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Development of *Sitophilus zeamais* and *Tribolium castaneum* in Whole, Cracked, and Ground Pearl Millet[1]

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ABSTRACT: Rates of population growth of *Sitophilus zeamais* Mots. and *Tribolium castaneum* (Herbst) on whole and processed forms of pearl millet, and loss in dry weight of the millet were determined. The forms were whole grain; 10% cracked, 90% whole grain; cracked grain; and millet flour. The population of *S. zeamais* increased rapidly in the whole and 10% cracked grain treatments, causing a mean loss in dry weight of 8.2 and 7.2%, respectively, in 76 days. Few progeny were produced in the cracked treatment, and in millet flour all adult weevils died within 2–3 weeks. The population of *T. castaneum* increased slowly in the whole and cracked grain treatments, causing only a 1.38% dry matter loss in the whole grain during the 78-day incubation period. The population increased significantly more in the cracked treatment than in the whole and 10% cracked grain, while large numbers were produced in the millet flour.

Developmental success of, and loss in dry weight caused by, *Sitophilus zeamais* Mots. (maize weevil) and *Tribolium castaneum* (Herbst) (red flour beetle) in pearl millet (*Pennisetum americanum*) were tested. Pant and Dang (1969) reported that *T. castaneum* developed successfully in flour of *Pennisetum typhoides*. The present study measured the relative success of the insects by number of progeny in whole and processed forms of pearl millet.

Materials and Methods

The millet was partitioned into three particle size ranges. Whole grain was threshed millet, twice passed over an $^{8}/_{64}$-inch (0.0275 cm) triangle-hole sieve to remove dust, small pieces and broken kernels. Visual analysis of six 100-g random samples showed that the whole grain contained no less than 98% unbroken kernels ($\bar{x} = 98.3$, $s = \pm 0.2$, $P < 0.05$). Cracked grain was

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millet broken by coarsely grinding it in a coffee grinder and passing it through a 10× (0.065 in = 0.143 cm) wire screen, but over a 20× (0.0328 in = 0.07216 cm) wire screen. Millet flour was prepared by grinding whole millet in commercial-type roller mills then passing it through an 870-micron screen but over a 130-micron screen. Most of the embryo remained in the millet flour.

The three preparations of millet were then tempered to approximately 13% moisture content and sealed in containers for 10 days at −14°C. All material, still sealed, was then equilibrated at room temperature for three days.

Moisture content was determined by the air-oven method, drying ground samples at 130°C for one hour.

A separate test was done for each species, using nearly identical procedures. Four treatments of millet were tested: whole grain; 10% cracked, 90% whole grain; cracked grain; and flour. Six 300-g samples of each treatment medium were prepared for each insect species, and placed in quart mason jars.

The "10% cracked grain" consisted of 270 g whole grain mixed with 30 g cracked grain. The jars were agitated to disperse the cracked grain, but complete uniformity was not achieved. All mason jars were fitted with wire screens covered with filter paper. Fifty insects, 2–3 weeks old, were added to each jar. All jars were held at 26.7°C, 65–70% r.h.

TESTS WITH S. ZEAMAIS: After 78 days the whole grain was sieved to remove insects and frass, the grain was weighed, the moisture content was determined, and percent loss of dry weight was calculated. Insects, frass and cracked grain were removed from the 10% cracked grain treatment by sieving. After removing the insects and frass from the cracked grain, the cracked portion was returned to the whole grain, and the weight and moisture content were determined so that percent loss could be calculated. No attempt was made to measure weight loss in the cracked grain or flour treatments because of the extremely small insect populations.

TESTS WITH T. CASTANEUM: After 76 days the whole kernel treatment was sieved over a 10× screen to remove insects and frass. The weight and moisture content were determined, and percent weight loss calculated. The adult insects, pupae and larger (approximately third instar and older) larvae were removed by sieving and counted. Percent loss was not determined in the other treatments because frass and very small larvae could not be separated from the grain product.

Results and Discussion

SITOPHILUS ZEAMAIS: The populations developed rapidly in both the whole grain and 10% cracked grain treatments. The mean percent weight loss for the whole grain treatment was 8.2%, while in the 10% cracked treatment the mean was 7.2%. The means were not significantly different at the 0.1 level

Table 1. Mean numbers of insects and mean percent weight loss resulting from 50 adults of *S. zeamais* or *T. castaneum* in 300-g samples of whole or processed millet[1]

Treatment	No. insects[2]	Mean % wt. loss (±SD)
S. zeamais		
Whole kernel	1341.8 a	8.2 ± 1.7 (n = 6)
10% cracked	1149.2 a	7.2 ± 0.8 (n = 6)
Cracked	75.3 b	
Flour	50.2 b	
T. castaneum		
Whole kernel	268.7 a	1.38 ± 0.15 (n = 6)
10% cracked	244.7 a	
Cracked	612.0 b	
Flour	1417.0 c	

[1] *T. castaneum* populations after 76 days at 26.7°C, 65–70% r.h.; *S. zeamais* populations after 78 days, same conditions.

[2] Means followed by the same letter are not significantly different according to Tukey's $HSD_{.05}$.

(Table 1). Apparently there were sufficient whole kernels to produce as many weevils in the 10% cracked treatment as in the whole grain. Morrison (1964) observed that maize weevils produced more progeny in whole kernels than in halved or smaller pieces of sorghum kernels. All of the adult weevils died within 2–3 weeks after being placed in the millet flour, while nearly all insects including the original adults in the whole and 10% cracked grain were alive after 78 days. In a test in our laboratory (unpublished), most individuals in a population of *S. zeamais* survived more than 100 days on clear wheat flour, so the early mortality of the weevils in millet flour was unexplained.

TRIBOLIUM CASTANEUM: Many of the beetles observed in the whole and cracked millet were newly emerged, indicating that the developmental period in millet may be about 70 days in these media and under the conditions of the study. The populations developed slowly and caused little weight loss in the whole and 10% cracked grain, but were able to affect a ten-fold increase in numbers in the cracked grain (Table 1). The population increased rapidly in the millet flour. This is consistent with the data of Sinha (1972), who reported that broken kernels of the millets *Panicum miliaceum* L. and *Setaria italica* L. were more susceptible than whole kernels to infestation by *T. castaneum* and certain other storage insects. Although it is commonly believed that *Tribolium* spp. cannot attack whole kernels, Birch (1947) and Daniels (1956) reported them developing populations on whole wheat. Our "whole millet" had up to 2% broken kernels which could have been influential in the population development of the beetles, but it is obvious that whole kernels of millet are not as susceptible as broken kernels.

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