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# DEVELOPMENT OF RESISTANCE TO WEEVIL, CYLAS FORMICARIUS, IN SWEET POTATO

**Franklin W. Martin**[1/]

The sweet potato weevil, Cylas formicarius, is the principal pest of the sweet potato in the tropics and in much of the temperate zone as well. Weevils chew the surface of stems and storage roots, damaging them, and predisposing them to diseases. Weevils also lay eggs in stems and in roots, and their larvae bore tunnels through the tissues. In the roots, such damage causes the development of bitter substances which make even otherwise undamaged tissue inedible. The magnitude of loss attributable to weevil reaches 100 percent in some plantings. Furthermore, many farmers will not plant sweet potatoes due to the risk of weevil.

Methods to combat weevil are not very effective. These include various sanitation measures to assure clean planting material, isolation to avoid existing infestations, and insecticides applied at various stages. Clearly the desirable alternative is to breed resistant varieties.

Several serious attempts have been made to identify weevil resistances in the sweet potato and to select resistant varieties. Cockerham and Harrison (1952) searched for resistance to weevils among seedlings and identified two seedlings that were especially promising. Singh (1973) first identified some resistance to the African weevil in C. puncticollis. From a diallele cross of 8 varieties differing in susceptibility to weevil Soenarjo (1976) concluded that although resistances were found, their heritability is low and the variation associated with environment is high. Waddill and Conover (1978) found significant differences among so-called white-fleshed sweet potatoes to weevil. Their materials included local varieties and selections from Cuban materials where presumably the species had coexisted with the weevil for untold centuries.

Measurement of weevil resistance is a problem. Frequently field tests have not given reliable results due to the sporadic and irregular nature of infestation (Mullen, et al., 1981). A special box has been designed and tested by Mullen et al. (1980) which permits a more reliable comparison of harvested roots. Resistance in the field can be seen as differences in the degree that stems are attacked as well as differences in the degree of attack of roots (Hahn & Leuschner, 1981a). In the more resistant varieties the larva of the weevil has been shown to require a longer growth period than in normal varieties (Hahn & Leuschner, 1981b). The author has observed varieties in Puerto Rico and in the Dominican Republic that are known for their relative resistance to weevil.

Why has the interest in and observation of weevil resistance not led to satisfactory control by resistant varieties? I believe it is because

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1/ Mayaguez Institute of Trocpical Agriculture, Mayaguez, Puerto Rico.

of relative weakness of the resistances found, the very slow progress by conventional breeding methods, and the lack of continuing systematic effort.

Recently Jones et al. (1976) has developed and proved the value of mass selection in sweet potato. Starting with weak levels of resistance to a complex of insects, through mass selection in populations he has increased resistance to a number of insect pests. Six breeding lines were released that carry a high level of resistance, including some resistance to weevil, as well as the color and horticultural characteristics desired in the United States (Jones et al., 1981).

I have recently developed a sweet potato breeding program for Puerto Rico and the tropics, using the mass selection techniques developed by Jones, but with breeding objectives more appropriate to the tropics. One objective of the program is to develop techniques to identify weevil resistant varieties.

## MATERIALS AND METHODS

Seedlings representing sweet potato germ plasm from the United States, West Africa, and Taiwan were established in the field at Mayaguez, Puerto Rico, where there are few problems with weevil. From each of 3000 plants a 30 cm tip cutting was taken and planted at Santa Isabel, Puerto Rico, where weevils are a problem. The presence of weevils was guaranteed by the distribution in the field of weevil infested storage roots. The plants were dug by machine at 4 months and inspected in the field for weevil damage.

Plants with a minimum of damage in crown and root were selected. Uniformly sized roots were taken to Mayaguez where they were placed in screened boxes that contained roots with heavy infestations of weevil as well as a large population of adult weevils. The roots were placed at random but positions were changed each week to insure equal opportunity for infestation. In the box the roots were covered with a light opaque cloth to provide relative darkness.

After one month the roots were inspected and divided into classes according to the degree of weevil damage observed. They were then placed in shallow boxes, covered with sterile sand, and watered lightly to stimulate germination. When sprouting occurred, the sprouts were transplanted to the field, and the root was dug, washed, observed carefully, peeled and sliced to determine the degree of weevil damage. The relative number of holes where adult weevils escaped from the roots, the relative amount of weevil damage revealed by peeling, the average depth of penetration, and the relative damage to the interior were noted.

The seedlings that were most resistant to the weevil were planted, together with previously identified partially resistant varieties, in a randomized crossing block in which the plants were trained to 1.5 metre bamboo poles. Thus, plants were stimulated to flower, and were cross-pollinated by honey bees.

## RESULTS

A high degree of infestation was encountered in the Santa Isabel trial, where every plant was exposed repeatedly to attack from weevils. However, growth was excellent and good yields were obtained. Weevil attacks of the stem resulted in swollen stems riddled with weevil tunnels and rotting with secondary infections. Only slight differences were found in apparent susceptibility of stems to weevils.

Weevil infestation of the roots was irregular. Sometimes only one root from a plant was infested. From the 3,000 plants, 160 selections were made of weevil free, or relatively free roots from plants relatively free of stem damage.

After 5 weeks of exposure in cages to weevils the 160 roots were classified into 9 classes according to the degree of damage observed (Table 1). Only 25 roots from classes 7 and 8 were retained. In wet sand all of the roots produced shoots.

After shoots were removed, when roots were peeled and sliced, a uniform pattern became clear. The flesh of all roots was white, whitish yellow or only light orange. Even after 12 weeks from the first exposure to weevils, very few adult weevils had emerged from the roots (Table 2). Nevertheless, the superficial portion of all roots had been attacked, sometimes lightly and sometimes heavily. Penetration from the surface to the interior varied from about 0.5 cm to 3 cm, but usually a large central core was free of attack. Larvae, pupa, and adult weevils were frequently encountered. In spite of the fact that all of the roots had been exposed to weevils at the same time, the state of infection of roots varied. Some contained only larvae, others pupas, and some principally adults.

## DISCUSSION

Weevil resistance in the sweet potato appears to be of several types that include preference as well as antibiosis. Screening of three thousand seedlings with a broad genetic base by three different methods appears to have been useful in identifying less than 1 percent of the sweet potatoes that combine some resistance. Probably preference accounts for some of the differences, yet antibiosis, as described by Hahn & Leuschner (1981b) was the most powerful expression of resistance.

The present screning method is advantageous in that large numbers of seedlings can be screened rapidly, and that finer screening is then possible to reduce the number of seedlings to a workable number. It is still uncertain whether resistance is associated with a large number of genes in which case mass selection would be useful, or a few genes that can be rapidly selected and constitute a limit to selection progress.

Table 1.--Classification of roots of selected sweet potato seedlings into classes based on damage after 5 weeks heavy exposure to weevils

| Class | Description of class | Number of seedlings |
|---|---|---|
| 1 | Structure completely destroyed by weevils | 0 |
| 2 | Heavy feeding damage, 16 or more exits | 0 |
| 3 | Heavy feeding damage, 6-15 exits | 10 |
| 4 | Heavy feeding damage, 1 to 5 exits | 13 |
| 5 | Heavy feeding damage, but only doubtful exits | 7 |
| 6 | Medium to heavy feeding damage, no exits | 58 |
| 7 | Light feeding damage, no exits | 44 |
| 8 | Very minimum damage, no exits | 28 |
| 9 | Free of damage | 0 |

Table 2.--Weevil damage after 10-12 weeks in the case of roots of 5 selected sweet potato seedlings

| Characteristic | Range | Average | Lowest value obtained |
|---|---|---|---|
| Relative frequency of exit holes 1/ | 0-3 | 1.5 | 0 |
| Relative damage to the surface 2/ | 0.5-4 | 3.0 | 0.5 |
| Depth of penetration (mm) | 3-25 | 12 | 3 |
| Relative damage to the interior 3/ | 0.4 | 1 | 0 |

1/ 0 = none; 1 = 1-3; 2 = 4-8; 3 = 8-16; 4 = more than 16;

2/ 0 = none; 1 = up to 25% of surface showing damage; 2 = up to 50% of surface damaged; 3 = up to 75% of surface damaged; 4 = more than 75% damaged.

3/ 0 = no damage in central core; 1 = no more than 1 weevil tunnel in central core; 2 = 1-3 tunnels; 3 = 3-6 tunnels; 4 = 7 or more tunnels.

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