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Development of *Sitophilus zeamais* Motsch. in WURLD wheat

ROBERT B. MILLS

Department of Entomology, Kansas State University, Manhattan, Kansas, U.S.A.

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Abstract—WURLD wheat, a parboiled, lye-peeled product, was tested, along with untreated white wheat and pearled white wheat, and a hard red winter wheat bulgur, for susceptibility to the maize weevil, *Sitophilus zeamais* Motsch. The order of suitability of the wheats for multiplication of the weevils was pearled, untreated, bulgur and WURLD.

GELATINIZED wheat of a kind known as bulgur, has been used as food in the Middle East for several hundred years (HALEY and PENCE, 1960) and relatively recently, large quantities of it have been produced in the U.S.A. primarily for government shipment overseas. It is produced variously by soaking, cooking, drying, debranning and usually cracking. It retains nearly all the nutrients of whole wheat (SHEPHERD *et al.*, 1965) and is easier and quicker to prepare for eating and is reported to be much more susceptible to attack by insects and micro-organisms (RASMUSSEN 1962; PENCE 1963). ROBINSON and MILLS (1971) demonstrated that although the maize weevil *Sitophilus zeamais* Motsch. and the lesser grain borer, *Rhyzopertha dominica* (F.) developed successfully in bulgur, especially at high relative humidities (71 per cent), the time required to develop was consistently longer than in untreated wheat.

Another form of gelatinized wheat is WURLD wheat from the Western Utilization Research and Development Division, ARS, USDA, Albany, California, U.S.A. (MORGAN *et al.*, 1964). This is whiter than bulgur and has virtually all the bran removed (Fig. 1). One process of preparation includes parboiling, lye-peeling, dilute acid neutralization and drying. WURLD wheat has less of some nutrients than bulgur but is an excellent food superior to patent flour (SHEPHERD *et al.*, 1965).

BOLES and ERNST (1969) found that WURLD wheats were not very attractive to rice weevils, *Sitophilus oryzae* (L.), that developmental periods of this species were longer on them than in unprocessed wheat and that the red flour beetle, *Tribolium castaneum* (Herbst), could not develop in them.

I compared susceptibilities to maize weevil attack of bulgur, 3 WURLD wheats, 2 pearled wheats, and an unprocessed white wheat.

MATERIALS AND METHODS

The samples exposed were supplied by the Western Utilization Research Laboratory, ARS, USDA, Albany, California, except for a hard red winter wheat bulgur

obtained from FARMARCO, Hutchinson, Kansas. The maize weevils were from cultures maintained on wheat in the Department of Entomology since original acquisition from Arkansas in 1955. Test boxes were plastic, 4·4 × 4·4 × 1·9 cm, with each lid having a 3·8 cm hole covered with 60-mesh brass screen (Fig. 1). Eight grams of each material were placed mostly as entire kernels in each of six boxes:

Hard red winter wheat bulgur
Untreated white wheat (Gaines)
WURLD wheat, scarified before processing, then acetic acid neturalized
WURLD wheat, acetic acid neutralized
WURLD wheat, benzoic acid neutralized
Pearled white wheat, light abrasion (86–90 per cent yield)
Pearled white wheat, heavy abrasion (70–75 per cent yield)

The test boxes were placed in a rearing room with 80 ± 1°F and 68 ± 2 per cent r.h. for an 18-day, moisture-equilibration period, then 6 male and 10 female maize weevils were placed in each test box for a 7-day oviposition period, then removed. Standard air-oven, moisture determinations were done the day samples were infested.

Beginning 25 days after start of the oviposition period, each box was checked daily for weevils emerged from kernels. The number of progeny removed was recorded for each replicate. Developmental periods were calculated from the 3rd day of the oviposition period to emergence of adult progeny from the kernels.

RESULTS AND DISCUSSION

An analysis of variance showed a highly significant difference ($P < 0·01$) among the treatments for both variables. The LSD (0·05 level) was used to group the means (Table 1). The correlation coefficient between the progeny numbers and developmental periods was −0·84 (significant, $P < 0·01$).

The uncooked white and pearled wheats produced more weevil progeny than the heat-processed bulgur and WURLD wheats, although 'scarified' WURLD wheat produced nearly as many as the unprocessed white wheat. ROBINSON and MILLS (1971) found differences in numbers of maize weevil progeny from hard red winter wheat and bulgur made from it, at 58 per cent r.h. but not at 71 per cent r.h.

Average developmental periods were longer in the heat-processed (37·9–41·5 days) than in the other wheats (33·5–34·5 days)—differences similar to those found by ROBINSON and MILLS (1971) for these weevils in hard red winter wheat and bulgur.

Factors that cause heat-processed wheats to be less suitable for the weevils are not known. The WURLD wheats and the bulgur equilibrated at lower moisture contents than unprocessed wheats did, as previously demonstrated with bulgur (FERREL *et al.*, 1966; ROBINSON and MILLS, 1971). PIXTON (1968) demonstrated that heat treatment alone caused a decrease in equilibrium moisture content of Manitoba wheat (0·3 per cent at 70 per cent r.h. and 0·9 per cent at 50 per cent r.h.); the decreases in the bulgur and WURLD wheats were greater (at 68 per cent r.h.), but the processing was much different from Pixton's.

There were variations in physical characteristics of the different types of kernels.

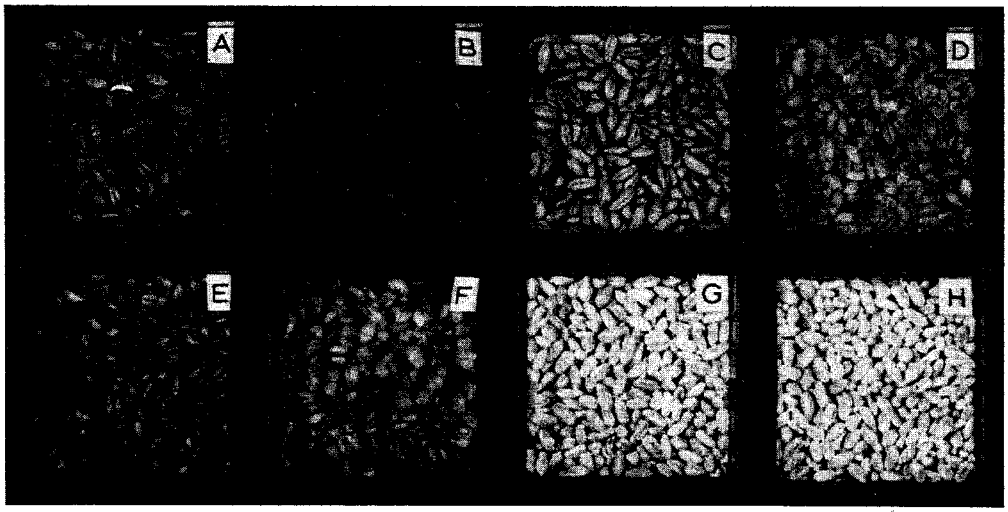

FIG. 1. A. Untreated hard red winter wheat (not tested in this experiment).
B. Bulgur processed from hard red winter wheat.
C. Untreated white wheat (Gaines).
D. WURLD wheat, scarified before processing, then acetic acid neutralized.
E. WURLD wheat, acetic acid neutralized.
F. WURLD wheat, benzoic acid neutralized.
G. Pearled wheat, light abrasion (86–90 per cent yield).
H. Pearled wheat, heavy abrasion (70–75 per cent yield).

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TABLE 1. NUMBER OF PROGENY AND DEVELOPMENTAL PERIODS OF MAIZE WEEVILS REARED IN WHEAT PRODUCTS. SIX MALES AND 10 FEMALES WERE PLACED FOR 7 DAYS OVIPOSITION IN 8 g OF EACH MEDIUM; 6 REPLICATES

Medium	Moisture content	Developmental period all progeny (days)* Range	Average	Number progeny per replicate Range	Average
WURLD wheat, benzoic acid neutralized	12·24	32–63	41·5	81–158	113·7[a]
WURLD wheat, acetic acid neutralized	12·11	31–67	39·5[a]	109–151	129·2[a]
WURLD wheat, scarified prior to processing, and acetic acid neutralized	12·24	30–56	38·8[a]	147–177	156·5[bc]
Hard red wheat bulgur	12·79	30–57	37·9	89–160	135 [ab]
Untreated white wheat	13·47	27–61	34·4[b]	124–179	159·5[c]
Pearled white wheat, heavy abrasion (otherwise unprocessed)	13–54	27–52	33·7[c]	202–230	213·7[d]
Pearled white wheat, light abrasion (otherwise unprocessed)	13·53	26–51	33·5[c]	151–207	194·7[d]
	LSD (0·05 level)		0·81		24·06

* From 3rd day of oviposition until adults emerged from kernels.
a–d . . Means followed by same letter are not significantly different.

Fifty per cent or more of the pericarp was removed from the kernels of pearled wheats and bulgur, and nearly all from the WURLD wheats. The kernels of WURLD wheat tended to be open at the crease, especially the benzoic acid-neutralized. The sizes of the kernels were reflected in the numbers per 8 g sample; approx 240 and 260 in bulgur and untreated white wheat; 297 and 335 in pearled wheat with light and heavy abrasion; and 242, 270 and 340 in the benzoic acid, acetic acid, and scarified-acetic acid-neutralized WURLD wheats, respectively; the larger number and smaller size of kernels perhaps resulted in the latter producing nearly as many progeny as the untreated wheat. Also, the numbers of cracked kernels were greater in the heat-processed wheats and greatest in the bulgur.

How lower moisture content and/or physical and chemical changes due to processing are responsible for the differences in these test results need to be investigated.

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