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PHYSIOLOGICAL SPECIALIZATION OF STRIGA HERMONTHICA AND CROP SPECIFICITY

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Abstract Six samples of Striga hermonthica (Del.) Benth. from sorghum and eight from millet (Pennisetum americanum (L.) K. Schum) were tested against two susceptible cultivars each of sorghum and millet in 1981 and 1982 pot experiments to present evidence for crop specificity. The Striga seed samples were collected from latitudes ranging from 10°42'N to 13°29'N and thus represent a narrow geographical distribution of Striga hermonthica. The results indicate that sorghum cultivars were able to germinate and support Striga from both sorghum and millet hosts whereas millets could only support Striga from millet. However, in certain regions both the crops were attacked by both types of Striga. Extreme host specificity was not exhibited by the Striga samples included in the present investigation. They represent intermediate forms which were able to attack sorghum more than millet since sorghum is more extensively grown in the region under study. In areas where millet Striga samples were collected they attacked millet but also retained the capacity to attack sorghums. It is suggested that specialization is the outcome of the intensity with which a particular host crop is grown at the exclusion of the other thus creating a reproductive isolation between sorghum and millet Striga strains.

INTRODUCTION

Striga hermonthica (Del.) Benth. is wide-spread in the semi-arid zones of northern tropical Africa from 5°S to 20°N latitude. From East to West it is distributed across the width of Africa. It attacks several food crops like sorghum, millets, maize, upland rice, sugarcane, and also several wild grasses in fallow lands and field bunds. This particular species of Striga is cross pollinating and thus able to generate genetic variability for its pathogenicity. Inspite of genetic variability no morphological differences have been reported in this species even though different morphophytes exist in Striga asiatica (L.) Kuntze a self pollinating species (Ramaiah etal 1983). Different forms of Striga hermonthica have not become fixed and maintained because of continuous cross pollination and exchange of genes within the Striga population. However, several detailed investigations including laboratory and field experiments by Wilson Jones (1955) and Bebawi (1981) in the Sudan, by King and Zummo (1977) and Ramaiah (1983) in West Africa and by laboratory experiments of different samples from Africa (Parker and Reid 1979) have established that there are atleast two biotypes in Striga hermonthica, one specific to millet (Pennisetum americanum (L.) K. Schum) in the relatively drier and low rainfall zones where millet is the major cereal and another biotype specific to sorghum in areas where sorghum is the predominant crop grown. The crop specificity of these extreme forms is reported to be based on different germination stimulant requirements (Parker and Reid, 1979) in contrast to the report by Wilson Jones (1955) that specificity is due to

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References

BENTHAM, G. (1835) Synopsis of the Buchnereae, A tribe of Scrophulariaceae. Companion to the Botanical Magazine 1, 356-365.

MUSSELMAN, L.J. and PARKER, C. (1981) Studies on indigo witchweed, the American strain of Striga gesnerioides (Scrophulariaceae). Weed Science 29, 594-596.

NICKRENT, D.L. and L.J. MUSSELMAN. (1979) Autogamy in the American strain of witchweed, Striga asiatica (Scrophulariaceae). Brittonia 31, 253-256.

SALDANHA, C.J. (1963) The genus Striga Lour. in Western India. Bulletin of the Botanical Survey of India 5, 67-70.

WETTSTEIN, R. (1893). Scrophulariaceae in Engler, A. and Prantl, K. Die Naturlichen Pflanzenfamilien 4 (36), 39-107.

factors that operate after germination. Our own field observations and pot experiments in West Africa (ICRISAT 1980) confirmed that this physiological specialization is true when one considers the extreme Striga samples particularly those collected from millet host, those from Maradi in Niger and Bambey in Senegal which represent extreme drier zones where sorghum is almost absent. But there are regions is West Africa where both sorghum and millet act as hosts (Ramaiah, 1983). A preliminary report of the variability in pathogenicity in relation to host crops and geographical distribution revealed that this species varies from North to South but very little from East to West (Ramaiah, 1983). At Maradi, Niger and Bambey, Senegal which are North of latitude 13°N Pennisetum millet is the predominant host whereas in Kamboinse Upper Volta, Kobo, Ethiopia, Abu Naama and Wad Medani, Sudan, and Busia, Kenya sorghum is the principal host. Striga was found to be attacking both sorghum and millet crops in such locations as Farako-Bâ, Upper Volta and Mintimbougou, Mali where both the crops are grown. Host specificity has been previously reported (Wilson Jones, 1955., King and Zummo, 1977., Parker and Reid, 1979., and Bebawi, 1981). The present study, limited to latitudes ranging from 10°42'N in Upper Volta includes samples of Striga collected from sorghum and millet in the same latitude zone for detailed crop specificity studies.

MATERIALS AND METHODS

1981:

Seven Striga seed samples collected in different rainfall zones of Upper Volta from pure millet fields and three from pure sorghum fields were tested against two susceptible cultivars of sorghum (CK60B and IS9289) and two susceptible cultivars ofmillet (ICH241 and ICH7819) in a split plot design with four replications. The details are given in Table 1.

1982:

Eight Striga samples, four from sorghum and four from millet, were tested against two susceptible cultivars of sorghum (CK60B and BTx623) and two susceptible cultivars of millet (Ex-Bornu and ICH241) in a split plot design with six replications. The details are given in Table 1.

Striga seeds of the same source could not be used in both years because of the shortage of seeds. As seen from the table the samples used in both the years are from about the same latitude zones. In both years split plot design was used with the cultivars as main plots and Striga as sub plots. The experiments were carried out in 5 kg pots in the rainy seasons of each year. Soil, sand, and farmyard manure were used in the proportion of 50:25:25. by volume. Approximately 6,500 Striga seeds per pot were mixed in the top 5 cm soil before sowing the host crop seeds. Four to five seeds of host crop were sown in each pot at a depth of 3-4 cm and thinned to one plant later. Additional fertilizer was not used. Pots were irrigated as required.

Table 1

Details of Striga hermonthica seed samples used in the experiments

Striga code	Location (Upper Volta)	Latitude (approximate)	Host crop	Year of collection	Year of extpt.
STS-25	Banfora	10°42'N	Sorghum	1981	1982
STS- 7	Zandkom	13°08'N	"	1979	1982, 1981
STS-17	Tangaye	12°10'N	"	1979	1982
STS-13	Djibasso	13°07'N	"	1979	1982
STS-14	Fada N'Gourma	12°02'N	"	1979	1981
STS-16	Kamboinsé	12°28'N	"	1979	1981
STP-21	Banfora	10°42'N	Millet	1981	1982
STP-10	Korsimoro	12°49'N	"	1979	1982
STP-15	Tangaye	12°10'N	"	1980	1982
STP-12	Djibasso	13°07'N	"	1979	1982
STP- 4	Zitango	11°08'N	"	1979	1981
STP-11	Roumassi	13°06'N	"	1979	1981
STP- 8	Koupela	12°11'N	"	1979	1981
STP- 1	Ouahigouya	13°29'N	"	1979	1981

Counts of emerged Striga were made from the date of first emergence at intervals of two weeks. The maximum emergence was 64 and 70 days after sowing in 1981 and 1982 respectively. The data were transformed using log (X+1.1) transformation and analysed. In each trial analysis was carried out separately for millet and sorghum Striga.

RESULTS

1981 Striga from millet:

Results presented in Table 2 indicate no significant differences among the cultivated varieties though sorghum cultivars supported more Striga than millet cultivars. The differences among Striga samples and the interaction between Striga and cultivars were highly significant. The emergence of STP-4 and STP-8 Striga samples was highest and lowest respectively. STP-11 and STP-1 were intermediate and not significantly different from each other. STP-4 and STP-1 did not interact significantly with the host crops whereas STP-11 and STP-8 interacted significantly. STP-8 attacked sorghum more than millet whereas STP-11 did not show any specificity to the crops.

1981 Striga from sorghum:

The results presented in Table 3 show significant differences between cultivars, between Striga samples and for the interaction

Table 2

Effect of crop cultivars on emergence of S. hermonthica originating from millet host (1981): Striga emergence per pot 64 days after sowing (log X+1.1)

Cultivars	Striga[c]				cultivar mean[a]
	STP-4	STP-11	STP-8	STP-1	
CK60B (Sorghum)	1.46	1.23	1.02	0.89	1.151
IS 9289 (Sorghum)	1.08	0.79	0.54	0.99	0.850
ICH241 (Millet)	1.06	0.78	0.11	1.02	0.742
ICMV7819 (Millet)	1.16	1.00	0.30	0.78	0.809
Striga mean[b]	1.193	0.950	0.493	0.920	

a = LSD (5%) for cultivars = 0.342
b = LSD (5%) for Striga = 0.142
c = LSD (5%) for Striga at same cultivar level = 0.283
LSD (5%) for cultivars at same Striga level = 0.420

between Striga and cultivars. Sorghum supported emergence of these Striga samples significantly more than millet, but the difference was small in the case of STS-7. Sorghum cultivars did not interact significantly with the Striga samples in contrast to millet cultivars. ICH241 interacted differently with all the Striga samples whereas ICMV 7819 supported significantly fewer plants of STS-16.

Table 3

Effect of crop cultivars on emergence of S. hermonthica originating from sorghum hosts: Striga emergence per pot 64 days after sowing (log X+1.1)

Cultivars	Striga[c]			cultivars mean[a]
	STS-7	STS-14	STS-16	
CK60B	1.25	1.31	1.25	1.270
IS 9289	1.15	1.18	1.23	1.186
ICH241	0.97	0.42	0.15	0.513
ICMV 7819	0.71	0.87	0.48	0.688
Striga mean[b]	1.019	0.946	0.778	

a = LSD (5%) for cultivars = 0.149
b = LSD (5%) for Striga = 0.257
c = LSD (5%) for Striga at same cultivar level = 0.257
LSD (5%) for cultivars at same Striga level=0.257

1982 Striga from millet:

The results presented in Table 4 indicate no significant differences among the cultivars whereas Striga samples exhibited significant differences. There was also a highly significant interaction. STP-21 gave highest germination and STP-10 the lowest. STP-15 and STP-12 were intermediate. STP-21 and STP-12 did not interact significantly with host cultivars whereas STP-10 and STP-15 did interact significantly. STP-10 was germinated significantly more by millet compared to sorghum where STP-15 was germinated significantly more by sorghum than by the millet.

Table 4

Effect of crop cultivars on emergence of S. hermonthica originating from millet (1982): Striga emergence per pot 70 days after sowing (log X+1.1)

Cultivars	Striga [c]				cultivars mean[a]
	STP-21	STP-10	STP-15	STP-12	
CK60B	1.56	0.42	1.32	1.31	1.150
BTx623	1.56	0.04	1.45	1.02	1.029
Ex-Bornu	1.45	1.55	0.99	1.20	1.285
ICH241	1.56	1.12	0.97	1.03	1.172
Striga mean[b]	1.534	0.784	1.180	1.140	

a = LSD (5%) cultivars = 0.281
b = LSD (5%) Striga = 0.185
c = LSD (5%) for Strigas at same cultivar level = 0.369
LSD (5%) for cultivars at same Striga level= 0.426

1982 Striga from sorghum:

The results presented in Table 5 reveal significant differences among cultivars and among Striga samples. The interaction between cultivars and Striga was also significant. Sorghum cultivars supported significantly more Striga than millet. STS-25 and STS-13 did not interact significantly with the host cultivars while both STS-7 and STS-17 emerged out of the soil significantly more with sorghum cultivars than with millet cultivars.

DISCUSSION

In the present investigation out of eight Striga samples from millet studied in 1981 and 1982, five samples STP-4, STP-11, STP-1, STP-21, and STP-12 have not shown any crop specificity whereas

Table 5

Effect of crop cultivars on emergence of S. hermonthica originating from sorghum (1982): Striga emergence per pot 70 days after sowing (log X+1.1)

Cultivars	Striga[c]				Cultivar mean[a]
	STS-25	STS-7	STS-17	STS-13	
CK60B	1.74	1.40	1.67	1.10	1.478
BTx623	1.52	0.65	1.72	1.10	1.247
Ex-Bornu	1.39	0.04	0.39	0.77	0.647
ICH241	1.29	0.25	0.45	0.87	0.717
Striga mean[b]	1.485	0.585	1.056	0.961	

a = LSD (5%) for cultivars = 0.234
b = LSD (5%) for Striga = 0.259
c = LSD (5%) for Striga at same cultivar level = 0.518
LSD (5%) for cultivars at same Striga level = 0.507

STP-10 (from Korsimoro) has exhibited partial specificity to millet while STP-15 (from Tangaye) and STP-8 (from Koupela) attacked the sorghum cultivars more than the millet.

On the contrary a majority of Striga samples from sorghum have shown specificity to sorghum. Among the six Striga samples tested in both the years four Striga samples viz., STS-7, STS-14, STS-16, and STS-17 have exhibited specificity to sorghum whereas STS-25 and STS-13 did not show any specificity but attacked both the crops. STS-7 was tested in both the years and maintained its crop specificity. Two sets of Striga samples are of special interest. STP-12 and STS-13 (from millet and sorghum respectively from Djibasso) and STP-21 and STS-25 (from millet and sorghum respectively from Banfora). In each case the pairs of samples attacked both crops without showing any crop specificity. This is in contrast to Wilson Jones (1955) findings that S. hermonthica from sorghum and millet Kordofan, Sudan attacked more millet cultivars than sorghum cultivars thus suggesting crop specificity. However, other Striga samples from sorghum (STS-14) and millet (STS-8) collected from the same latitude zone (around 12°N) attacked sorghum cultivars significantly more than the millet cultivars indicating that this is principally a sorghum strain. The sorghum cultivars tested were able to germinate and support most of the Striga samples tested irrespective of the host crop from which they were harvested within the latitude zone that is under investigation whereas millet cultivars could only germinate Striga from millet and two of the samples from sorghum. Sorghum root exudate may thus include the stimulant compounds that could stimulate both the groups of Striga whereas millet root exudate has only the stimulant compound that is specific to millet Striga. Debawi (1981 personal communication) reported that sorghum root

exudate germinated more of sorghum Striga than millet Striga in the Sudan but with increase in temperature it also germinated more of millet Striga. At higher temperatures host specificity tended to disappear. Parker and Reid (1979) using two samples each of sorghum and millet Striga against sorghum and millet root exudates demonstrated clear crop specificity based on stimulant compounds in the root exudates. These results agree with those of Ramaiah (1983) where the Striga strains show extreme specialization. The Striga samples studied in this present investigation perhaps represent intermediate forms of specialization as they are found only within a limited geographical range in which both sorghum and millet are grown.

Inspite of statistically significant differences, millet cultivars were able to support emergence of a proportion of sorghum Striga in our own experiments as well in other published reports. Given enough time in evolutionary process sorghum Striga could adapt to millet cultivars. This is proved by two Striga samples, STS-25 and STS-13, where intensity of attack on millet cultivars was comparable to that on sorghum cultivars. Similarly one could also hypothesize that Striga could develop extreme crop specificity in regions where only one host crop is grown. Examples are millet Striga from Maradi, Niger, and from Bambey, Senegal (King and Zummo, 1977; Parker and Reid, 1979; Ramaiah, 1983) and sorghum Striga from Kamboinse in Upper Volta (Ramaiah, 1983).

It is hypothesized that the S. hermonthica seed populations are genetically heterogeneous and respond to stimulant substances produced by roots of both sorghum and millet crops. During the course of evolution depending upon the host crop that is predominantly grown at the exclusion of the other, thus creating reproductive isolation between sorghum and millet Striga, the proportion of Striga seeds that respond to that particular crop root exudate buildsup whereas the other form remains in a smaller proportion but does not disappear completely because of long viability. The genetic basis of this crop specificity needs to be investigated.

References:

BEBAWI, F.F., (1981). Intraspecific physiological variants of Striga hermonthica. Experimental Agriculture, 17: 419-423.

ICRISAT, (1980). Annual Report, 1980. Ouagadougou, Upper Volta. Section D. on Striga Resistance Breeding.

KING, S.B., and ZUMMO, N. (1977). Physiological Specialization in Striga hermonthica in West Africa. Plant Disease Reporter 61: 770-773.

PARKER, C., and REID, D.C. (1979). Host specificity in Striga species-some preliminary observations. Pages 77-90 in Proceedings, 2nd International Symposium on Parasitic Weeds, Raleigh, North Carolina, U.S.A.

RAMAIAH, K.V., (1983). Striga Research at ICRISAT, Upper Volta. Pages 53-60 in Proceedings of Second International Symposium, Ouagadougou, Upper Volta, 1981.

RAMAIAH, K.V., PARKER, C., VASUDEVA RAO, M.J., and MUSSELMAN, L.J. (1983). Striga Identification and Control Handbook. Information Bulleting No. 15, Patancheru, A.P., India: International Institute for the Semi-Arid Tropics.

WILSON JONES, K., (1955). Further experiments on witchweed control. I: The existence of physiological strains of Striga hermonthica. Empire Journal of Experimental Agriculture, 23; 206-213.

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GLUTAMINE SYNTHETASE ISOENZYMES OF ANGIOSPERM PARASITES

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Abstract. Elution profiles of multiple forms of glutamine synthetase from leaf or shoot tissue of angiosperm stem and root parasites were obtained from ion-exchange chromatography and identified as cytosolic (GS_1) or chloroplastic (GS_2) enzymes using immunological techniques. Both GS_1 and GS_2 were present in the chlorophyllous leaf tissue of the hemi-parasite, Melampyrum arvense L. (ratio of GS_1 to GS_2 = 30:70), the obligate stem parasite, Arceuthobium oxycedri (D.C.) M. Bieb. (ratio of GS_1 to GS_2 = 90:10) and the obligate root parasites, Striga hermonthica (Del.) Benth. and S. gesnerioides (Willd.) Vatke. (ratio of GS_1 to GS_2 = 90:10). In contrast, the achlorophyllous stem (Cuscuta australis L.) and root (Orobanche minor Smith; O. cernua Loefl.; O. hederae Duby; O. ramosa L.; Lathraea clandestina L. and L. squamaria L.) parasites and non-photosynthetic tissue of S. gesnerioides possessed only one form of glutamine synthetase, identified immunologically as the cytosolic enzyme. The possible physiological role(s) in ammonia assimilation of each of the GS isoforms is discussed in relation to the parasitic habit.

INTRODUCTION

Glutamine synthetase (GS) catalyses the following reaction: L-glutamate + NH_4^+ + ATP $\xrightarrow{Mg^{2+}}$ L-glutamine + ADP and Pi, and is considered to be the major enzyme involved in ammonia assimilation in higher plants (Miflin and Lea, 1976). Moreover, glutamine synthetase has been implicated to function in the reassimilation of ammonia released during photorespiration and the catabolism of nitrogenous transport and storage compounds (Keys et al., 1978; Miflin et al., 1980). These multiple physiological functions are carried out by different isoforms of glutamine synthetase which can occur in various plant organs. In photosynthetically active tissue of barley (Hordeum vulgare L.) (Mann et al., 1979), pea (Pisum sativum L.) (Hirel and Gadal, 1981) and sorghum (Sorghum vulgare L.) (Hirel and Gadal, 1982), two forms of glutamine synthetase have been identified by ion-exchange chromatography. Subcellular localization (Mann et al., 1979) and immunocytochemical (Hirel et al., 1982) studies have shown one isoform to be present in the cytosol (GS_1) and the other isoform localized in the chloroplast (GS_2). The two leaf isoforms display different kinetic, regulatory and physiochemical properties (Mann et al., 1980; Ahmad et al., 1982; McNally et al., 1983a,b; Hirel and Gadal, 1980).