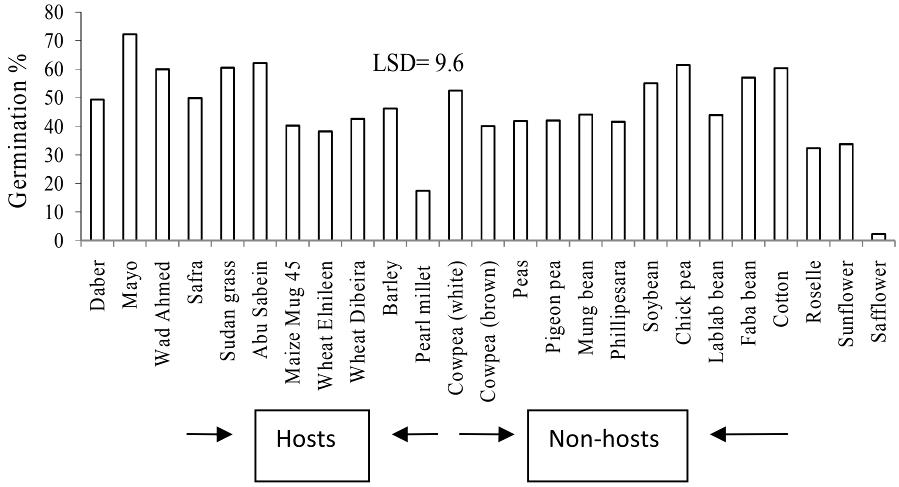

Fig. 1. Germination of *S. hermonthica* plants in response to root exudates of host and non-host crops in root chambers tests
Data were analysed using protected LSD at 5% level of probability.

Attachment

Attachment of *S. hermonthica* was induced by host and non-host plant species including maize var. Mug 45 (64.8%), soybean (58.8%), sorghum var. Safra (57.8%), and wheat var. Dibeira (49.5%), with no significant differences between the hosts and non-host species. The majority of the hosts and non-host plant species supported moderately striga attachment. These were phillipesara (47.6%), peas (47.1%), wheat var. Elneelian (47%), roselle (46.2%), sorghum var. Wad Ahmed (42%), brown seed cowpea (40.9%), chick pea (39.7%), barley (39.2%), sorghum var. Dabar (36.6%), lablab bean (34.9%), cotton (34.7%), white seed cowpea (34.5%), sorghum var. Mayo (34%) and Sudan grass (33.6%).

The group that support lower striga attachment were the following host and non-host plant species: Sorghum var. Abu Sabein (32.6%), sunflower (32.2%), pigeon pea (31.8%), faba bean (31.7%) and mung bean (30.7%).

The least striga attachment supporters were pearl millet var. Ashana (11.8%) and safflower (3.1%) (Fig. 2).

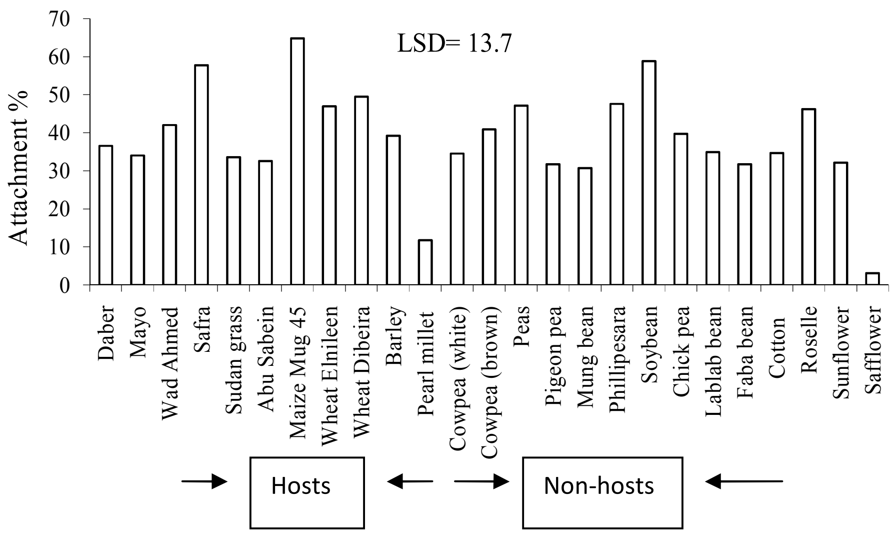

Fig. 2. Attachment of *S. hermonthica* plants in response to root exudates of host and non-host crops in root chambers tests

Data were analysed using protected LSD at 5% level of probability.

Development

Almost all host plants tested were able to support subsequent development of striga plants bearing green leaves. The mean of the developed striga plants ranged from 13.8 % to 52.9%. Among the non-host crop species tested, peas, lablab bean and chick pea encouraged striga development by 17.4%, 15.9% and 13.9%, respectively, and were comparable to some host species such as sorghum var. Mayo and barley which enhanced striga development by 14.8% and 13.9%, respectively. The other non-host crops gave lower development percentages ranging from 3.1% to 12.6%. However, other non-host plant species, like soybean, roselle and safflower, did not support striga development (Fig. 3).

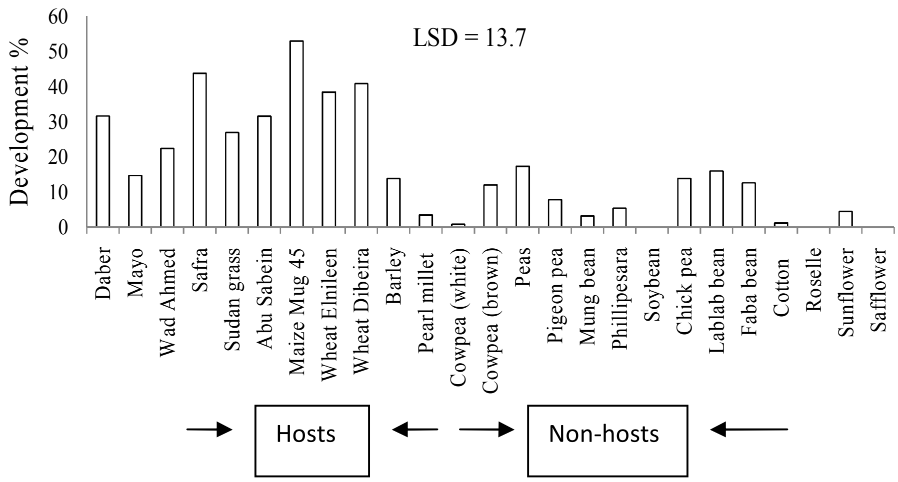

Fig. 3. Development of *S. hermonthica* plants supported by host and non-host crops in root chambers tests

Data were analysed using protected LSD at 5% level of probability.

DISCUSSION

Wheat, barley, maize var. Mug 45 and sorghum (host plants) stimulated seed germination, attachment and development of *S. hermonthica*. This indicates that the four cereals tested were highly susceptible to striga. However, wheat and barley were not reported before as striga hosts, under Sudan field conditions. This is mainly due to the fact that these two crops are sown during the winter season, where the temperature goes below 20°C, especially during the night. The optimum temperature required for germination and attachment of striga is around 30°C (Dawoud and Sauerborn 1994). In addition, wheat in Sudan is grown under irrigation with application of high doses of nitrogen which suppresses striga seed germination and attachment. These factors are known to inhibit striga germination (Ahonsi *et al*. 2002). However, striga may affect wheat production in the future due to the climatic changes leading to increasing temperatures. It has been estimated that the temperature in Africa will increase by between 2°C and 5°C by the year 2100 (Hulme *et al*. 2000). Another factor that may aggravate the problem of striga is that wheat breeders in Sudan are looking for heat tolerant varieties.

All the non-host plants tested except soybean, cotton and safflower induced germination, attachment and subsequent development of striga plants. Non-host plants, such as peas, lablab bean, chick pea, faba bean and cowpea, induced striga germination, attachment and development in percentages comparable to those of host species like sorghum var. Safra.

Observations on *S. hermonthica* under field conditions proved that this semi-parasite attacks leguminous crops in Sudan. A flowering striga plant was seen growing in a plot sown with phillipesara in a field near Abu Haraz, Wad Medani, Sudan. In the same field, sorghum was highly susceptible to striga, indicating that phillipesara was able to induce germination, attachment and development of complete flowering striga plants. This was confirmed in this study where phillipesara and chick pea induced striga seed germination and supported development of striga plants.

Soybean, roselle, sunflower and safflower induced striga seed germination and attachment but failed to support subsequent development of striga plants. A dark stain along the interface of attachment between soybean and striga was observed which could explain soybean resistance. This was reported to be due to dark stain accumulation in case of *Striga asiatica* on cowpea (Hood *et al.*1998). Also, the dark staining is believed to be provoked by crushed and compressed host cells (Neuman *et al.*1999). These observations indicate that soybean, cotton and safflower are resistant to striga and could be a good choice for intercropping/ rotation to reduce striga seed bank in the soil. In Africa, non-host legumes cultivars, selected for their efficiency in inducing *S. hermonthica* seed germination and leading to suicidal death, are being used in rotation with cereals to control *S. hermonthica* (Berner *et al*. 1996; Khan *et al.* 2007).

It could be concluded that leguminous crops such as peas, lablab bean, chick pea, faba bean, cowpea and phillipesara could be potential hosts for *S. hermonthica*. Also, the geographical range of this semi-parasite may extend to North Africa and Mediterranean countries endangering the production of wheat and chick pea. Furthermore, the striga investigated in this study could be a new strain of *S. hermonthica,* so intensive research work on this aspect is needed.

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REFERENCES

Ahonsi, M.O.; Berner, D.K.; Emechebe, A.M. and Lagoke, S.T. (2002). Effect of soil pasteurization and soil nitrogen status on the severity of *Striga hermonthica* (Del.) Benth. in maize. *Soil Biology and Biochemistry* 34, 1675- 1681.

Berner, D.K.; Carsky, R.; Dashiel, K.; Kling, J. and Manyoung, V. (1996). A land management based approach to integrated *Striga hermonthica* control in Sub-Saharan Africa. *Outlook Agriculture* 25,157-164.

Dawoud, D.A. and Sauerborn, J. (1994). Impact of drought stress and temperature on the parasitic weeds Striga *hermonthica* and *Alectra Vogelii* in their early growth stages. *Experimental Agriculture* 30, 249- 257.

Hood, M.E.; Condon, J.M.; Timko, M.P. and Riopel, J. L. (1998). Primary haustorial development of *Striga asiatica* on host and non-host species. *Phytopathology* 88, 70-75.

Hulme, M.; Doherty, R.; Ngara, T.; New, M. and Lister, D. (2000). African climate change: 1900- 2100. *Climate Research* 17, 145-168.

Humphery, A.J. and Beale, M.H. (2006). Strigol: Biogenesis and physiological activity. *Phytochemistry* 67, 636-640.

Khan, Z.R.; Midega, C.A.O.; Hassanali, A.; Pickett, J.A. and Wadhams, L.J. (2007). Assessment of different legumes for the control of *Striga hermonthica* in maize and sorghum. *Crop Science* 47, 730- 736.

Linke, K.H. and Vogt, W. (1987). A method and its application for observing germination and early stages of *Striga* (Scrophulariaceae) and *Orobanche* (Orobanchaeae), pp. 501-509. In: *Proceedings of the 4th International Symposium on Parasitic Flowering Plants*. H. Chr. Weber and W. Forstreuter (Edts.), Marburg, FRG.

López-Ràez, J.A.; Matusova, R.; Cardoso, C.; Jamil, M.; Charnikhova, T.; Kohlen, W.; Ruyter-Spira, C.; Verstappen, F. and Bouwmeester, H. (2008). Strigolactones: Ecological significance and use as a target for parasitic plant control. *Pest Management Science* 64, 471-7.

Neuman, U.; Vian, B.; Weber, H.C., and Salle', G. (1999). Interface between haustoria of parasitic members of Scrophulariaceae and their host: A histochemical and immunocytological approach. *Protoplasma* 207, 84- 97.

Parker, C. and Riches, C.R. (1993). *Parasitic Weeds of The World: Biology and Control*. CBA International, Wallingford, U.K.

Sauerborn, J. (1991). The economic importance of the phytoparasites *Orobanche* and *Striga*, pp. 137-143. In: *Proceedings of the 5the International Symposium of Parasitic Weeds*. J.K. Ransom, L.J. Musselman, A.D. Worsham, and C. Parker (Edts.), CIMMYT, Nairobi, Kenya.

Vasey, R.A.; Scholes, J.D. and Press, M.C. (2005). Wheat (*Triticum aestivum*) is susceptible to the parasitic angiosperm *Striga hermonthica*, a major cereal pathogen in Africa. *Phytopathology* 95 (11), 1294-1300.

Worsham, A.D. (1987). Germination of witchweed seeds, pp. 45- 61. In: *Parasitic Weeds in Agriculture*. Volume 1: *Striga.* L.J. Musselman (Edt.), CRC Press. Boca Raton, FL. U. S. A.

إنبات والتصاق ونمو نباتات البودا *Striga hermonthica* (Del.) Benth مع المحاصيل العائلة و غير العائلة

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و يواخم سوربورن

معهد انتاج المحاصيل في المناطق المدارية و شبهة مدارية – جامعة هوهنهايم اشتودقارد، المانيا

المستخلص: البودا *Striga hermonthica* نبات زهري يتطفل على جذور محاصيل الحبوب ويقلل من إنتاجية الذرة الرفيعة والذرة الشامية والدخن وقصب السكر والارز في المناطق المدارية و شبه المدارية الجافة. انبات بذور الطفيل يحث بواسطة افرازات من جذور النباتات العائلة وغير العائلة. هدفت هذه الدراسه لمقارنة قدرة بعض المحاصيل العائله وغير العائله علي إحداث إنبات لبذور البودا وتكوين الممصات وكذلك التأكد من قابلية القمح والشعير للإصابه. درس إنبات بذور البودا، والتي جمعت من ابوحراز بولاية الجزيره في موسم 2005/2004، بواسطة المحاصيل العائلة وغير العائلة وذلك باستخدام غرف الجذور والتي تمكن من ملاحظة الانبات والالتصاق ومراحل تطور طفيل البودا تحت سطح التربه. اوضحت النتائج ان بذور البودا نبتت مع كل المحاصيل التي تم اختبارها. بالإضافة الى اصناف الذرة الرفيعة والذرة الشامية، نبتت البودا والتصقت وتطورت الى نباتات خضراء مع الشعير وصنفين من القمح المحلي، ويعتبر هذا اول تقرير عن البودا كطفيل للقمح والشعير في السودان. أثبت استخدام غرف الجذور ان بعض المحاصيل البقولية تصاب بالبودا (*S. hermonthica*). والحمص (*Cicer arietinum* L.) والفيليبسار(*Vigna trilobata* L.) واللوبيا العفن (*Lablab purpureus* L.) واللوبيا الحلو ذوالبذورالبنيه (*Vigna unguiculata* L.) والبسلة (*Pisum sativum* L.) واللوبيا العدسي (*Cajanus cajan* L.) والفول المصرى (*Vicia faba* L.) واللوبيا الذهبية [*Vigna radiata* (L.) R Wilczek] حثت الانبات والالتصاق وتكوين ممصات

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ونمو نباتات بودا خضراء. حثت بذور فول الصويا الكركدى وزهرة الشمس والقرطم إنبات بذور البودا والتصاق الممصات دون تكوين نباتات بودا كامله. كما لوحظ ان منطقة التصاق ممصات البودا مع جذور النباتات المذكورة سابقا تتلون باللون البني. توضح هذه النتائج ان البودا *S. hermonthica* قد تصيب عددا" كبيرا" من النباتات بما فيها المحاصيل البقولية.