corneousness contributes towards resistance to grain molds in white-grained genotypes. The iodine vapor absorption test described facilitates visual assessment of endosperm corneousness in sorghum.

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A New Method of Inoculating Grain Sorghum Spikelets with Sorghum Midge Eggs by Water Injection

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A new method of infesting flowering sorghum [*Sorghum bicolor* (L.) Moench] spikelets for midge (*Stenodiplosis sorghicola* Coquillett) resistance screening work has been developed. It uses midge eggs injected into individual sorghum spikelets with an adjustable volume micro-pipette. This method was developed to overcome the inconsistent egg lay achieved across a range of midge-resistant sorghum lines.

In the new method, a small volume of water containing a set number of eggs is injected between the glumes of each spikelet. After injection the water evaporates leaving the eggs attached to the inside structures of the spikelet. A variety of egg densities were tested, ranging from exactly 2 eggs per spikelet up to 4—6 eggs per spikelet. Not all eggs remained within each spikelet. One trial that involved infecting exactly 2 eggs per spikelet over a number of lines with spikelets of different size and shape resulted in an average of 0.8-1.1 eggs per spikelet, and 50-75% egg infestation of spikelets with eggs. Similarly injecting 4-6 eggs per spikelet resulted in 2-3 eggs per spikelet, and 80-95% infestation of spikelets with eggs. In all the trials, most of the eggs were found positioned on the inside of the glumes regardless of spikelet dimensions, with the remaining eggs on other structures within the spikelet, or on the outside of the glumes.

The possibility of using eggs stored in water for prolonged periods was tested in a laboratory bioassay by the water injection method. Freshly laid midge eggs were stored in water from 0- 21 days in the refrigerator at 4°C. The results indicated that eggs stored in water for 4 h were significantly more viable (80%) hatch) than eggs stored for 1-7 days in the refrigerator (40-65% hatch). No viable eggs were retrieved after 14 or 21 days.

Using midge eggs stored in water prior to injection into sorghum spikelets appears to be a useful and practical technique for midge-resistance studies. This technique needs to be improved for precise and consistent egg insertion into each spikelet across a range of sorghum lines. It could then be used to conduct a range of tests for antibiosis and tolerance mechanisms for resistance to sorghum midge.

Integrated Pest Management (IPM) Components for Control of Armored Bush Cricket on Pearl Millet and Sorghum in Farmers' Fields in Namibia and Zambia

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Armored bush crickets (*Acanthoplus* spp) are sporadic but economically important pests of cereals in several countries in southern Africa. In outbreak seasons, *A. discoidalis* J. Irish causes on average 30% grain yield loss on pearl millet in Namibia (Wohlleber 1996), while *A. speiseri* Brancsik causes up to 60% yield losses on sorghum in the Gwembe valley of southern Zambia (Musonda and Leuschner 1990). In both countries, and in neighboring Zimbabwe, Botswana, Mozambique, Malawi, and Tanzania, the pest is a threat to poor farmers' livelihoods both in outbreak seasons and also in years of low pest population density.

Before the 1990s, the biology of armored bush crickets was very poorly understood. Recently however, the taxonomy of the group has been improved by a revision of southern African genera (Irish 1992), whilst Mbata (1992) and Musonda and Leuschner (1990) have extended ecological knowledge of these pests. Musonda and Leuschner (1990), Leuschner (unpublished), and especially Wohlleber (1996) and Wohlleber et al. (1996) have started to develop management strategies. These strategies include; use of short-duration varieties, clean weeding within and around fields, use of insecticide baits along field borders, selective spraying on nearby bushes, and egg search and collection. Farmers in Namibia and Zambia have developed their own cultural practices that include early sowing, clean weeding, field border trenches, early harvesting, stooking pearl millet, and hand-picking crickets in Namibia, and lower leaf stripping on sorghum in Zambia.

The strategies were tested individually in Namibia and Zambia and most of them were found effective to some degree (Musonda and Leuschner 1990; Wohlleber 1996). To ensure sustainability however, these strategies were combined to form an integrated pest management (IPM) strategy) and tested for the first season in 1997/98. Different component combinations were tested and verified in on-farm trials in Namibia and Zambia. The combinations were:

Namibia. Early sowing and hand-picking were common to most farmers;

1. Mixed local cultivars of pearl millet and sorghum; clean weeding
2. Short-duration pearl millet variety Okashana 1 mixed with local cultivar Karango; clean weeding; selective bush spraying; field edge baiting
3. Mixed local cultivars of pearl millet and sorghum; clean weeding; predatory birds
4. Okashana 1 mixed with local pearl millet cultivar and cowpea *[Vigna unguiculata* (L.) Walp.]; clean weeding; kraal manure application
5. Okashana 1 mixed with local pearl millet, sorghum, cowpea and melons *(Cucumis* and *Citrullus* spp); early sowing at field borders, late sowing in the middle of fields; clean weeding; trench preparation along bushy field borders
6. Okashana 1 mixed with cowpea and melons; kraal manure application; clean weeding; early harvesting, and stooking
7. Mixed local cultivars of pearl millet and sorghum; kraal manure application; clean weeding; early harvesting and stooking

Zambia. Early sowing, sole crop of short-duration sorghum variety Kuyuma, mixed cropping of long-duration variety Longo, were common to all on-farm participating farmers;

1. Early-sown Kuyuma; clean weeding; lower leaf stripping; and hand-picking
2. Early-sown Kuyuma and Longo; trench preparation for Kuyuma field; clean weeding within and around fields; hand-picking
3. Early-sown Kuyuma; clean weeding; hand-picking
4. Early-sown Kuyuma; weeding once at 4 weeks after germination.
5. Local cultivar Longo mixed with cowpea, mung beans [*Vigna radiata* (L.) Wilczek], and melons

In Namibia and Zambia, farmers' fields (0.25-0.5 ha) were used as replicates. In cases where farmers own large fields and agreed to have different combinations, farmers acted as blocks. Crickets were counted at crop maturity/ harvest on 5-m x 5-m sub-plots marked out randomly in each field. Crop maturity/harvest period coincides with the highest population peak for the crickets. Similar but separate sub-plots were used for damage and yield assessments.

The estimated cricket population density in Namibia and Zambia during the 1997/98 season was 25-30% that of a normal outbreak season. The low pest population densities were an outcome of low and unevenly distributed rainfall in Namibia (total 250-350 mm) and Zambia (total 400-500 mm). Grain yield loss was estimated at 5-15% on pearl millet in Namibia and 10-40% on sorghum in Zambia. Tables 1 and 2 show the cricket population density, panicle damage, and estimated grain yields under different component combinations tested in Namibia and Zambia.

In Zambia the long-duration sorghum cultivar Longo suffered severely from terminal drought that resulted in no grain being produced. Despite low and poorly distributed rainfall for crop establishment, the improved short-duration pearl millet variety Okashana 1 and improved short-duration sorghum variety Kuyuma performed well in terms of the grain yields that farmers harvested at the end of the season. Similarly, most of the components especially early sowing, use of kraal manure, weeding,

Table 1. Performance of IPM components for control of armored cricket on pearl millet, Namibia, 1997/98.

Cropping pattern	IPM component combinations	Crickets at at harvest (numbers)	Damaged panicles (%)	Estimated grain yield (t ha^{-1})
Mixed local cultivars of pearl millet and sorghum	Early sowing[1], clean weeding, hand-picking[1]	5.2	20.4	0.5
Okashana 1 mixed with local millet Karango	Clean weeding, Selective bush spraying, field edge baiting	3.1	15.3	0.8
Mixed local cultivars of pearl millet and sorghum	Clean weeding, predatory birds	5.3	18.2	0.5
Okashana 1 mixed with local sorghum and cowpea	Clean weeding	5.4	9.0	0.7
Okashana 1 mixed with local millet, sorghum, cowpea, melons	Early sowing along field borders and sowing in middle of fields, trench along bushy borders	3.0	4.3	0.9
Okashana 1 mixed with cowpea and melons	Clean weeding, kraal manure, Early harvesting and stooking	5.1	4.1	1.3
Mixed local cultivars of pearl millet and sorghum	Clean weeding, kraal manure, Early harvesting and stooking	22.4	4.2	0.6
Mean		7.1	10.8	0.8
SE		± 1.5	± 2.6	± 0.3

1. Practices common to all farmers in northern Namibia

Table 2. Performance of IPM components for control of armored cricket on sorghum, Zambia, 1997/98.

Cropping pattern	IPM component combinations	Crickets at at harvest (numbers)	Damaged panicles (%)	Estimated grain yield (t ha^{-1})
Sole crop short-duration variety Kuyuma	Early sowing[1], clean weeding, leaf stripping, hand-picking[2]	2.2	5.4	0.7
Sole crop Kuyuma	Clean weeding, trench around field, hand-picking[2]	2.1	4.5	0.8
Sole crop Kuyuma	Clean weeding, hand-picking[2]	3.1	5.3	0.5
Sole crop Kuyuma	One weeding within field 4 weeks after germination	9.3	33.2	0.3
Local long-duration cultivar Longo mixed with cowpea, melons and mung beans	Clean weeding	4.3	No panicles matured	No yield
Mean		4.2	9.7	0.5
SE		± 1.1	± 2.9	± 0.2

1. Early sowing was practiced by all participating farmers
2. Practice imported from Namibia and accepted by some farmers in Zambia

hand-picking, early harvesting, and stooking were all advantageous to crop performance.

The pest population estimates were similar for Namibia and Zambia. However, damage was slightly higher in Zambia than in Namibia due to the fact that all farmers' families in Namibia have a traditional commitment to hand-picking the crickets daily from their fields and crushing them or suffocating them in polythene bags before burning them. This tradition is lacking in Zambia. Some of the extension personnel in Namibia have also been trained to use a forecasting tool (a cricket egg-hatching trap) developed by Wohlleber et al. (1996) to monitor cricket egg hatch after the first heavy rains. This information enables the extension staff to inform farmers in time to initiate management practices. The Sorghum and Millets Improvement Program (SMIP) facilitated exchange visits of one technical staff directly involved with the farmers in each of Namibia and Zambia. These visits were in anticipation that the exchange of technologies between the two countries will continue to develop.

During the course of field work in the 1997/98 season, a few Zambian farmers were convinced and accepted that hand-picking crickets from their fields was helpful in reducing panicle damage. According to the farmers in Zambia, hand-picking did not involve extra costs from them because it was carried out at the same time as farmers were scaring birds from their fields. The search for additional management components including population forecasting and the use of semio-chemicals (chemical smells or cues, e.g., pheromones) and bio-pesticides to complement the above practices is anticipated in the near future. The technologies were only tested and verified with a few farmers, particularly in Zambia. There is a need for follow-up verification with more farmers for effective diffusion and spillover to neighboring countries.

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Evaluation of Sorghum Genotypes for Relative Resistance to Corn Leaf Aphid, *Rhopalsiphum maidis*

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The corn leaf aphid, *Rhopalsiphum maidis* (Fitch.), was first reported in Haryana on sorghum by Singh (1985). For the last few years corn leaf aphid attacks on maturing sorghum have been observed to be increasing during September and October when they reduce grain and green fodder yields and the quality of the fodder. The aphids initially appear in patches in the field and are generally found deep in the whorl of middle leaflets, and on the undersides of leaves. Even stems and panicles can be seen to be infested. Both nymphs and adults suck the plant sap and cause yellowish mottling of the leaves. Consequently marginal leaf necrosis appears. The aphids produce an abundance of honeydew on which molds grow.

This pest is becoming a regular problem on sorghum at the harvesting stage, a time when chemical control is very difficult and uneconomic. Thus, sorghum genotypes with resistance to aphids would be an extremely valuable way to control this pest. The present investigations were undertaken to identify the sorghum genotypes least susceptible to corn leaf aphid.