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Protective Effect of Barley Hulls Against the Rice Weevil[1,2,3]

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ABSTRACT

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Rice weevil, *Sitophilus oryzae* (L.), were unable to reproduce in pellets prepared from ground, covered barley. Also, more rice weevil progeny were produced on hand-dehulled grains in a shorter time than on the covered grains. Pellets, prepared from dehulled grains of 'Larker,' produced about the same number of progeny as did the covered grains. Failure of pellets, prepared from covered grains, to support insect growth is attributed to the presence of ground hull material.

The presence of tight husks is the most obvious of the several factors identified or suggested (Mills 1972, Howe 1973) as affecting resistance of grains to insects. Bhatia (1976) reviewed many of the studies concerning the effect of tight hulls on the resistance of corn, rice, oats, sorghum, and barley to stored grain insects and postulated that such studies had "fully established" the importance of tight husks on corn in imparting field resistance to weevils. Boles and Pomeranz (1977) subsequently identified the importance of barley hulls in imparting resistance to rice weevils.

In the study reported here, we utilized 4 barleys, all well established cultivars, including 3 covered barleys widely grown commercially in the US and 1 experimental naked barley. The tests were conducted to further define the role of hulls and hull tightness in conferring insect resistance to barleys and to help "fully establish" the importance of barley hulls in producing resistance against the rice weevil, *Sitophilus oryzae* (L.).

Materials and Methods

The 3 covered barleys were 'Firlbecks III,' a 2-rowed hulled malting barley, and 'Larker' and 'Conquest,' 6-rowed malting barleys. Larker has a white aleurone and Conquest a blue aleurone. CI 4362, the naked barley, is a 2-rowed white aleurone barley that is not acceptable for malting but is rich in protein. At the time of the test, all 4 cultivars were begin grown as part of a comprehensive study of the effects of nitrogen fertilization on malting properties (Pomeranz et al. 1976) and on amino acid composition and nutritive values (Pomeranz et al. 1977). The plantings were setup as a split plot with varieties as main plots and levels of nitrogen fertilization as subplots. The main plots were arranged in a randomized block design. Each treatment was replicated 3 times. The description of the plot designs are given to emphasize that the grains used were produced from cultivars planted from seed of the same source under a scientifically controlled and planned experiment.

In the tests to recheck resistance of covered grains vs. naked grains, five 100-kernel sample replicates of each of the 3 replications of each fertilizer rate of each barley cultivar were selected for uniformity and absence of damaged or broken kernels. These samples were then weighed and placed in vials screened on the top and bottom and were infested with insects.

In the subsequent tests, pellets were prepared from ground whole and ground hand-dehulled grains of each of the barleys by using a modification of the procedures of Schoonhoven et al. (1974). Grinding of the barleys was done in a Krups type 203 laboratory mill using a 30-sec grinding period. Pellets were prepared by moistening the ground material with distilled water and pressing it into soda straws (7 mm diam). After the dough had hardened slightly, it was pushed out of the straws onto a sheet of aluminum foil and cut into ca. 1-cm-long sections. Dehulled grains, used to make pellets, were obtained by removing the palea and lemma by hand from kernels that were slightly moistened by dipping for 10–15 sec in water.

Testing procedures with both grains and pellets were the same as described by Boles and Pomeranz (1977). After the moisture of the kernels had equilibrated in a room maintained at a constant 26.7°±2°C and 60% RH, the individual samples were infested with 6 and 3 rice weevils (14±7 days old). Parent weevils were allowed to mate and oviposit for 7 days and were then removed. Beginning 25 days later, vials were examined for progeny every day for 35 days. Emerged progeny was removed from the vials on each count day; thus, a daily record of emergency was obtained. After emergence was completed, contents of the vials were weighed so we could determine weight loss.

Results and Discussion

When pellets were prepared from the whole grains of the 4 cultivars, progeny was obtained only from pellets made from the naked barley (Table 1). Also, production of progeny from such pellets was usually similar to production from the naked whole grains, although weight losses of the pellets were slightly greater. Thus, there was greater larval feeding on these pellets than on the whole grains. The production of progeny on the whole grains of the naked barley was much greater than the production on the whole grains of the 3 covered barleys.

To determine whether the incorporation of the ground hulls into the pellets made from the covered barleys was the determining factor in preventing production of larvae, we hand-dehulled grains of Larker barley and made pellets from these grains. The results of rearings in these materials were:

[1] Coleoptera: Curculionidae.

[2] Received for publication, Apr. 28, 1978.

[3] This paper reports the results of research only. Mention of a commercial product does not constitute a recommendation or an endorsement by the USDA.

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Material	No. of progeny (means of creplications, each sample replicated 5 times)
Covered whole grains	11.4
Dehulled grains	30.7
Pellets from whole grains	0.0
Pellets from dehulled grains	16.3

It is clear that grains with hulls removed produced many more progeny than covered grains. However, pellets prepared from dehulled grains produced ca. as many progeny as the covered grains. The failure of the pellets prepared from whole grains to support insect growth thus resulted from the presence of silica-rich ground hull material in the pellets which either made them unpalatable or unavailable to young weevils developing from eggs or made them unsatisfactory as egg-laying sites for the female weevils. To determine whether longer exposure of the pellets to weevils would result in young, we kept some under insect pressure (mixed males and females) for 90 days. No progeny was recovered, but examination of pellets and vials revealed feeding or boring activity by the adult weevils during their exposure on the pellets.

More detailed investigation was made of the effect of removing hulls from grains of the 3 covered barleys (also shown in Table 1). In all cases, the removal increased the production of progeny. However, the 3 covered barleys varied somewhat in the number of progeny produced, although numbers produced on the dehulled barleys were similar. Also, X rays of the exposed grains indicated that egg-laying by weevils was greater in dehulled grains than in covered grains, and only 5 of 300 whole kernels were found with 2 larvae, compared with 35 of 300 dehulled kernels.

Objective determination of the tightness of hull adherence to the grains was difficult but hulls of Firlbecks III grains looked "looser" and were easier to hand strip. This judgement plus the greater numbers of progeny from kernels of Firlbecks III may reflect an effect of hull tightness on insect development. In fact, there was no difference in development times of larvae in grains of the 3 cultivars but development times were consistently longer in covered grains than in dehulled grains, further evidence that the hulls interfered with oviposition or with the developing larvae. These findings are consistent with the results of workers with other grain crops. Breeze (1960) found the rice weevil unable to feed and reproduce in mature rough rice with intact husks, and Rogers and Mills (1974) found that sorghum with glumes that completely enclosed the seed were nearly immune.

Fig. 1 shows emergence patterns for progeny from each variety, progeny production of the covered grains, and the "leveling effect" of dehulling on progeny production.

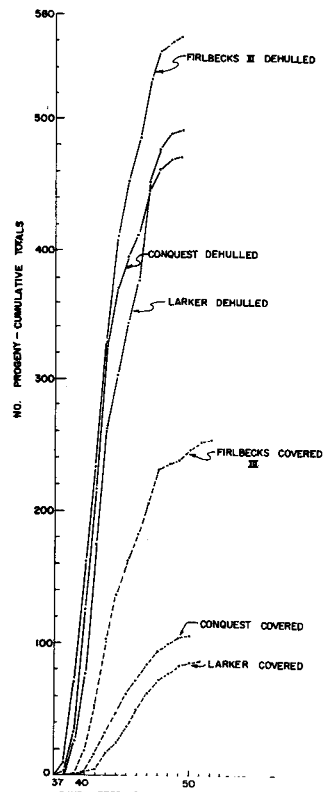

FIG. 1.—Total cumulative emergence from all replications of hand-dehulled and covered barleys. Each cumulative emergence line represents totals of 27 replications, each sample replicated 3 times.

Table 1.—Number of rice weevil progeny from whole grains, dehulled grains, and pellets prepared from 4 barley cultivars. Figures for each cultivar are means of 9 replications, with each replication in turn, sample replicated 5 times.

	Progeny, avg weight loss/insect produced, and avg development time from								
	Whole grains			Dehulled grains			Pellets		
Variety	Progeny	Avg wt loss/ insect produced	Avg develop. time	Progeny	Avg wt loss/ insect produced	Avg develop. time	Progeny	Avg wt loss/ insect produced	Avg develop. time
CI4362 (Naked)	38.1	9.3	41.6	—	—	—	39.7	12.1	40.0
Larker (Covered)	10.2	15.9	45.8	46.3	12.0	43.2	0.0	0.0	—
Conquest (Covered)	12.0	15.0	45.2	53.0	11.8	38.6	0.0	0.0	—
Firlbecks (Covered)	28.9	13.6	44.3	62.6	12.3	42.6	0.0	0.0	—

These studies confirm the findings of previous investigations concerning the protection from insect attack provided by the hulls on covered barleys. Therefore, it is important to handle covered grains throughout their storage life in a manner that will preserve hull integrity. The inability of rice weevils to reproduce in pellets prepared from ground barley grains suggests that some component (presumably silica) in the hulls has adverse effects either on developing rice weevil larvae or on the ability of the rice weevil females to cut into the pellets to effect egg-laying. In the latter case, the egg-laying female may avoid cutting through the hulls and seek open or weak spaces between the hull components.

The fact that barleys with tightly adhering hulls are preferred for malting would tend to insure that such barleys would benefit most from the protective effect of the hulls.

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