Methodology for Screening Sorghum Resistance to Storage Pests

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Abstract

*To assist plant breeders in obtaining suitable material for screening sorghum resistance to storage insect attack, test grain from a susceptible variety (Red Swazi) was used to determine the best combination of minimal trial material with optimal infestation. Three masses of 10, 15, and 20 g were infested with 10, 15, 20, 25, 30, 35, and 40 10-day-old adult weevils (*Sitophilus oryzae*) and with the same quantities of eggs of the grain moth (*Sitotroga cerealella*). Results are discussed according to progeny output in relation to infestation levels and grain mass. Combinations of 30 weevils and 20 g of grain, and 40 grain moth eggs and 15 g of grain are recommended for use in further resistance screening.*

Introduction

Adequate storage of sorghum grain by small-scale farmers is vital for food security in rural areas of the SADC region. Farmers usually store 50% of their harvested grain for various lengths of time depending on the amount harvested (Giga 1986). One of the main constraints to storage is attack by insects which, according to Giga and Katerere (1986), can destroy 6–15% of the stored harvest in one storage season in Zimbabwe. The main storage insects in the region are *Sitophilus zeamais* (Motschulsky), *S. oryzae* (L.) (Curculionidae: Coleoptera), and *Sitotroga cerealella* (Olivier) (Gelechiidae: Lepidoptera). Sorghum is mainly infested by *Sitophilus oryzae* (95%) and *Sitotroga cerealella*.

Insecticides such as malathion and pirimiphos methyl (actellic) are commonly used to control these insects because they are effective. But both can be harmful to humans if not properly used, and they are expensive.

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Fortunately, however, farmers are fully aware of the alternative advantages that can be gained through sowing varieties with host-plant resistance. This character is often present in local landrace varieties of sorghum, and breeding for the selection of this character is an inexpensive and durable control method, that is harmful neither to the environment nor to humans.

Because farmers place great emphasis on insect resistance when they evaluate new varieties in their fields, it is necessary that any new variety proposed for release to farmers should be carefully screened for its level of resistance to storage insects.

Sources of resistance are available (SADC/ICRISAT 1993), and breeders are encouraged to use them to improve resistance levels in newly bred varieties. To assist in this process, it became necessary to develop a reliable and efficient resistance- screening method that reduced to a minimum the amount of seed required for breeding trials and ensured an optimum number of infesting insects. The objective of this study was to identify the optimum ratio of insects to the grain offered for testing in further screening.

Materials and Methods

Adult weevils (*Sitophilus oryzae*) and grain moth (*Sitotroga cerealella*) eggs were obtained by laboratory culture. (In earlier tests with *S. cerealella* egglaying was found to be highly variable when adults were used. Consequently, in this study grain moth infestation was done with eggs rather than adult females.)

The insects were reared on the susceptible sorghum variety Red Swazi at 27°C and 70% RH. Three different masses of Red Swazi grain (10, 15, and 20 g) were infested with 10, 15, 20, 25, 30, 35, and 40, 10-day-old adult weevils; and the same masses of grain were infested with the same number of eggs of the grain moth. Eggs were collected according to a method described by Mills (1965). Before infestation the grain was deep-frozen for 48 hours (-24°C) to eliminate any natural infestation. Grain moisture was 13.5%, measured with a Dole Grain Moisture Meter.

Weevils for infestation were not sexed, since separation of sexes can be done only by examining their genitalia, which is a time-consuming process. It was assumed that a 1:1 female to male ratio exists, which is supported by Widstrom et al.(1978). Each insect/grain mass combination was replicated 20 times, and kept in pill boxes measuring 35 mm in diameter and 60 mm in height for weevil tests, and 60 mm diameter and 75 mm height for grain moth tests. The trial was organized as a randomized block design and the material was kept at 27°C and 70% RH in a temperature- and humidity-controlled room. Adult weevils were left for 7 days in the test jars and then removed to ensure oviposition for a given period only.

The progenies—adult weevils and moths—were collected from 28 days after infestation onwards at 1-day intervals for a total of 14 days. Data from both tests were subjected to analysis of variance.

Results and Discussion

Grain weevil

Results showed significant differences in progeny output from the different grain masses ($P = 0.01$) (Table 1).

Table 1. Number of *Sitophilus oryzae* progenies developing from different adult infestation levels and three grain masses, SADC/ICRISAT, Zimbabwe, 1994.

No. of adults	10 g of grain	15 g of grain	20 g of grain
10	41.1	42.4	56.5
15	50.9	57.8	64.2
20	50.8	68.9	65.3
25	55.2	78.9	78.2
30	69.6	91.6	137.2[1]
35	85.4	127.7	165.2
40	78.6	109.9	187.5
SE	±2.05	±3.35	±5.31
Mean	61.63	82.46	107.69
CV (%)	31.39	35.19	35.39

1. Selected and recommended combination.

Progenies derived from the infestation of 10 g of grain with 10–40 weevils indicate that the gain in progenies with increasing infestation is small up to 25 weevils. Progeny output peaks at 35 weevils, and declines in real terms with 40 (Fig. 1) when progeny differences between 35 and 40 are taken into account.

Comparison of these results with progeny outputs from grain masses of 15 and 20 g (Table 1) shows that a 10-g mass is too low, and limits the number of eggs laid and, consequently, the output of adult progeny.

A similar trend is observed from 15 g of grain infested. A fairly steady linear increase in progenies can be observed from 10 to 30 weevils. But at 35 weevils a significant progeny peak (127.7) appears, followed by a decline in real terms at 40 weevils (Fig. 2). Limited availability of grain for oviposition seems to be the dominating factor when 40 weevils are used for infestation.

When a grain mass of 20 g was infested, there was a low increase in progenies up to 25 weevils and a significant peak (137.2) at 30 weevils (Table 1). Higher infestation levels of 35 and 40 weevils showed a further increase but, in real terms, a decline compared with 30 weevils (Fig. 3).

The results of all three grain masses indicate that a critical number of weevils is required for maximum progeny output. This critical infestation level can only show its full reproduction potential if enough oviposition sites (grains) are available. This is illustrated (Table 1) by the increasing progenies produced by the combinations of

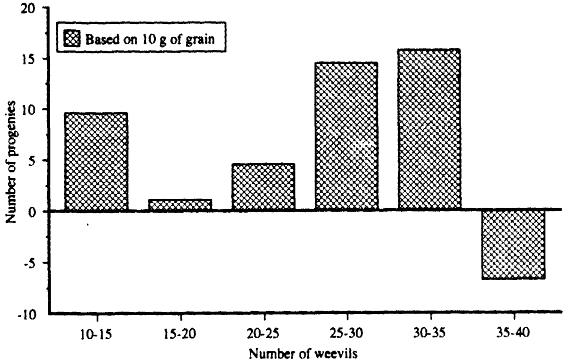

Figure 1. Increase/decrease in weevil progeny output with 10 g of grain between different infestation levels.

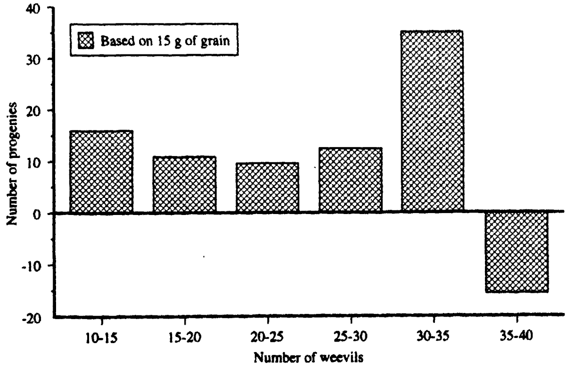

Figure 2. Increase/decrease in weevil progeny output with 15 g of grain between different infestation levels.

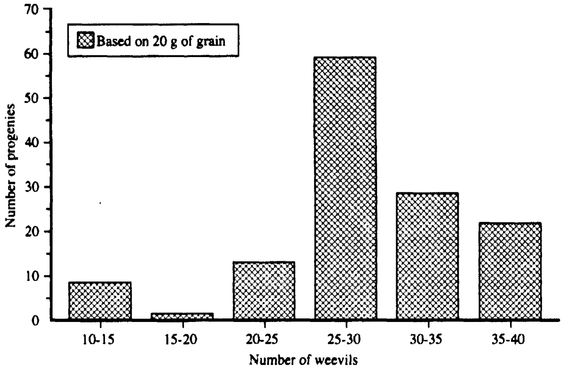

Figure 3. Increase/decrease in weevil progeny output with 20 g of grain between different infestation levels.

35 weevils 10 g^{-1}, 35 weevils 15 g^{-1}, and 30 weevils 20 g^{-1} (Table 1). With each 5-g increase of grain mass, progeny numbers approximately doubled.

Since in the case of 40 weevils and 10 and 15 g of grain progeny numbers decreased in real and relative terms, it is assumed that 35 weevils are the optimum number for these masses of test grain.

In the case of 20 g of grain 30 weevils produced the optimum number of progenies, followed by a relative decline when weevil numbers were increased to 35 and 40 (Fig. 3).

A comparison between progeny output based on 30 weevils across the three different grain masses showed that the largest increase took place with 20 g (Fig. 3). When increased progeny output from 30 to 35 weevils was compared in the same way, 15 g yielded an increase over 10 g but showed a relative decline at 20 g (Figs 1, 2, 3).

This can be interpreted to mean that 15- and 20-g grain masses are still too low to realize the full reproduction potential of this infestation level. Therefore 30 weevils and 20 g of seed mass are considered optimal for future resistance screening tests.

Grain moth

The results of the trial (Table 2) showed no significant progeny output differences between grain masses. This is also illustrated in Figure 4, which shows the clear linear relation between infestation levels and progeny output.

Table 2. Number of *Sitotroga cerealella* progenies developing from different egg infestation levels and three grain masses, SADC/ICRISAT, Zimbabwe, 1994.

No. of eggs	10 g of grain	15 g of grain	20 g of grain
10	6.5	8.2	7.4
15	9.2	7.7	12.0
20	17.0	16.9	15.2
25	22.8	22.9	19.0
30	19.1	28.2	27.4
35	24.1	26.9	27.5
40	37.6	38.6[1]	36.6
SE	±0.98	±1.02	±0.97
Mean	19.44	21.34	20.69
CV (%)	33.69	29.45	31.86

1. Selected and recommended combination.

This can be interpreted in two ways. The most obvious explanation is that, in this test, only relatively small numbers of eggs have been used for infestation. The larvae:grain ratio was therefore largely in favor of the grain, and enough grain kernels for feeding were available. Based on the 1000-grain mass of 16 g of Red Swazi sorghum, 625, 925, and 1250 grains will have been available for feeding the 10–40 larvae developing from the egg infestation.

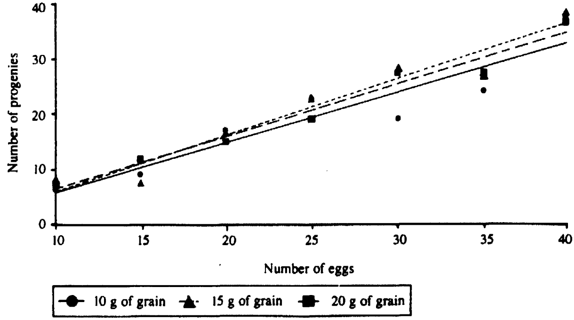

Figure 4. Differences between three grain masses infested with different numbers of grain moth eggs.

In addition, because of their fragile nature, *S. cerealella* adults can infest only the top layer of a grain mass (Mills 1985). This means that only the grains on the surface of the grain mass, and not the total number of grains, determines the number of eggs laid. The resulting larvae also may not have penetrated deeply into the grain mass, feeding only on the top 5 cm of the heap (in the absence of manual disturbance). Larger test jars were therefore used in this test to increase the grain surface.

Based on these results, any of the egg/grain mass combinations could theoretically have been used. But it was decided to select the combination 40 eggs and 15 g of grain. This reduces the demand for breeders' seed and gives a fairly high infestation level for better determining the differences between progenies possibly related to levels of sorghum variety resistance.

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