THE EFFECT OF SUBLETHAL DOSAGES OF PYRETHRINS ON THE MATING EFFICIENCY OF THE RICE WEEVIL, SITOPHILUS ORYZAE (L.) (Coleoptera: Curculionidae)[1]

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ABSTRACT

Rice weevils were treated by exposure to filter paper impregnated with pyrethrins in combination with piperonyl butoxide. Individual male and females from these exposures were mated to determine the effects of pyrethrin exposure on the number of progeny produced from such matings.

The effect of the treatment, as measured by progeny production, was affected by the dosage of the insecticide received, the recovery and postexposure times of the treated weevils, the numbers of insects present, and the sexual condition of the insects both before and after treatment.

Pyrethrins, in combination with piperonyl butoxide, continues to be one of only two approved materials for use as protective treatments to grains used for animal feed or for human consumption. This paper reports results of a study to determine the effects of treatment with

[1] Mention of a pesticide in this paper does not constitute a recommendation of this product by the U.S. Department of Agriculture.

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this material on the mating efficiency of individual male and female rice weevils (*Sitophilus oryzae* (L.)). Boles (1971) has previously reported on the effects of sublethal dosages of pyrethrin-piperonyl butoxide combinations on the ovipositional responses of rice weevils in tests involving both sexes.

MATERIALS AND METHODS

TEST INSECTS.—The standard strain of rice weevil used in the study reported here had been reared for many generations under laboratory conditions and had no history of insecticidal exposure. Rearing was done in a room maintained at a constant temperature of 26.7 ± 2°C. and 60% RH. Hard red winter wheat of the Scout variety was used as the rearing medium. The moisture content of the wheat was 13%.

Virgin males and females were obtained by placing individual grains, from cultures containing developed but not emerged adults, into individual gelatin capsules. These capsules were held on boards and the adults removed and sexed as soon as they emerged. Sexing was accomplished by observing the characters described by Richards (1947).

TREATMENT EXPOSURES.—The treatment was done by using the methods described by Boles (1971). Exposure cages, which allowed the insects to be in constant contact with the treated surface, were made from half-pint cylindrical ice-cream cartons. The bottom of each carton was removed and the sides lined with treated filter paper. The lined carton ring was then slipped down into the carton top, which contained a treated 9-cm filter disk. The bottom of a petri dish containing another treated 9-cm filter disk was used to cover the container.

Treatment of the filter papers was done by preparing acetone solutions of treatment materials so that 1 ml applied to a 9-cm filter disk would deliver a treatment rate of 10 mg per square foot of pyrethrins in combination with piperonyl butoxide at 100 mg per square foot.

The insects were exposed to the treated filter paper with synergized pyrethrins immediately after their emergence. Males and females were exposed in separate lots. In progeny production tests, all weevils, after mating, were left on the grain during a 14-day oviposition period. The control insects were handled in the same manner.

RESULTS

SUSCEPTIBILITY OF MALE AND FEMALE ADULT RICE WEEVILS.—Treatment of male and female rice weevils demonstrated that the female was much less susceptible to pyrethrins poisoning than was the male. The greater resistance of the female also was apparent in the rates of recovery from knockdown.

MATING ON TREATED SURFACES OR FOLLOWING EXPOSURE TO TREATED SURFACES.—Virgin pairs placed on surfaces treated with pyrethrins plus piperonyl butoxide often mated during the first few minutes of exposure

TABLE 1. Number of progeny from treated rice weevils that had been confined to wheat kernels for a 14-day oviposition period. Weevils were selected as virgins prior to a 4-hour treatment which produced no knockdown effect. Each total is for 30 matings.

Mating Treated (T) Untreated (UT)	Total progeny	Mean[1]	Avg. days from oviposition start till emergence	Treated÷ Untreated
	(No.)	(No.)	(No.)	(%)
1. T-female × UT-male	170[2]	5.7[a]	36.7	12
2. T-female × 2 T-males	433	14.4[a]	37.3	31
3. T-male × T-female	977	32.6[b]	35.8	70
4. UT-female × UT-male	1393	46.4[c]	40.0	

[1] Means followed by the same letter do not differ significantly at the 5% level (Duncan 1955).
[2] Progeny produced by only 10 of 30 pairs.

but rarely mated more than once during a 4-hour observation period immediately following these first few minutes. Couplings that occurred were usually much shorter in duration than those seen with the untreated controls. Untreated (UT) pairs usually mated (at least coupled) several times during the 4-hour period. Some of these matings lasted for a considerable length of time.

Matings of males and females, first treated in exposure cages before pairing, produced results similar to those mated on treated surfaces. Couplings that occurred were usually much shorter in duration than those occurring among the untreated controls. Only rarely did more than one mating of a treated male (T) and female occur during the 4-hour observation period.

MATINGS OF VIRGIN RICE WEEVILS (MALES AND FEMALES) EXPOSED 4 HOURS TO TREATED SURFACES IN THE CARTON EXPOSURE CAGE BEFORE MATING.—Progeny resulting from pairings of males and females (treated as virgins) on wheat for a 14-day period suggested that the effect of a 4-hour exposure on treated surfaces before mating was to reduce, in some cases, the effectiveness of the matings that occurred in the wheat. Thirty matings of males and females given a 4-hour treatment without knockdown before mating produced an average of 32.6 progeny after a 14-day oviposition period on wheat, compared with an average of 46.4 progeny for 30 matings of untreated males and females (Table 1 matings 3 and 4). The progeny of the treated insects started to emerge before the progeny of the untreated controls in almost all matings, indicating a quicker start on the egg laying by the treated insects. The emergence of progeny from the eggs laid by the treated insects also was completed before emergence of the progeny of the untreated controls.

TABLE 2. Number of progeny from treated rice weevils that had been confined to wheat kernels for a 14-day oviposition period. Weevils were selected as virgins prior to a 16-hour treatment. Each total is for 10 matings.

	Mating treated (T) untreated (UT)	Knock-down effect	Post exposure for recovery	Total progeny mean[1]	Avg. days from oviposition start till emergence	Treated ÷ Untreated
			(Hrs.)	(No.)	(No.)	(%)
1.	T-male × T-female	Positive	96	12.3[a]	38.5	25.0
2.	2 T-females × T-male	Negative	0	17.7[b]	43.0	35.9
3.	T-female × 2 T-males	Positive	8	26.5[bc]	41.3	53.8
4.	T-female × 2 T-males	Negative	0	30.4[bcd]	41.2	61.7
5.	T-female × UT-male	Positive	24	38.5[cde]	45.8	78.2
6.	T-male × T-female	Positive	30	40.2[cde]	43.8	81.7
7.	T-male × T-female	Negative	0	43.1[de]	42.2	87.6
8.	T-male × T-female	Positive	24	49.2[ef]	44.6	100.0
9.	UT-male × UT-female (Controls)	Negative	None	49.2[ef]	43.3	—
10.	T-male × T-female	Positive	8	63.0[f]	38.0	128.0

[1] Means followed by the same letter do not differ significantly at the 5% level (Duncan 1955).

When each of 30 virgin females that had been exposed for 4 hours to a surface treated with synergized pyrethrins was mated to an untreated male immediately after the female was removed from the treated surface, progeny resulted from only 10 of the 30 pairs. The average number of progeny from these 10 pairs was 17 (mating 1). When each of 30 virgin females that had been exposed for 4 hours to a surface treated with synergized pyrethrins was mated to two males similarly treated immediately after the males and females were removed from the treated surfaces, 28 of the 30 mated females produced progeny. The average number of progeny per female from these matings was 14.4 (mating 2). The two latter production levels were different from the production levels of the untreated checks at the 0.05 level of significance.

MATINGS OF VIRGIN RICE WEEVILS (MALES AND FEMALES) EXPOSED 16 HOURS TO TREATED SURFACES IN THE CARTON EXPOSURE CAGE BEFORE MATING.—Increasing the exposure time to 16 hours increased production of progeny in some matings over the production obtained after a 4-hour exposure. Insects showing no knockdown effect after 16 hours of treatment produced progeny numbers equal to 87.6% of those produced by the untreated controls (Table 2 mating 7). Insects knocked down and

requiring 8 hours for recovery produced 28% more progeny than the untreated controls (mating 10) and those requiring 24 hours for recovery produced a number equal to that of the untreated control group (mating 8). Insects requiring longer than 30 hours for recovery after treatment produced less progeny. Insects requiring 30 hours for recovery produced 81.7% (mating 6) and those requiring 96 hours produced only 25% of the progeny numbers of the untreated controls (mating 1). These reductions were significantly less than the production of the untreated checks (mating 9).

The addition of another treated male or treated female to the treated pair significantly reduced the production of progeny. When 10 females treated 16 hours were each placed with two similarly treated males, they produced only 61.7% of the progeny levels of the untreated controls (mating 4). Ten matings of males and females treated 16 hours and requiring 8 hours for recovery produced 128% of the progeny of the untreated group (mating 10). When 10 similarly treated females also requiring 8 hours for recovery were placed with two similarly treated males, progeny production was only 53.8% of the progeny level of the controls (mating 3). Ten matings, each of two treated females with one treated male requiring no recovery period produced on 35.9% of the production of progeny of the untreated control (mating 2). Treated females mated with untreated males and requiring 24 hours for recovery produced 78.2% of the progeny production level of the untreated controls (mating 5).

Pairs requiring 24 hours or more for recovery, had the start of progeny emergence slightly delayed over that for weevils requiring other times for recovery.

MATINGS OF TREATED RICE WEEVILS (MALES AND FEMALES) THAT HAD FIRST BEEN ALLOWED TO MATE PRIOR TO TREATMENT (TREATED AS NONVIRGINS).—Females mated before treatment and held alone (Table 3, mating 1) show the importance of the continued presence of a male for good production of progeny in that these females produced only 18.2% of the untreated controls. When such females were remated with treated males (mating 6), production of progeny was increased to 70.6% of that of the untreated controls.

Matings made with pairs requiring a short recovery time (2 hours, mating 2) produced only 37.8% as many progeny as the controls. When pairs requiring 24 hours for recovery were remated after 48 hours of postexposure (mating 4), the production of progeny was lowered to 56.5% of the production of progeny of the untreated and when the postexposure was increased to 72 hours (mating 3), the production of progeny dropped to 39% of the production of progeny of the untreated controls. Increasing the postexposure time to 120 hours (mating 8) raised the production level again to 88.9% of the production of progeny level of the untreated controls.

The use of a long postexposure for females treated for short periods

TABLE 3. Number of progeny from treated rice weevils that had been confined to wheat kernels for a 14-day oviposition period. Weevils were mated prior to treatment and remated after treatment. Each total is for 10 matings.

	Mating Treated (T) Untreated (UT)	Knockdown effect	Treatment exposure	Post exposure for recovery	Post exposure before mating	Total progeny mean[1]	Avg. days from oviposition start till emergence	Treated÷ Untreated
			(Hrs.)	(Hrs.)	(Hrs.)	(Hrs.)	(Hrs.)	(%)
1.	T-female	Positive	16	24	—	7.9[a]	43.8	18.2
2.	T-male × T-female	Positive	16	2	2	16.4[ab]	49.5	37.8
3.	T-male × T-female	Positive	16	24	72	16.9[ab]	44.1	39.0
4.	T-male × T-female	Positive	16	24	48	24.5[bc]	38.5	56.5
5.	T-male × T-female	Positive	16	24	6 Days	28.9[bcd]	37.2	66.7
6.	T-male × T-female	Positive	16	24	24	30.6[cd]	38.9	70.6
7.	T-female × UT-male	Positive	16	24	6 Days	33.5[cd]	35.3	77.3
8.	T-male × T-female	Positive	20	24	120	38.5[de]	39.3	88.9
9.	T-female × UT-male	Positive	20	24	120	39.2[de]	37.4	90.5
10.	T-female × UT-male	Negative	3	0	24	39.4[de]	40.1	90.9
11.	UT-female × UT-male (Controls)	Negative	None	—	—	43.3[e]	37.9	—

[1] Means followed by the same letter do not differ significantly at the 5% level (Duncan 1955).

before being mated with untreated males also had beneficial effects on production of progeny. Females treated for 3 hours produced 90.9% as many progeny as the untreated group after a 24-hour postexposure period before mating (mating 10). This compares to the lower production of progeny by virgin females treated for 4 hours and then mated with untreated males (mating 1) Table 1). Females treated by a 20-hour exposure to insecticide and given a 120-hour postexposure before mating with an untreated male, gave next to the highest production of any of the pairs in these exposures. The progeny production for this group was 90.5% that of the controls (mating 9).

The use of a 6-day postexposure before remating (mating 5) did not increase the production of progeny over that from insects remated immediately after a 24-hour postexposure recovery period (matings 7). Pairs treated 16 hours and requiring 24 hours for recovery and given a 6-day postexposure before mating produced 66.7% of the production of the untreated controls (mating 5). Females similarly treated and mated with untreated males after a 6-day postexposure produced 77.3% of the production level of the untreated controls (mating 7).

SUMMARY AND CONCLUSIONS

These studies indicate that exposure of rice weevils to a surface treated with synergized pyrethrins, can cause a definite response in the level of progeny production, even when the weevils are removed from the treatment and allowed to recover before mating and egg-laying. The treatment, as measured by progeny production, was affected by the dosage of the insecticide received, the recovery and post-exposure times of the treated weevils, the numbers of insects present, and the sexual condition of the insects both before and after treatment. More progeny were produced by weevils after exposure to an insecticide-treated surface for 16 hours without knockdown and with knockdown requiring 30 hours or less for recovery than after exposure for 4 hours without knockdown. However, the need for a 96 hour post exposure recovery period after a 16 hour treatment caused a significant reduction in progeny production. The addition of an additional treated male or female to a treated pair also reduced the number of progeny produced by treated females, indicating that the additional insect interfered with the mating process, possibly through competition.

The use of an untreated male with females given a 4-hour exposure without knockdown significantly reduced progeny production from that observed when two similarly treated insects (male and female) were used. This suggests that in the pairing the treated females with the treated males, the females carried enough pyrethrins odor to repel the untreated males. Females mated prior to a 16-hour treatment and then isolated following treatment, produced significantly less progeny than similarly treated females not isolated from males. This indicates that a male is necessary for continued egg-laying by the female.

It is concluded that evaluation procedures to determine the effectiveness of control programs for insects in stored grains should be extended to include all insects which are found in the immediate area of the grain holding structures. These evaluations should be directed towards determining the producing potential of progeny not subjected to control procedures as well as of progeny which may have survived the control procedures within the grain mass.

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