Susceptibility of Twelve Genotypes of Triticale to the Rice Weevil (Coleoptera: Curculionidae) and the Lesser Grain Borer (Coleoptera: Bostrichidae)[1, 2]

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ABSTRACT Population development by the rice weevil, *Sitophilus oryzae* (L.) and feeding damage caused by the lesser grain borer, *Rhyzopertha dominica* (F.), were assessed on twelve triticale (*X Triticosecale* Wittmack) genotypes maintained at 25°C and at 11.7 or 14.2% moisture content. Among genotypes at 14.2% moisture content, total progeny production by the rice weevil ranged from 7.1 (GA82014) to 8.8 (87AB13541) weevils per female-day; mean time to adult emergence ranged from 35.5 (GA82014) to 36.9 days (87AB13541 and CT4699); and rate of emergence (a measure of the slope of the cumulative emergence curve at the average emergence day) ranged from 0.59 (87AB13541) to 0.72 ('Morrison'). Although there were some statistical differences among these population growth parameters on different triticale genotypes, all genotypes were at least as susceptible as the long grain brown rice (*Oryza sativa* L.) and soft red winter wheat (*Triticum aestivum* L., cultivar 'Florida 302') controls tested concurrently. Development time of rice weevils was significantly delayed and total progeny production after 65 days was reduced about 17-fold on triticale genotypes at 11.7% moisture content.

About 3-fold more frass was produced by lesser grain borers feeding for 7 days at 25°C on triticale genotypes at 14.2% moisture content compared to that obtained on genotypes at 11.7% moisture content. Significantly more feeding and frass production by lesser grain borers occurred on triticale and wheat than occurred on rice.

KEY WORDS Triticale, cultivars, genotypes, *Sitophilus oryzae,* rice weevil, *Rhyzopertha dominica,* lesser grain borer, population growth, insect damage.

Plant breeders have continued to produce triticale cultivars with improved nutritional quality, fertility, grain quality, yield, and field performance (National Research Council 1989). A number of cultivars of this cereal crop, a cross between wheat (*Triticum*) and rye (*Secale cereale* L.), have been developed through research conducted at CIMMYT (International Maize and Wheat Improvement Center) in Mexico. Since nutritional characteristics of some triticale cultivars and wheat cultivars are similar, as assessed by bioassay with *Tribolium castaneum* (Herbst) (White and Loschiavo 1988), it is not surprising that a number of stored product insects, including *T. castaneum, Cryptolestes ferrugineus* (Stevens), *Lathridius minutus* (L.), *Ahasverus advena* (Waltl), *Rhyzopertha dominica* (F.), and *Sitophilus*

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oryzae (L.) have been found in triticale storages (Dolinski et al. 1971, Greening 1983). Because of the high protein content and relatively soft floury endosperm of some of the first cultivars produced, triticales were particularly susceptible to attack by primary insect pests of stored grain such as *Sitophilus* weevils (Dobie and Kilminster 1978).

Seven triticale cultivars, 'Beagle 82,' 'Council,' 'Florico,' 'Florida 201,' 'Morrison,' 'Sunland,' and 'Thomas' have been released in the southeastern U.S. and the acreage planted to this crop will likely increase (Barnett et al. 1990). Because of the likelihood of an increase in the amount of stored triticale and the potential susceptibility of triticale to insect damage, five U.S. cultivars, two Georgia experimental lines, and five lines developed by CIMMYT for climates similar to that found in the Southeast were assessed for resistance to the rice weevil, *S. oryzae,* a major cosmopolitan grain pest and the lesser grain borer, *R. dominica,* the major primary grain pest in some states (Cuperus et al. 1986).

Materials and Methods

Triticale genotypes. Five triticale cultivars, Beagle 82, Florico, Florida 201, Morrison, and Sunland; two Georgia experimental lines, GA82014 and 87AB13541; and five CIMMYT advanced lines from the 19th International Triticale Yield Nursery, B6712, B7011, CIT1367, CT4161, and CT4699 were evaluated. Tests with soft red winter wheat ('Florida 302') and long grain brown rice (unknown cultivar) were run concurrently. Seed size was determined by weighing 5 replicate groups of 50 kernels of each genotype. Mean seed weight (mg) was determined and expressed as dry weight based on the moisture content of each genotype.

Insect cultures. Rice weevils and lesser grain borers were obtained from laboratory cultures maintained on whole soft red winter wheat at 27°C and 50-60% RH with a 16 h photophase.

Moisture content. Moisture content was adjusted and controlled by equilibrating seed of each genotype in constant relative humidities over saturated salt solutions. For these tests, samples (250 g) of each genotype were placed in one-half pint (0.236 L) jars and held in plastic containers over saturated solutions of K_2CO_3 or NaCl which give relative humidities of about 43 and 75%, respectively (Greenspan 1977). After an eight week equilibration at 25°C the moisture content of the samples was determined with a Burrows DMC Model 700 moisture meter and 25 g replicates were prepared for bioassay.

Bioassay with the rice weevil. Three development parameters, total progeny production, average number of days to adult emergence, and rate of emergence (in the sense of slope of the cumulative emergence curve at the average emergence day) were determined at 25°C for rice weevils reared on the triticale genotypes and on control treatments of long grain brown rice and soft red winter wheat (Florida 302). Details of the bioassay procedure are in Baker et al. (1991). Five females were allowed to oviposit for 3 days at 25°C in 25 g samples of each genotype held in 16 dram (3.2 × 8 cm) snap-cap prescription vials that had screened lids. Five replicate 25 g samples of each genotype equilibrated to each of two different moisture contents were tested. Beginning 30 days after the middle day (day 0) of the three day oviposition period, emerged weevils were counted daily and removed.

Feeding damage by lesser grain borer. Susceptibility of triticale genotypes to feeding and boring damage by the lesser grain borer was measured by weighing frass material produced after adults were allowed to feed on samples of each genotype for 7 days. For these tests, two-week-old adult lesser grain borers were sifted from laboratory cultures and placed on fresh wheat for 24 hours. Samples of each triticale genotype (and the rice and wheat controls) equilibrated over NaCl or K_2CO_3 were screened through a U.S. standard No. 20 sieve to remove fine material, arranged into 5 replicates of 10 g each, and placed in 3.2 × 8 cm vials with screened lids. Fifteen borers were aspirated directly into each vial. After 7 days, each vial was rescreened on the No. 20 sieve and the frass recovered and weighed.

Statistical analyses. Mean values, mean separations, analyses of variance and correlations of kernel weights, growth parameters of the rice weevil, and weights of frass produced by the lesser grain borer were determined with SAS Procedures ANOVA, GLM, and Corr (SAS Institute 1987, 1988). Mean comparisons were carried out with the Waller-Duncan Bayesian MSD (minimum significant difference) test in SAS (Waller and Duncan 1969).

Results and Discussion

Mean initial moisture content of the triticale genotypes was 12.7 ± 0.5% (mean ± SD). After an 8 wk equilibration, mean moisture contents were 14.2 ± 0.6% for genotypes held over saturated NaCl (average gain of 1.5%) and 11.7 ± 0.4% for genotypes held over K_2CO_3 (average loss of 1%). Rice equilibrated to 11.1% moisture content over saturated K_2CO_3.

Emergence curves and growth parameters of rice weevils reared on triticale genotypes at 14.2% moisture content are compared with those obtained on wheat and rice in Figure 1 and Table 1. Total progeny produced by 5 female rice weevils ovipositing 3 days ranged from 132.4 on 87AB13541 to 106.8 on GA82014. These oviposition rates correspond to 8.8 and 7.1 weevils per female-day, respectively, and are similar to values obtained for rice weevils reared on 30 culitvars of soft wheat (Baker et al. 1991) as well as the density-dependent optimum oviposition rate of about 7 weevils per female-day described for rice weevils by Longstaff (1981). Generally, progeny production was about 10% greater on triticale genotypes than that obtained on brown rice or soft red winter wheat. The minimum significant difference among means ($P < 0.05$) was 19.9 progeny. Although there were some significant differences among genotypes, there was little practical difference in susceptibility to progeny productions by the rice weevil.

There were significant differences in kernel size among the triticale genotypes and between the triticale genotypes and rice and wheat (Table 1). Since replicates were set up by weight and not by number of kernels, genotypes with smaller kernels have more kernels or potential oviposition sites within each sample. However, across all genotypes there was very low correlation ($r = 0.120$, $P = 0.681$) between kernel weight and total numbers of progeny produced.

Among triticale genotypes the average number of days to adult emergence ranged from 35.5 for GA82014 to 36.9 for 87AB13541 and CT4699 (Table 1). Minimum significant difference among means ($P < 0.05$) was 0.5 day. Development on rice was significantly faster than that obtained on wheat and all triticale genotypes except Florida 201, Morrison, and GA82014.

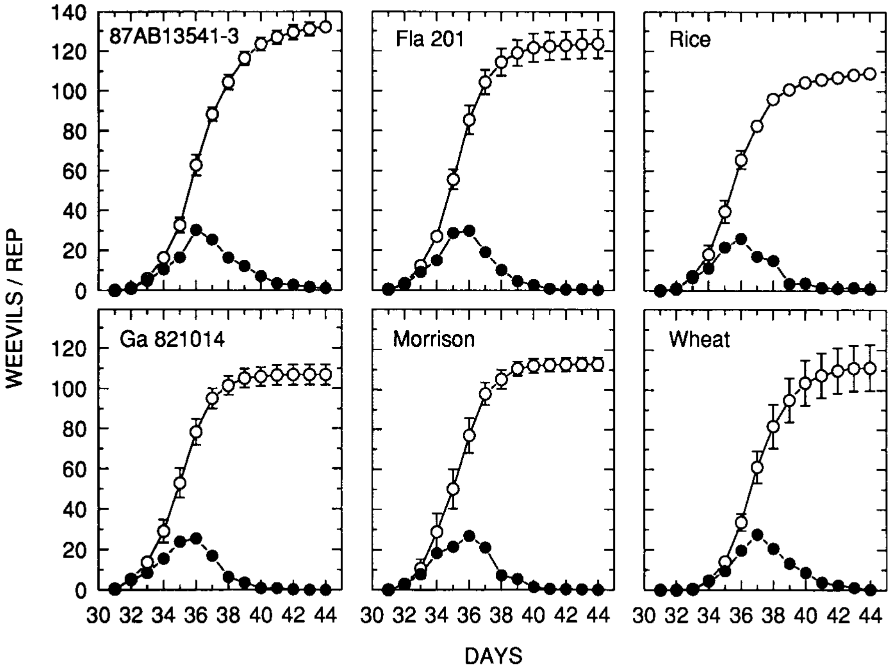

Fig. 1. Cumulative emergence (open circles) and daily emergence (solid circles) per replicate for rice weevils developing on four triticale genotypes (87AB13541, Florida 201, GA821014, and Morrison), long grain brown rice, and soft red winter wheat at 25°C and 75% RH (14.2% moisture content). Each replicate consisted of 5 females ovipositing on 25 g samples for 3 days. Points with SE bars represent mean number of progeny emerging daily from 5 reps/genotype.

The rate parameter is a measure of the slope of the cumulative emergence curve at the average emergence day (Baker 1988). Among triticale cultivars the rate parameter ranged from 0.59 on 87AB13541 to 0.72 on Morrison. Minimum significant difference was 0.05.

Progeny production by rice weevils was dramatically reduced and mean development time was lengthened when the triticales and both rice and wheat were at 11.7% moisture content. No weevils had emerged by 45 days in any of the genotypes and across all genotypes a mean of only 6.8 ± 1.2 (SE) progeny per replicate was obtained after 65 days when the experiment was terminated.

Lesser grain borers are active feeders and produce about 4-fold more frass or grain dust compared with *Sitophilus* weevils when feeding on wheat (Campbell and Sinha 1976). In our tests there was no difference in production of frass material after 7 days among the triticale genotypes and the wheat control at 14.2% moisture content (Table 2). However, frass production on rice was reduced by about 50% compared to that on the triticale genotypes and wheat. About 3-fold more frass

Table 1. Development parameters of the rice weevil, *S. oryzae,* reared at 25°C and 75% RH on twelve genotypes of triticale at 14.2% moisture content and comparison with development obtained on long grain brown rice and soft winter wheat.

		Development parameters		
Genotype	Kernel wt (mg)	Total*	Average day†	Rate‡
87AB13541	33.9 ± 1.3 d	132.4 ± 3.2 a	36.9 ± 0.1 a	0.59 ± 0.02 e
B6712	27.1 ± 1.0 f	126.6 ± 4.1 ab	36.5 ± 0.2 abcd	0.66 ± 0.02 bc
B7011	31.0 ± 2.2 e	114.0 ± 6.8 ab	36.4 ± 0.3 bcd	0.67 ± 0.03 abc
Beagle 82	35.6 ± 1.1 c	125.0 ± 5.5 ab	36.2 ± 0.1 cde	0.65 ± 0.01 bcd
CIT1367	30.8 ± 0.8 e	122.4 ± 3.3 ab	36.2 ± 0.1 de	0.66 ± 0.02 bc
CT4161	31.9 ± 0.6 e	126.6 ± 5.0 ab	36.6 ± 0.1 abcd	0.66 ± 0.01 bc
CT4699	31.8 ± 2.0 e	118.0 ± 5.1 ab	36.9 ± 0.2 ab	0.65 ± 0.01 bc
Florida 201	35.6 ± 1.1 c	123.6 ± 7.5 ab	35.8 ± 0.1 ef	0.66 ± 0.02 bc
Florico	35.1 ± 1.6 cd	124.6 ± 2.1 ab	36.2 ± 0.2 cde	0.62 ± 0.01 bc
GA82014	40.1 ± 0.7 a	106.8 ± 5.0 b	35.5 ± 0.2 f	0.69 ± 0.02 ab
Morrison	32.2 ± 0.8 e	112.8 ± 3.4 ab	35.8 ± 0.3 ef	0.72 ± 0.02 a
Sunland	38.4 ± 0.6 b	109.8 ± 5.2 b	36.7 ± 0.3 ab	0.62 ± 0.01 cde
Rice	18.3 ± 0.1 g	109.8 ± 2.4 b	35.4 ± 0.2 f	0.59 ± 0.03 de
Wheat§	25.7 ± 0.3 f	111.8 ± 11.5 b	36.5 ± 0.2 abcd	0.64 ± 0.02 cd

Column means (± SE) followed by the same letter are not significantly different ($P > 0.05$).

* Total progeny produced/replicate ($F = 2.09$, $P > F$ 0.0296, MSD - 19.9).

† Average number of days to adult emergence ($F = 6.11$, $P > F0.001$, MSD = 0.5).

‡ Rate = $^{1}/\text{variance}^{0.33333}$ ($F = 3.78$, $P > F$ 0.0002, MSD = 0.05).

§ Florida 302.

Table 2. Effect of moisture content on production of frass material by adult lesser grain borers, *R. dominica,* feeding for 7 days at 25°C on eleven genotypes of triticale and comparison with feeding on long grain brown rice and soft red winter wheat.

	Frass weight after 7 days (mg)	
Genotype	11.7% moisture	14.2% moisture
87AB13541	8.6 ± 1.2 ab	23.3 ± 1.9 a
B6712	6.3 ± 0.4 abc	19.2 ± 2.0 a
B7011	6.2 ± 0.7 bc	19.1 ± 2.8 a
Beagle 82	6.6 ± 1.3 abc	17.6 ± 2.9 a
CIT1367	6.2 ± 1.1 abc	18.9 ± 1.8 a
CIT4161	5.9 ± 0.7 bc	17.6 ± 1.3 a
CT4699	6.5 ± 0.7 abc	16.7 ± 2.3 a
Florida 201	7.3 ± 0.8 abc	22.9 ± 2.6 a
Florico	6.7 ± 1.4 abc	22.3 ± 2.4 a
GA82014	6.6 ± 0.6 abc	22.4 ± 1.6 a
Morrison	9.3 ± 0.6 a	23.3 ± 0.8 a
Rice*	4.7 ± 0.4 c	9.1 ± 0.3 b
Wheat†	5.4 ± 1.1 c	20.1 ± 1.9 a

Column means followed by the same letter are not significantly different ($P > 0.05$).

* Rice equilibrated to 11.1% moisture content over saturated K_2CO_3.

† Florida 302.

production occurred on genotypes at 14.2% moisture content than occurred with genotypes at 11.7% moisture content.

These overall results support previous studies (Dobie and Kilminster 1978) and indicate that triticale remains very susceptible to attack by primary grain pests. In our tests there was little practical difference in susceptibility of the twelve tested triticale genotypes to weevil population development. Also, during initial feeding responses, lesser grain borers showed little preference for one triticale genotype over another. However, as with most stored grain, reduction in triticale moisture content during storage can significantly reduce population development by these major insect pests.

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