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Resistance of sorghum varieties to the shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) in Southern Africa

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Abstract

The sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae), is considered to be the predominant shoot fly species attacking sorghum. No information is available on the levels of resistance of to *A. soccata* sorghum varieties and breeding material released in the countries of the Southern African Development Community. Three field trials were conducted during the 1998/99 to 2001/2002 growing seasons to determine the level of resistance of sorghum varieties to shoot fly. Twenty-five varieties were evaluated in two of the seasons and 24 in the other. High shoot fly densities in the trials were achieved by planting late and using fishmeal to attract flies to the fields. The incidence of dead-heart symptoms in each variety was determined 4 weeks after seedling emergence. Significant differences in resistance to shoot fly damage were observed in two of the three seasons. The incidence of dead-heart symptoms ranged from 32 to 71% during the 1998/99 season, from 27 to 54% during the 1999/2000 season and from 58 to 88% in the 2001/02 seasons. Varieties Pirira-1 and Pirira-2 were the most resistant across seasons. Although the level of resistance in many of the sorghum varieties was low, several varieties with moderate levels of resistance were identified.

Keywords: Atherigona soccata, *resistance, sorghum, SADC*

1. Introduction

The sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) is considered the predominant shoot fly species attacking *Sorghum bicolor* (L.) Moench, in Africa and Asia (Young and Teetes 1977). The fly is attracted to sorghum seedlings from the first to sixth leaf stage. Eggs are laid on the leaves of plants and after hatching larvae migrate to growing points to feed. Destruction of growing points causes the central whorl leaf to die, resulting in characteristic 'dead-heart' symptoms. Small seedlings may be killed by larvae, resulting in stand loss. Larger seedlings continue to produce tillers and form tufts. These seldom grow taller than 30 cm and produce no panicles (Young and Teetes 1977).

This pest has been indicated to reach economically important infestation levels in various countries in Southern Africa. Moderate to high shoot fly infestation levels have been reported in Tanzania, Zambia (Leuschner 1988) and Swaziland (Sithole et al. 1987). Infestation levels of shoot fly in Malawi have been reported to be as high as 80% (Chikonda 1989). Sithole and Maramba (1986) reported an increase in the importance of shoot fly in Zimbabwe. In a national survey of pests and diseases of sorghum in Zimbabwe, shoot fly infestation levels of 20–30% were observed in communal farming areas (Sithole 1987). In South Africa, infestation levels up to 43% may occur in late sorghum plantings (Van Rensburg and Van den Berg 1992; Sherwill et al. 1999). *A. soccata* has been listed as a major pest of sorghum in Botswana and Tanzania (Leuschner and Pande 1991).

Only systemic insecticides provide effective shoot fly control (Young and Teetes 1977). However, this is not a viable option in resource-poor and dry land farming systems. Cultural control in the form of early and uniform planting dates limits shoot fly infestation (Jotwani 1981; Nwilene et al. 1998) but is not always viable with dry-land sorghum production. Host plant resistance to shoot fly has, however, been observed under field conditions and could provide a tool for the management of this pest.

Techniques for evaluating shoot fly resistance in sorghum have been developed (Sharma et al. 1992) and many sources of resistance have been identified (Taneja and Leuschner 1985, 1991; Nwanze et al. 1991; Peterson et al. 1997). Shoot fly resistant sorghums have been used in the breeding programme of the International Crops Research Institute for the Semi-Arid tropics (ICRISAT) in India and resistant varieties and hybrid sorghums were released in that country (Jotwani 1981). As part

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of the SADC/ICRISAT programme, sorghum breeding material was evaluated for resistance to shoot fly in Zimbabwe during the late 1980s. Resistant sources were identified and incorporated in the sorghum breeding programme of the Sorghum and Millet Improvement Programme (SMIP). However, no information is available on the levels of resistance of sorghum varieties released by ICRISAT through SMIP in the countries of the Southern African Development Community (SADC). SADC countries include Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

The level of pest resistance in sorghum varieties, breeding lines and hybrids developed by the SADC/ICRISAT/SMIP and National Agricultural Research Systems (NARS) in the SADC is not determined in breeding programmes. The shoot fly resistance levels of these varieties, planted by resource-poor farmers over approximately 500 000 ha in southern Africa (ICRISAT 1993) are unknown. Large-scale deployment of SMIP-released varieties in the region calls for more comprehensive knowledge on resistance levels that exist in these varieties and breeding materials. Such information would be of practical value in development of IPM systems. The aim of this study was to evaluate the status of resistance of sorghum varieties to shoot fly across seasons.

2. Material and methods

Three field trials were conducted at the ARC-Grain Crops Institute, Potchefstroom, South Africa, during the 1998/99 to 2001/2002 growing seasons. Seed of the sorghum genotypes were obtained from SADC/ICRISAT/SMIP at Matopos in Zimbabwe. Commercial sorghum hybrids planted in South Africa were included as standards in the first season. The genotypes that were evaluated consisted of hybrids, selections and breeding lines that are annually evaluated for adaptability in regional fields trials across the SADC-region.

High shoot fly density in the trials was achieved by planting late and using fishmeal to attract flies to the fields. The planting date used was mid-January. Moistened fishmeal was placed in plastic containers between rows using the methods described by Sharma et al. (1992).

Forty-three varieties were evaluated (Table I). Twenty-five sorghum varieties were evaluated in each of the 1998/99 and 2001/2002 seasons while 24 varieties were evaluated in the 1999/2000 season. The experimental layout was a randomised block design with three replicates. Each plot consisted of a 4-m row and the inter-row spacing was 1.5 m. Seedlings were thinned to an inter-plant spacing of 10 cm, 7 days after crop emergence.

A uniform plant stand per plot row was ensured by hand thinning 5 days after plant emergence. The number of stems with dead-heart symptoms was determined 4 weeks after plant emergence. The incidence of dead hearts in each variety was expressed as a percentage of plant stand and subjected to ANOVA. Percentages were arcsin transformed before analysis. Untransformed data are shown.

3. Results and discussion

Significant differences in the levels of resistance of sorghum varieties to shoot fly damage were observed (Table II). Significant differences were observed in both the 1999/2000 and 2001/2002 seasons, but not during 1998/99. The incidence of dead-heart symptoms in the 1999/2000 season ranged from 27.1 to 54.0%. In similar evaluations of sorghum breeding material, Sharma et al. (1992) indicated that the resistant control (IS 18551) exhibited 28% dead-heart damage and that an incidence of below 35% can be considered as a low level. Results from this study indicate that some of the SMIP released varieties and breeding lines can be considered to be resistant to shoot fly or to exhibit a low incidence of damage under high infestation pressure. The high infestation pressure experienced in this study is normally not often observed under farming conditions.

The varieties Pirira-1 and Pirira-2 were the most resistant varieties across the 1999/2000 and 2000/2001 seasons. Similar results were observed in the 1998/99 season although differences were not significant. These two varieties were previously reported to be resistant to shoot fly (ICRISAT 1995a,b). The variety Macia exhibited a comparatively low incidence of damage in two of the three seasons (Table II).

The incidence of dead-heart symptoms observed in widely planted three commercial South African sorghum hybrids was high with 40% for PAN 8564, 67% for SNK 3939 and 59% for NK283. These hybrids were however only planted in the 1998/99 season.

Two new sources of resistance to shoot fly, Pirira-1 and Pirira-2, as well as several lines and varieties that exhibited a low incidence of damage, were identified in this study. As far as could be ascertained, the sources of resistance identified by Sharma et al. (1992) were not used in the development of SMIP released varieties, since they are not mentioned in the breeding pedigrees of this material (Obilana 1998).

The SADC/ICRISAT/SMIP programme serves as an ideal platform from where pest resistant sorghum varieties can be developed and released to farmers. For example, the variety Macia, which did comparatively well in this study, was released in Botswana Mozambique, Namibia, Tanzania and Zimbabwe. Pirira-1 and Pirira-2 were released in Malawi. It is estimated that at an adoption rate of 40% for the more successful SMIP-released sorghum varieties, the area planted to released varieties in southern Africa can be 848 000 ha by 2010 (ICRISAT 1993).

Table I. Description of sorghum varieties and hybrids evaluated for shoot fly resistance.

Genotype*	Pedigree	Remarks
Sima	IS 23520 derivative	Selected from IS 23520 Released in Zambia
SDS2690-2	IS 23520 derivative	Selected from IS 23520 Released in Zambia
Pirira 1	(SC108-3xCS 3541) 19-1	SPV 351, ICSV1 synonyms Released in Malawi
SV-1	[(IS 12622Cx555) x (IS3612x2219B) 5-1 x E35-1]5-2	SPV475, ICSV 112
PAN 8564	Hybrid	Pannar, South Africa
SDSL 90173	KAD 1356-3-3-3-1 MAT	Selection from (F3G-773xF3G-32) = SDSL 871019
Pirira 2	SV-1 pedigree	SPV 475, ICSV112 synonyms Released in Malawi
SDSL 87046	(G3C-25-26xF3!)- 1	SMIP crossbred line
Mmabaitse	Selection from bulk sorghum population	Synonym with BOT 79 Released in Botswana
SDSL 87049	(F3A-777xG3C-3-4)- 1	SMIP crossbred line
SV2	A6460 population	Released in Zimbabwe ICSV 83060
SDSL 89473	ESIP12 x IS 2820-2	SMIP crossbred line
Larsvyt 46-85	M 81938-3-85	SMIP selection
Phofu	F3A-115-2	Synonyms: Macia, SDS3220, M 91057 Released in Botswana
SDSL 89426	SH 84185 ACROSS	SMIP crossbred line
SDSL 87021	(F3G-773xF3G-325)- 2-3	SMIP selection
Pato	Selection from IS 23496	Synonym SDS 2293-6 Released in Tanzania
Mahube	Selection from IS 2923	Synonym SDS2583 Released in Botswana
NK 283	Hybrid	From Northrop King, RSA
SDSH 94002	Hybrid (SPL33A x Macia)	SMIP Hybrid
SDSH 409	Hybrid (MA6 x R8602)	Synonym SDSH 89409
SNK 3939	Hybrid	From Sensako, RSA
SDSL 88298	IS 10487 x 3/64	–
SDSL 89420	SH 84185 ACROSS	–
SDSH 48	Hybrid, ICSA 12 x LARSVYT 13	SDSH 87046. Hybrid from SMIP
CHOKWE	Selection from SV1	Released in Mozambique
SDSL 98021		–
SDSL 88059	(8/89 X IS 23509)- 1	SMIP crossbred line selection
SDSL 98025		–
SDS 6019		–
ZSV 15	Introduction to SADC region	Selection from Zambia
Macia	F3A-115-2	Syn: Phofu, SDS 3220 Released in Mozambique, Zimbabwe, Tanzania and Namibia
SDSL 98014		–
AHM 718	Namibia collection	Local variety
SDSL 90007	(SC108.3 x C53541)-MAT-KAD	SMIP crossbred selection
SDSL 98020		–
SDSL 98028		–
SDSL 98018		–
Larsvyt 58-85	Salv-84-53-85	–
AWN 98		–
SDSL 87021	(F3G-773 x F3G-325)- 2-3	SMIP crossbred line selection
SDSH 378	Hybrid (ICSA 21 x R8602)	SMIP hybrid
SDS 3472		–
SSDSL 98420		–
SDS 6019		–
ACC 999		–
NL 9518		–
ACC 953		Zimbabwe NARS, New line
Kuyuma	Selection from Zambia	Syn: WSV 387, SDS3136-2, Released in Zambia
SV4		Released in Zimbabwe

*SDS, SADC Sorghum selection from introductions; SDSL, SADC Sorghum crossbred pure line from SMIP; SDSH, SADC Sorghum hybrid developed in SMIP; IS, International Sorghum numbers given by ICRISAT.

Table II. Incidence of dead-heart symptoms caused by *Atherigona soccata* 4 weeks after seedling emergence.

1998/99 season		1999/2000 season		2001/2002 season	
Variety	Dead heart (%)	Variety	Dead heart (%)	Variety	Dead heart (%)
Sima	32.9	Pirira-2	27.1 a	Pirira-2	58.3 a
SDS 2690-2	33.6	Chokwe	28.5 ab	SDSL 98014	62.9 a
Pirira-1	36.6	Pirira-1	29.4 abc	Pato	63.1 ab
SV-1	38.7	SDSL98021	29.6 abc	Pirira-1	63.5 ab
PAN8564	40.3	SDSL88059	29.7 abc	Macia	63.8 ab
SDSL 90173	40.8	SDSL98025	29.9 abc	Larsvyt46-85	64.3 ab
Pirira-2	43.9	Larsvyt46-85	30.6 abc	ZSV 15	64.4 ab
SDSL 87046	44.4	SDSL89473	31.6 abc	SDSL 98420	65.0 ab
Mmabaitse	44.9	SDSL89420	33.5 abc	AWN 98	66.6 ab
SDSL 87049	44.9	SDS6019	34.1 abc	SDS 6019	67.6 abc
SV-2	45.1	Sima	34.4 abc	Chokwe	68.3 abc
SDSL 89473	48.2	ZSV-15	34.8 abc	Acc 999	69.3 abc
Larsvyt46-85	48.6	Macia	35.0 abcd	NL 9518	70.2 abc
Phofu	50.8	SDSL 98014	35.3 abcd	SDSL 90007	73.3 abc
SDSL 89426	51.0	Kuyuma	35.7 abcd	Larsvyt58-85	73.3 abc
SDSL 87021	53.6	SDSL 96018	36.5 abcd	SDSL 98018	74.1 abc
Pato	53.7	AHM 718	37.2 abcd	Acc 953	74.4 abc
Mahube	55.8	SDSL 90007	37.4 abcd	SDSL 89473	74.6 abc
NK283	58.5	SDSL 98020	39.8 bcd	SDSL 98020	75.4 abc
SDSH 94002	63.5	SDSL 98028	40.2 cd	Sima	77.1 abc
SDSH 409	64.8	SDSL 98018	40.3 cd	Kuyuma	77.4 abc
SNK3939	66.9	Larsvyt58-85	40.8 cd	SDSL 98007	77.4 abc
SDSL 88298	68.4	Pato	45.0 de	AHM 718	80.1 bcd
SDSL 89420	70.5	AWN 98	54.0 e	SDSL 98021	82.4 cd
SDSH 48	71.6			SV-4	88.0 d
P value	0.09		0.03		0.04

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