ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE

January 1, 1994 - December 31, 1994

PROJECT TITLE: Protection of rice from invertebrate pests.

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LEVEL OF 1994 FUNDING: $51,224

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION:

Objective 1: To determine the most effective control of rice invertebrate pests while maintaining environmental quality compatible with the needs of society.

1.1) Rice water weevil - chemical control.

1.1.1) Evaluation of the efficacy of Furadan 5G, Furadan 4F, Fipronil, Karate 1E, Dimilin 25WP, Admire 2F, and one experimental Rohm & Haas compound, at various rates and application timings, in controlling the RWW.

1.1.2) Evaluation of the influence of application method and timing on the efficacy of various compounds for RWW control.

Objective 2: To revise the rice water weevil economic injury level of the most widely used commercial (susceptible) variety, and to determine the economic injury level for the most promising tolerant line; to evaluate the influence of rice seeding method on plant response to rice water weevil.

2.1) Evaluation of the effect of rice variety on rice plant response to rice water weevil infestation.

2.1.1) Study of the influence of rice water weevil on the growth, development, physiology, and yield of M-202, a widely-grown, susceptible variety.

2.1.2) Study of the influence of rice water weevil on the growth, development, physiology, and yield of PI 506230, a tolerant line under development.

2.2) Evaluation of the effect of rice seeding method on rice plant response to a controlled level of rice water weevil infestation.

2.2.1) Study of the influence of rice water weevil on the growth, development, physiology, and yield of water-seeded M-202.

2.2.2) Study of the influence of rice water weevil on the growth, development, physiology, and yield of drill-seeded M-202.

Objective 3: To evaluate the physical and biological factors that result in fluctuation and movement of pest populations that cause economic injury to rice plants.

3.1) Determine the seasonal trends (timing and magnitude) in the flight activity of the rice water weevil at the Rice Experiment Station near Biggs, and in Glenn, Colusa, and Sutter Counties.

3.2) Study of the overwintering characteristics and habitat/location of rice water weevil.

3.3) Survey for parasites of rice water weevil.

SUMMARY OF 1994 RESEARCH BY OBJECTIVE:

Objective 1:

1.1) Chemical Control of Rice Water Weevil

1.1.1 and 1.1.2) The efficacy of 6 chemical insecticide products and a total of 21 treatments was evaluated in a replicated field study. Several of these treatments were with new chemistry and some others had not been evaluated on RWW in California for several years. The following treatments were evaluated:

Treatment	Rate (lb. AI/A)	Timing	Treatment Date
1. Furadan 5G	0.5	Preflood, Incorporated	6 May
2. Furadan 4F	0.5	Preflood, Incorporated	6 May
3. Furadan 4F	1.0	Preflood, Incorporated	6 May
4. Furadan 4F	0.5	Preflood, Not Incorporated	6 May
5. Furadan 4F	1.0	Preflood, Not Incorporated	6 May
6. Karate 1E	0.03	Foliar, 3 leaf stage	23 May
7. Karate 1E	0.03	Foliar, 7 leaf stage	7 June
8. Fipronil	0.0125	Preflood, Incorporated	6 May
9. Fipronil	0.025	Preflood, Incorporated	6 May
10. Fipronil	0.05	Preflood, Incorporated	6 May
11. Fipronil	0.025	Postflood, 5 leaf stage	30 May
12. Dimilin 25WP	0.25	Foliar, 3 leaf stage	23 May

Treatment	Rate (lb. AI/A)	Timing	Treatment Date
13. Dimilin 25WP	0.25	Foliar, 5 leaf stage	30 May
14. Dimilin 25WP	0.25	Foliar, 7 leaf stage	7 June
15. RH-0345	0.5	Preflood, Incorporated	6 May
16. RH-0345	1.0	Preflood, Incorporated	6 May
17. RH-0345	2.0	Preflood, Incorporated	6 May
18. Admire 2F	0.25	Seed soak	6 May
19. Admire 2F	0.5	Seed soak	6 May
20. Admire 2F	0.5	Preflood, Incorporated	6 May
21. Untreated	--	--	--

Testing was conducted with 'M-202' in 8 ft^2 aluminum rings at the Rice Experiment Station. The plots were flooded and seeded on 6 May, 1994. The pre-flood applications were made on 6 May, the 3-leaf stage applications on 23 May, the 5-leaf stage applications on 30 May, and the 7-leaf stage applications on 7 June. The following application methods were used: a hand-held pump-up sprayer at 100 GPA for the liquid treatments, a "salt-shaker" granular applicator for the granular treatments, and for the seed treatments, the appropriate amounts of seed and product were placed into a 20 ml plastic vial, shaken vigorously and soaked for 24 hours before planting. Rice stand was evaluated and adjusted to 96 plants per 8 ft^2 aluminum ring from 16-25 May. The natural rice water weevil infestation was supplemented with 4, 2, 4, and 5 adults placed into each ring on 26 May, 6 June, 10 June, and 17 June, respectively.

The following sample methods and dates were used for this study:

Sample Dates:

Adult Leaf Scar Counts : 26 May, 7 June, 15 June
Larval Counts : 5 July, 17 July
Plant Growth Characteristics : 5 July, 17 July
Rice Yield : 23 September

Sample Methods:

Adult Leaf Scar Counts : percentage of plants with adult feeding scars on either of the two newest leaves (20 plants per ring per date)
Larval Counts : 44 in^3 soil core containing at least one rice plant processed by washing/flotation method (5 cores per ring per date)
Plant Growth Characteristics : plant height, root length, number of leaves, number of tillers, and leaf/root dry weights were recorded from plants which had been sampled for larvae
Rice Yield : entire plots were hand-cut and grain recovered with a "Vogel" mini-thrasher

The RWW infestation was very high in the 1994 test. We had high natural infestations within the rings, which is atypical, as the rings often inhibit adult movement into the rings. In addition, we supplemented the natural infestation by adding additional weevils into the rings in order to ensure a moderate to high infestation level in all rings. The spring establishment period was somewhat cooler then normal, which may have inhibited early-season root growth and may have ultimately reduced the root biomass which sustains RWW feeding.

Adult Leaf Scar Counts

The adult damage is generally insignificant in terms of rice plant growth and development. However, feeding scars are evaluated as a means to see what effect the treatments had on adult density. A reduction in adult density generally corresponds to a decrease in larval density (the primary damaging stage). In 1994, the feeding scar data must be considered within the context of 1.) when the supplemental RWW adults were added to the rings and 2.) when the post-flood treatments were applied. The Furadan 4F (1.0 lb. AI/A) treatment, Karate 1E (especially the 3 leaf stage application), and the Fipronil (postflood) application were the most effective treatments (Table 1).

Table 1. RWW adult leaf feeding scar data, 1994.

Treatment	Rate (lb. AI/A)	Timing	Mean % Plants with Adult Feeding Scars 6/7 & 6/15	Mean # RWW immatures per Soil Core 7/5 & 7/17
Furadan 5G	0.5	Preflood, Incor.	4.4 abc	1.4 bc
Furadan 4F	0.5	Preflood, Incor.	11.9 abcde	2.1 bcd
Furadan 4F	1.0	Preflood, Incor.	3.1 a	0.9 b
Furadan 4F	0.5	Preflood, Not Incor.	20.0 abcdefg	4.1 defg
Furadan 4F	1.0	Preflood, Not Incor.	3.2 ab	1.3 bc
Karate 1E	0.03	Foliar, 3 leaf stage	3.8 a	1.9 bcd
Karate 1E	0.03	Foliar, 7 leaf stage	21.3 abcdef	1.3 bc
Fipronil	0.0125	Preflood, incor.	13.9 abcdef	0.8 b
Fipronil	0.025	Preflood, incor.	9.4 abcd	0.3 a
Fipronil	0.05	Preflood, incor.	10.0 abcde	0.2 a
Fipronil	0.025	Postflood, 5 leaf stage	10.7 abcde	1.3 b
Dimilin 25WP	0.25	Foliar, 3 leaf stage	30.0 cdefg	4.5 efg
Dimilin 25WP	0.25	Foliar, 5 leaf stage	44.4 fg	4.8 efg
Dimilin 25WP	0.25	Foliar, 7 leaf stage	26.3 cdefg	3.5 def
RH-0345	0.5	Preflood, incor.	32.6 cdefg	6.7 fg
RH-0345	1.0	Preflood, incor.	50.0 g	4.6 defg
RH-0345	2.0	Preflood, incor.	45.7 g	4.3 def
Admire 2F	0.25	Seed soak	32.5 cdefg	8.6 g
Admire 2F	0.5	Seed soak	23.8 abcdefg	5.1 efg
Admire 2F	0.5	Preflood, incor.	37.6 defg	2.8 cde
Untreated	--	--	54.4 g	4.0 defg

Means within columns followed by the same letter are not significantly different.

Larval Counts

RWW larval counts were made twice during the season (Table 1). Most individuals were second to third instars and third instar to pupue at the first count and second counts, respectively. The population decreased in the untreated from the first to second evaluation probably because the larvae had damaged the roots to the extent that they ran out of food, i.e., starved. Densities ranged from 0.2 to 9.1 larvae per plant (soil core) on 5 July. The preflood Fipronil, Furadan 5G, and Furadan 4F (1.0 lb. AI/A) treatments were the most effective on this date. Good to moderate activity was also seen in the Karate, Dimilin (3 and 5 leaf applications), Admire (preflood), and Furadan 4F (0.5 lb. AI/A incorporated) treatments. On 17 July, the RWW immature density ranged from 0.2 to 8.1 per core. Results were generally similar to the previous date. The Furadan, Fipronil, and Karate treatments generally performed the best. The larval density in the untreated plots averaged 3.2 per core; levels were higher in some of the chemical treatments. This probably occurred because some control was provided by these treatments which reduced the larval population to the extent that starvation was reduced. This resulted in a greater number of larvae completing development. Starvation probably occurred in the untreated plots because of the high feeding pressure on the rice, ultimately resulting in a population crash.

Plant Growth Characteristics

Plant growth is a good measure of the immediate impact of RWW feeding. Rice plants in the untreated and less effective treatments were (visually) extremely stunted, chlorotic, and weakened. There were few statistically significant differences in plant height and number of tillers among the treatments (Table 2), although there were large numerical differences. Generally, the plants in the untreated and higher rates of RH-0345 were the smallest. It was interesting that plants in the Admire treatments (especially the seed soak) were among the tallest in spite of sustaining high densities of larvae. Comparing the plant weights (leaves and roots) (Table 2), there were no significant differences on 5 July for leaf weight and on 17 July for root weight. Generally, the weights were greatest in the Karate (3 leaf stage), Furadan 5G, Fipronil, Dimilin (3 leaf stage), and Admire (0.5 seed soak) treatments.

Table 2. Effects of RWW damage on rice plant growth, 1994.

Treatment	Rate (lb. AI/A)	Timing	Plant Ht. (cm)[a]	Num. Tillers[a]	Leaf Wt.(g)[a]	Root Wt.(g)[a]
Furadan 5G	0.5	Prefl, Incor.	64.7 ab	6.3 a	5.7 abc	1.5 a
Furadan 4F	0.5	Prefl, Incor.	62.8 ab	5.5 ab	4.7 abcde	1.2 a
Furadan 4F	1.0	Prefl, Incor.	59.2 abc	4.2 ab	3.3 cde	0.9 a
Furadan 4F	0.5	Prefl, Not Inc.	57.3 abcd	4.5 ab	3.8 bcde	1.2 a
Furadan 4F	1.0	Prefl, Not Inc.	60.8 abc	5.0 ab	4.6 abcde	1.5 a
Karate 1E	0.03	Foliar, 3 leaf	68.2 a	6.3 a	7.6 a	1.8 a
Karate 1E	0.03	Foliar, 7 leaf	59.7 abc	4.3 ab	4.1 bcde	0.9 a
Fipronil	0.0125	Prefl, incor.	58.5 abc	5.5 ab	4.7 abcde	1.2 a
Fipronil	0.025	Prefl, incor.	62.4 ab	5.1 ab	4.7 abcde	1.1 a
Fipronil	0.05	Prefl, incor.	65.3 a	5.3 ab	5.3 abcd	1.2 a
Fipronil	0.025	Postfl, 5 leaf	64.8 ab	5.5 ab	5.5 abcd	1.4 a
Dimilin 25WP	0.25	Foliar, 3 leaf	63.6 ab	5.2 ab	5.3 abcd	1.4 a
Dimilin 25WP	0.25	Foliar, 5 leaf	60.8 abc	5.6 ab	4.7 abcde	1.6 a
Dimilin 25WP	0.25	Foliar, 7 leaf	56.9 abcd	4.0 ab	3.9 bcde	1.1 a
RH-0345	0.5	Prefl, incor.	54.8 abcd	3.8 ab	3.7 bcde	1.1 a
RH-0345	1.0	Prefl, incor.	47.0 bcd	3.4 ab	2.3 cde	1.1 a
RH-0345	2.0	Prefl, incor.	42.6 d	2.7 b	2.0 de	0.7 a
Admire 2F	0.25	Seed soak	60.0 abc	4.6 ab	4.7 abcde	1.5 a
Admire 2F	0.5	Seed soak	60.6 abc	5.4 ab	5.9 ab	1.8 a
Admire 2F	0.5	Prefl, incor.	54.2 abcd	3.5 ab	3.4 bcde	0.9 a
Untreated	--	--	43.6 cd	2.6 b	1.6 e	0.7 a

Means within columns followed by the same letter are not significantly different.
[a] all measurements are from plants sampled on 17 July

Rice Yield

Rice grain yield was evaluated on 23 September (Table 3). Grain yield in the ring plots is generally inflated over that obtained by growers, but the relative yields can be compared with validity among the treatments. Numerically, yields were highest in the Furadan 5G, Furadan 4F (0.5 lb. AI/A incor. and 1.0 lb. AI/A not incor.), Karate (3 leaf stage), Fipronil (0.05 lb. AI/A preflood), and Admire (0.5 seed soak) treatments. Overall, there was a 45.5% reduction in yield from the best to worst yielding treatment.

Table 3. Effects of RWW damage on rice grain yield, 1994.

Treatment	Rate (lb. AI/A)	Timing	Grain Yield (g/ring)	Estimated Grain yield (lbs./acre)
Furadan 5G	0.5	Preflood, Incor.	880.9 a	11499
Furadan 4F	0.5	Preflood, Incor.	853.7 a	11019
Furadan 4F	1.0	Preflood, Incor.	816.4 ab	10537
Furadan 4F	0.5	Preflood, Not Incor.	706.2 abcd	9115
Furadan 4F	1.0	Preflood, Not Incor.	850.8 a	10982
Karate 1E	0.03	Foliar, 3 leaf stage	873.8 a	11278
Karate 1E	0.03	Foliar, 7 leaf stage	783.1 abc	10107
Fipronil	0.0125	Preflood, incor.	697.2 abcde	8998
Fipronil	0.025	Preflood, incor.	794.7 abc	10257
Fipronil	0.05	Preflood, incor.	850.2 a	10973
Fipronil	0.025	Postfl., 5 leaf stage	789.1 abc	10185
Dimilin 25WP	0.25	Foliar, 3 leaf stage	719.9 abcd	9292
Dimilin 25WP	0.25	Foliar, 5 leaf stage	724.4 abcd	9350
Dimilin 25WP	0.25	Foliar, 7 leaf stage	717.3 abcd	9258
RH-0345	0.5	Preflood, incor.	621.5 cdef	8022
RH-0345	1.0	Preflood, incor.	509.2 ef	6572
RH-0345	2.0	Preflood, incor.	480.3 f	6199
Admire 2F	0.25	Seed soak	855.5 a	11042
Admire 2F	0.5	Seed soak	616.1 cdef	7951
Admire 2F	0.5	Preflood, incor.	649.4 bcdef	8381
Untreated	--	--	559.9 def	7227

Means within columns followed by the same letter are not significantly different.

2.1) Evaluation of the effect of rice variety on rice plant response to rice water weevil infestation.

2.1.1 and 2.1.2) Several levels of rice water weevil infestation were established in 8 ft^2 aluminum rings at the Rice Experiment Station. The influence of rice water weevil feeding was evaluated on water-seeded M-202 and PI 506230. This is the second year of this study. This report will describe the results from 1994 as well as briefly compare the results from the two years. The basins were flooded on 12 May and seeded on 13 May. Rice stand was evaluated and adjusted to 96 plants per ring from 6 June to 14 June. The following treatments were established in the rings by adding the appropriate number of rice water weevils into each ring on 30 May (44% of the total) and 10 June (56% of the total):

1.) 0 RWW adults
2.) 18 RWW adults per ring
3.) 36 RWW adults per ring
4.) 54 RWW adults per ring
5.) Furadan 5G (0.5 lb. AI/A)
6.) Uncovered control (with Furadan 5G [0.5 lb. AI/A])
7.) 225 RWW eggs per ring

Sample dates are as follows:

Adult scar counts: 7 June, 15 June, and 24 June
Larval counts: 28 June, 11 July, and 25 July
Plant physiology and growth characteristics: 9 June, 28 June, 11 July, 25 July, 8 August, and 23 August
Plant maturity: 5 to 23 August
Rice yield: 22 September

The sampling method consisted of the following:

Adult scar counts: percentage of plants with RWW adult feeding scars on either of the two newest leaves (20 plants per plot).
Larval counts: 50 in^3 soil core samples containing one rice plant processed by a soil washing/flotation method.
Plant growth characteristics: plant height, root length, number of leaves, number of tillers, leaf area, leaf dry weight, and root dry weight from the plants sampled with the larval cores.
Plant physiology: change in CO_2 and water vapor content measured within a closed system (LICOR Model 6200), photosynthetic rate calculated, as well as other plant physiological parameters.
Plant maturity: 20 plants per plot were examined for panicle emergence.
Rice yield: entire plots hand-cut and grain recovered with a "Vogel" mini-thrasher.

Adult Feeding

The percentage of rice plants with RWW feeding scars (Fig. 1) varied according to the prescribed treatments. There were no obvious differences between the two rice varieties. In the uninfested treatment, about 5% of the plants had feeding scars (a few adults got into these rings). Across the three RWW infestation levels, damaged plants ranged from 41 to 68%. Leaf damage was low in the Furadan 5G and RWW egg treatments. These results were very similar to the 1993 results.

Larval Density

RWW larval density (Fig. 2) peaked at slightly higher levels on M-202 than on PI 506230; however, overall, the trends were similar between the two varieties.

Larval densities were low in the uninfested treatments and averaged 8.2 larvae in the 0.2, 0.4, and 0.6 adults per plant treatments. Differences among the three treatments were slight and not consistent. The lack of differences in larval density among these three treatments differs from the 1993 results. In 1993, as the adult infestation density increased, the larval density also increased. In 1994, the mid and high adult infestation levels failed to develop the larval infestation levels we saw in 1993. The reason for this difference is uncertain. The cool environmental conditions in 1994, compared with 1993, may have inhibited early root growth. The reduced root growth may have resulted in significant larval mortality, i.e., in the higher infestation treatments the larvae may have run out of root tissue. The RWW egg treatment, designed for ca. 2.3 eggs per plant, averaged 2.2 larvae per plant. Larval densities in the Furadan 5G treatment were low.

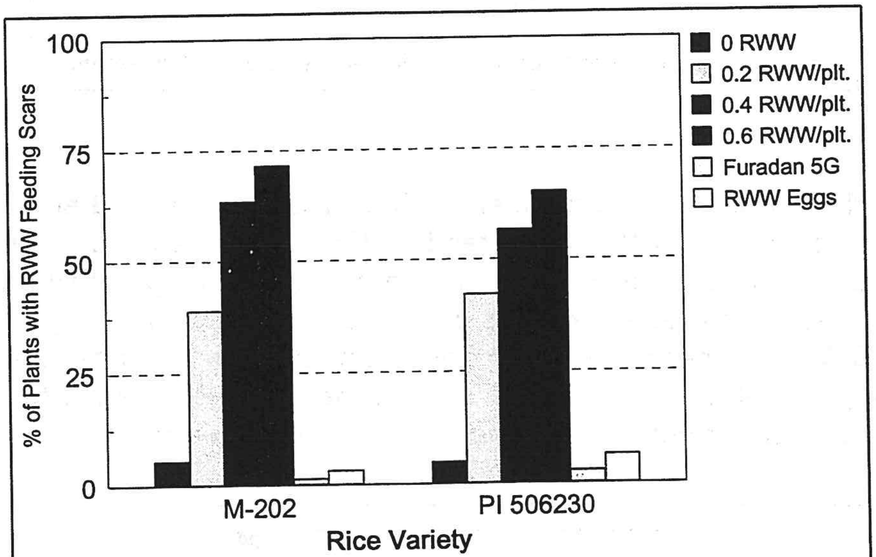


Fig. 1. Rice leaf scarring under controlled levels of adult infestation.

Plant Growth

Several plant growth parameters were evaluated in this study. Only a selected portion of these will be reported. In the 1993 study, the number of tillers per pl was severely reduced by RWW damage (Fig. 3). This largely accounted for the reduction in yield. In 1994, there was also a reduction in plant tillering with high levels of RWW damage; however, the effect was not as severe as in the previous year. On M-202, uninfested plants peaked at ~7 tillers per plant compared with only 4.5 tillers per plant in the high infestation regimes (0.4 and 0.6 RWW per plant).

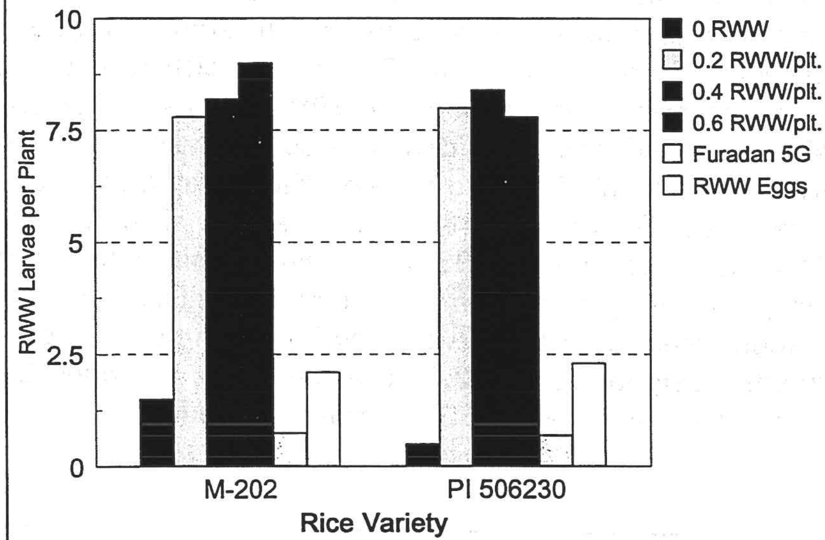


Fig. 2. RWW larval densities from controlled levels of adult infestation.

Plant Maturity

Rice maturity, in terms of date when 50% of the panicles had emerged, was not significantly effected by RWW larval feeding (Fig. 4). This is consistent with the 1993 data and is in contrast to the common belief regarding RWW damage. In the M-202 plots, 50% panicle emergence occurred on Aug. 8 and Aug. 7 in the uninfested and 0.6 RWW per plant treatments, respectively. Rice maturity in PI 506230 was slightly delayed (by about 1 day on the average) relative to M-202, but again there were no effects due to the level of RWW infestation.

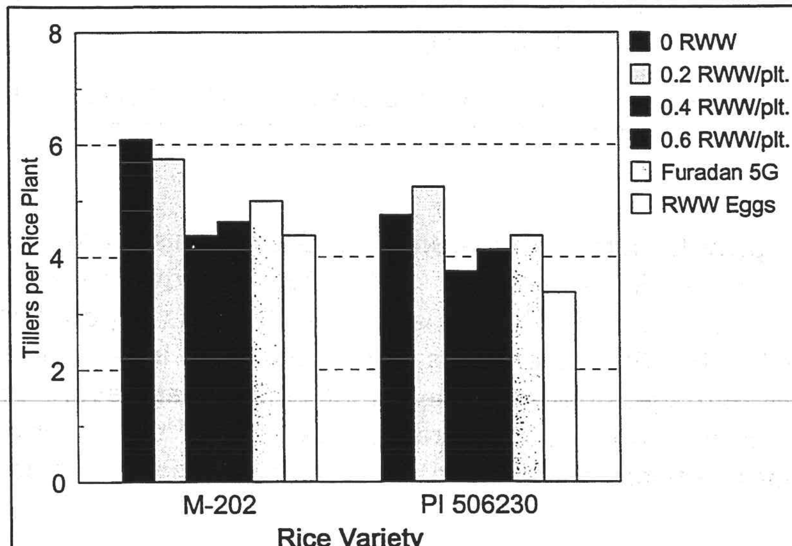


Fig. 3. Plant tillering (8 Aug.) under controlled levels of adult infestation.

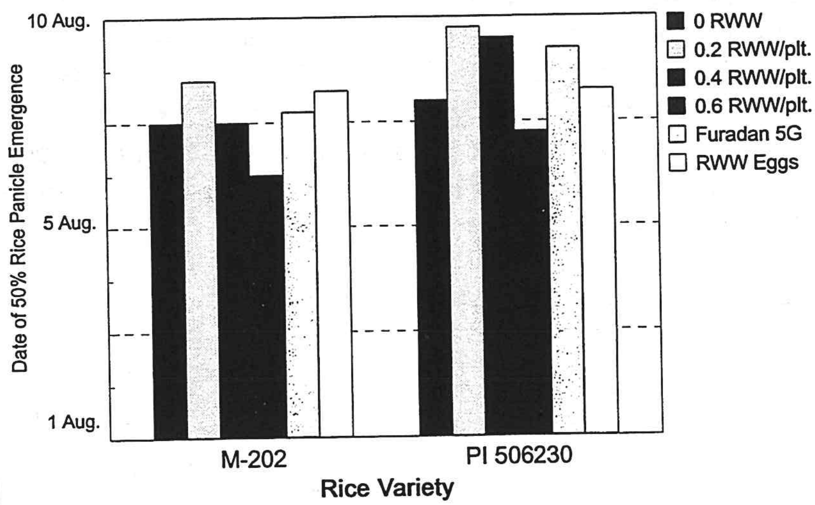


Fig. 4. Timing of panicle emergence under controlled adult infestation.

Rice Grain Yield

Rice grain yield of M-202 (Fig. 5) was significantly reduced by RWW damage, whereas there was not a corresponding reduction for PI 506230. In the M-202 plots, grain yield was highest in the uninfested, intermediate in the 0.2 RWW per plant infestation, and lowest in the 0.4 and 0.6 RWW per plant infestations. Grain

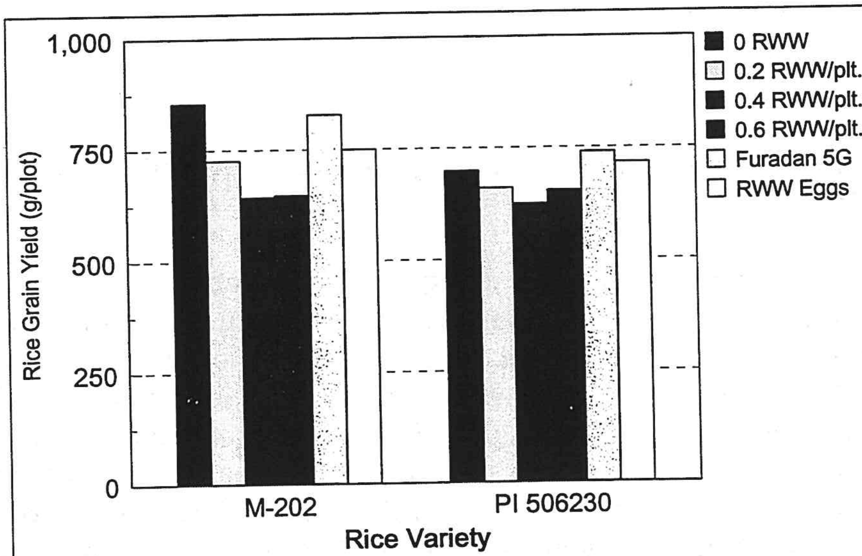
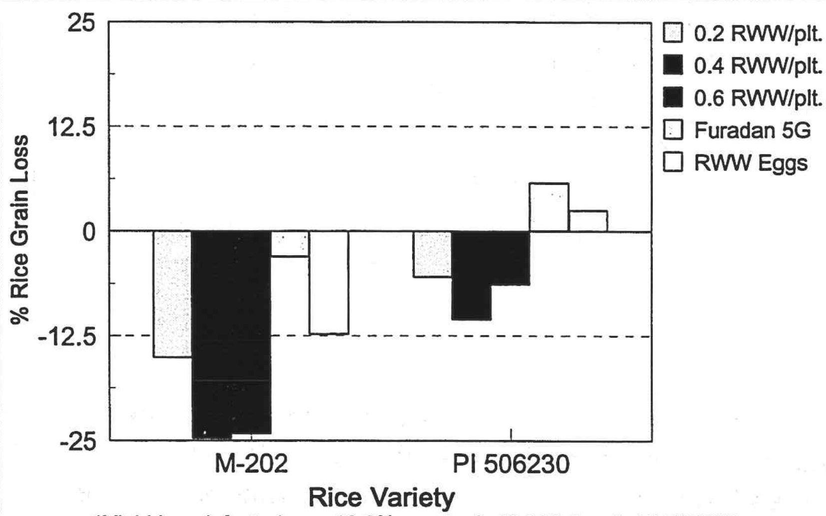


Fig. 5. Grain yield under controlled levels of adult infestation.

yield in the Furadan 5G treatment was similar to that in the uninfested. Grain yields in the PI 506230 plots were similar among the 0 to 0.6 RWW per plant treatments. Yields were slightly higher in the Furadan 5G and RWW egg treatments than the other treatments. On a percentage basis (Fig. 6), grain yields in M-202 were reduced by ~15 and 25% in the 0.2 and 0.4/0.6 RWW per plant treatments, respectively. The greatest percentage yield reduction in the PI 506230 treatments was ~12%. The yield reductions were less than those recorded in 1993. In 1993, the 0.6 RWW per plant infestation reduced the grain yield by 45% in M-202 and by 28% in PI 506230.



*Yield in uninfested was 18.3% greater in M-202 than in PI 506230

Fig. 6. Grain yield loss under controlled weevil infestations.

2.2) Evaluatation of the effect of rice seeding method on rice plant response to rice water weevil infestation.

2.2.1 and 2.2.2) Rice water weevil damage to water-seeded M-202 and drill-seeded M-202 rice was compared. Replicated field plots at the Rice Experiment Station within ~8 ft^2 rings were used. Water-seeded plots were established as described in 2.1. Drill-seeded plots were seeded on 6 May, flushed with water on 13 May, and the permanent flood was applied on 4 June. Rice stand was thinned to 96 seedlings per ring from 30 May to 3 June. The treatments, as outlined under 2.1, were initiated on 30 May and 10 June by adding the appropriate number of RWW per plot. The sample dates and sample methods were identical to those described under 2.1.

Adult Feeding

The incidence of feeding scars from RWW (Fig. 7) was significantly reduced in the drill-seeded conditions relative to the water-seeded treatment. The percentage of damaged plants peaked at 44% in the drill-seeded treatments compared with 72% with the highest infestation in water-seeded M-202. Similar results were obtained in 1993.

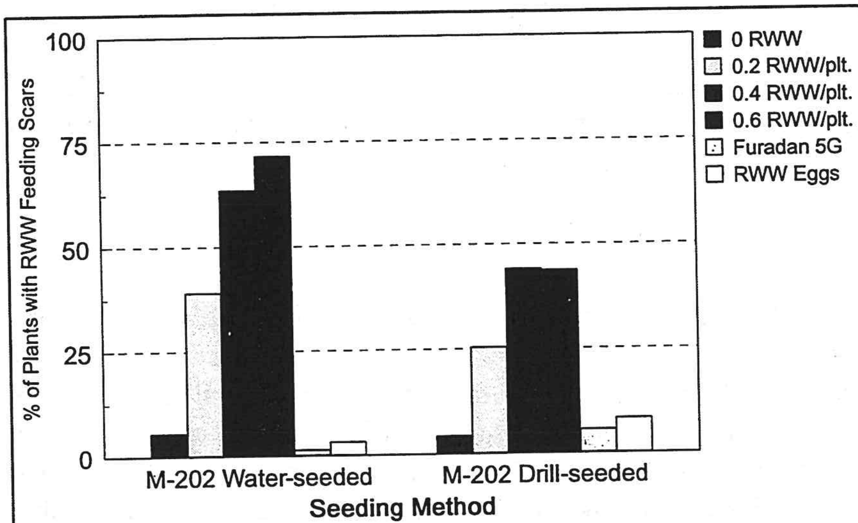


Fig. 7. Leaf scarring under controlled levels of adult infestation.

Larval Density

RWW larval densities (Fig. 8) at each adult infestation level, were similar in the two seeding methods, with the exception of the 0.2 RWW per plant treatment; a

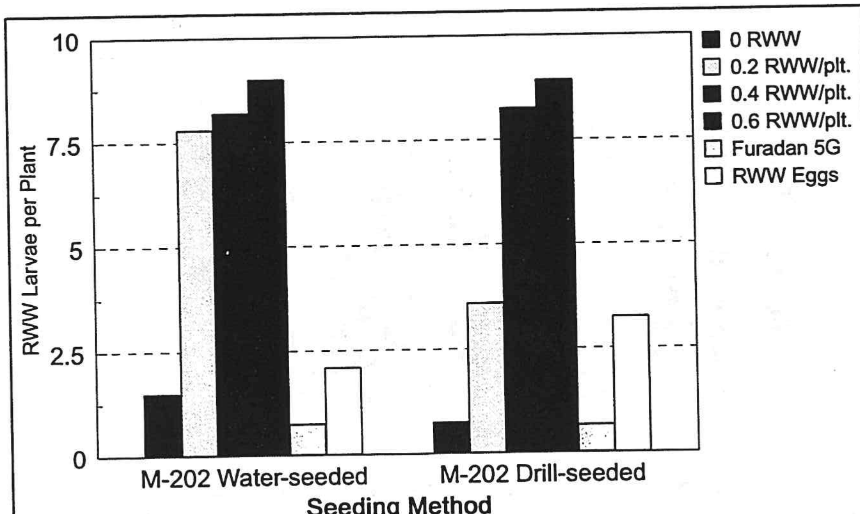


Fig. 8. Larval densities from controlled levels of adult infestation.

much higher larval density occurred in the water-seeded than drill-seeded rice. In the 0.6 RWW per plant treatments, larval densities were ~9 per plant in both seeding establishment methods. This is in complete contrast to the 1993 results. In 1993, drill-seeded conditions reduced larval densities by ~70% compared with water-seeded conditions. The apparent lack of a reduction of RWW in our drill-seeded plots may be partially accounted for by our experimental procedure. The drilled rings received 56% of their respective allotments of RWW after the permanent flood had been added. These weevils were not subjected to the non-flooded condition, and probably laid full compliments of eggs. This factor may have increased the severity of infestation in the drill-seeded plots, resulting in the lack of difference between the two treatments.

Plant Growth

The number of tillers per plant (Fig. 9) was not affected by RWW infestation in the drill-seeded treatment, in contrast to the water-seeded conditions. For instance, there were no differences between the 0 and 0.6 RWW per plant treatments in drill-seeded M-202, whereas the difference peaked at ~2.5 tillers per plant for the same infestation levels in the water-seeded M-202. The RWW egg infestation, which resulted in a low larval infestation, reduced the number of tillers per plant in the drill-seeded M-202. Overall, drill-seeding reduced the number of tillers by about 1.5 tillers per plant.

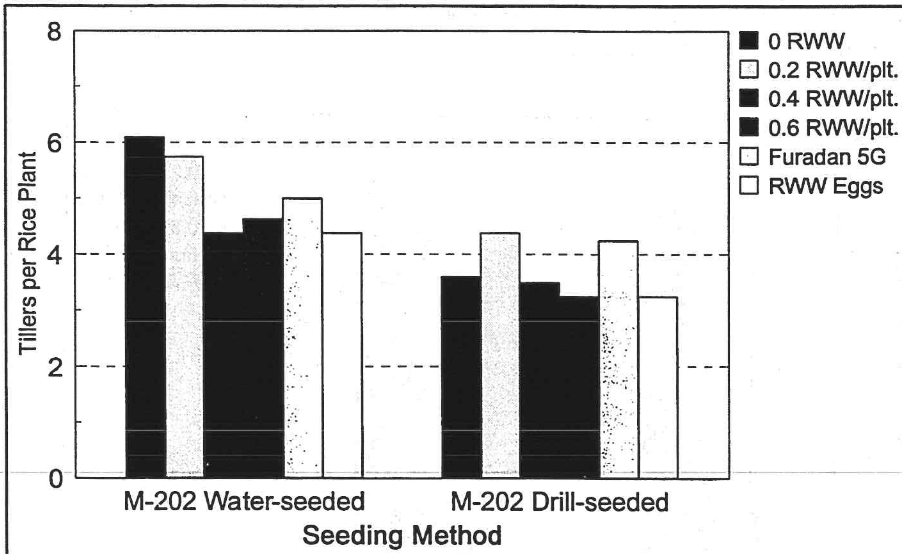


Fig. 9. Plant tillering (8 Aug.) under controlled adult infestations.

Plant Maturity

RWW infestation level had no significant effects on rice maturity (Fig. 10) in the drill-seeded M-202. The date of 50% panicle emergence ranged from 10 Aug. to 12 Aug., but the difference did not correspond to the RWW treatments. RWW injury also had no consistent effect on plant maturity in the water-seeded M-202. Plant maturity was delayed by about 3 days in the drill-seeded compared with water-seeded conditions. Similar results were seen in 1993.

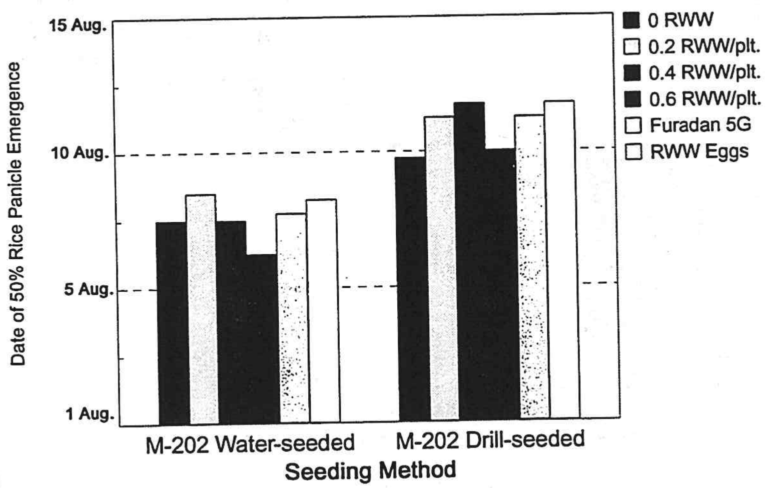


Fig. 10. Timing of panicle emergence under controlled adult infestations.

Rice Grain Yield

Rice grain yield (Fig. 11) was not reduced in the drill-seeded M-202. In the

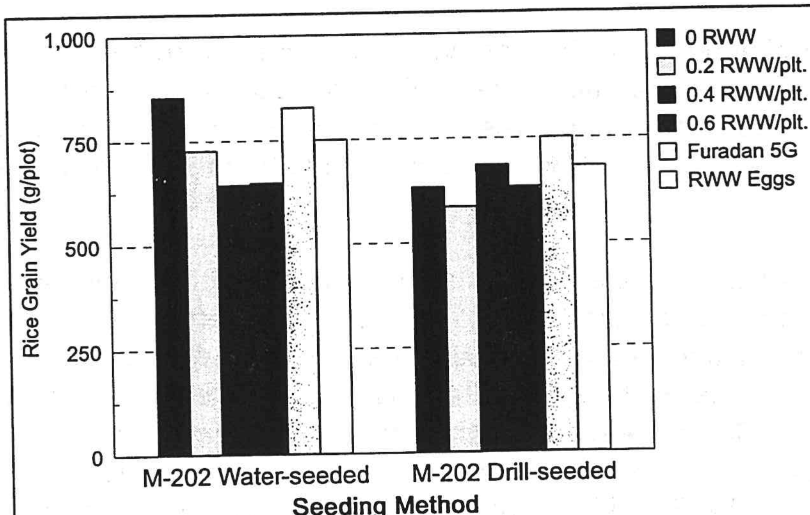


Fig. 11. Grain yield under controlled levels of adult infestation.

M-202 water-seeded treatments, yield reductions (Fig. 12) ranged from 16% to 21% at the moderate and high infestation levels, respectively. In 1993, there were moderate yield reductions (5-8%) in several of the RWW infestation treatments in the drill-seeded rice.

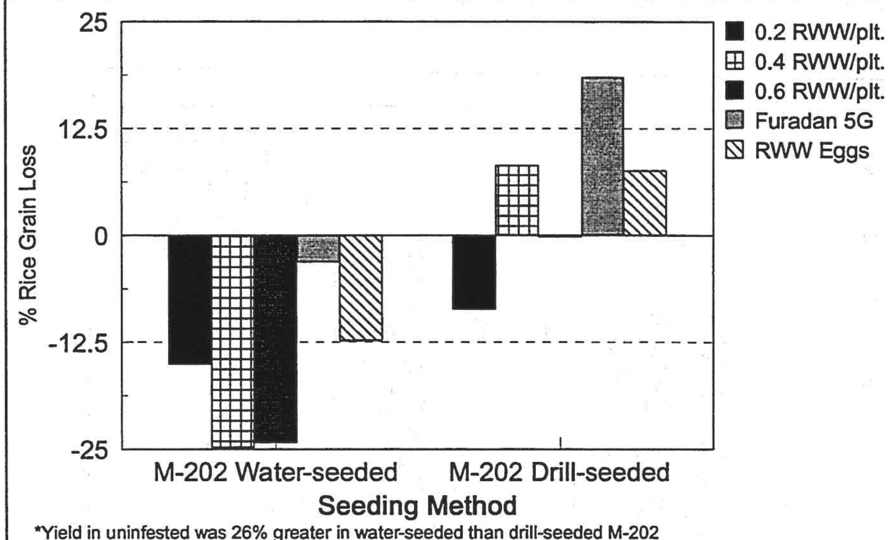


Fig. 12. Grain yield loss under controlled weevil infestations.

3.1) Evaluation of the physical and biological factors that result in flucuation and movement of pest populations that cause economic injury to rice plants.

Light trap collections for the rice water weevil are made annually to determine the levels and intervals of peak flight periods so as to interpret infestation magnitude and timing in research plots. In addition, this information may lead to a flight model which would allow predictions of flight timing and intensity.

In 1994, light traps were placed in Butte/Glenn, Colusa and Sutter counties with grower cooperators, as well as at the Rice Experiment Station in Butte county. These trap locations allowed us to measure variability in weevil flight across the Sacramento Valley. The Butte/Glenn site was ~5 miles east of Glenn, on the border of Butte and Glenn counties, at the Thompson Ranch. The Colusa site was four miles west of Maxwell at the Dennis Ranch. The Sutter site was ~4 miles south of Nicolaus at the Scheidel Ranch. The fourth trap, located at the RES, is used to provide a continuation of the light trap RWW record that began in 1962. The trap at the RES was an older "standard" model, and was different from the other 3 light traps used in 1992. Because of the trap designs, direct comparisons of the flight data from the "standard" trap and the other three traps is not appropriate.

Comparison of the 1994 light trap counts with those of previous years (Table 4), suggests that this year's flight was slightly greater in intensity than "average", based on 30 years of trap data. A total of 1,832 weevils were captured at Biggs, compared with 579 at the Butte/Glenn site, 341 at the Colusa site and 250 in Sutter county. Light trap data indicates that the spring dispersal flight consisted of three general peak periods (Figure 13). These periods were the first and third weeks in April, and the first two weeks in May. The RES trap was the only trap operational during the first peak, which occurred on 4 April, with the accumulation of 83 degree-days. The other three traps were started between 9-12 April. Flight at the Sutter site peaked on 16 April with a total capture of 235 weevils; only 13 additional RWW were captured after that date at Sutter. Flight at the Colusa site peaked on 13 May, when 300 weevils were captured; this represented 88% of the total number captured at that site. Two flight peaks occurred at the Butte/Glenn site, 3 May and 12 May.

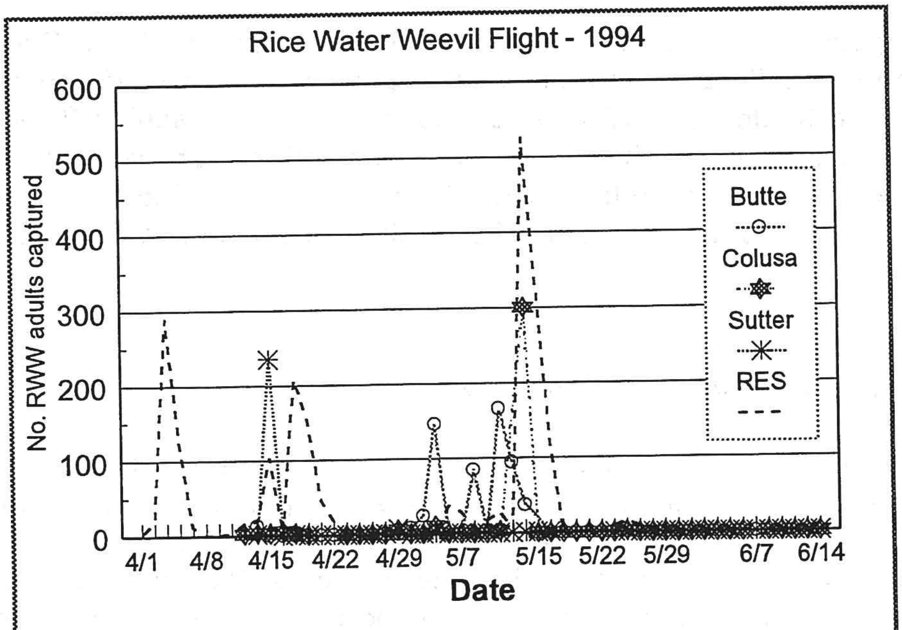


Fig. 13. RWW adults captured in light traps at four locations.

The date for completion of 95% of the flight was between 13 May and 16 May at the RES, and at the Butte/Glenn and Colusa sites, which is earlier than the long term average. The Sutter trap indicated that 95% of flight was completed by 18 April, which is extremely early based on a 30 year average. Monitoring at different locations in the Sacramento Valley is providing a measure of the extent of variability in flight magnitude and timing. With the majority of the flight having occurred before May 16 this year, later planted rice fields should have been subjected to reduced infestation by flying adults.

Table 4. Comparison of rice water weevil flight, from light traps in Butte/Glenn, Colusa, and Sutter counties, and at the Rice Experiment Station. 1991 - 1994

Year	Butte/Glenn	Colusa	Sutter	RES
1991	-	22	214	182
1992	1,061	51	152	1,620
1993	13	13	64	1,186
1994	579	341	250	1,832

3.2) Study of the overwintering characteristics and habitat/location of rice water weevil.

RWW overwintering biology was studied in the fall of 1994. Soil and root crown cores were collected from a rice basin and levees at two depths (surface to 1.5" and 1.5" to 3" deep). RWW were recovered by soil washing/flotation. RWW adults were concentrated in the top 1 inch of the soil/root crown area. Low numbers of adults were found between 1.5 to 3.0 inches. The adults will be dissected to determine the condition of their flight muscles and reproductive system.

3.3) Survey for parasites of rice water weevil.

Biological control may offer another means of managing the rice water weevil. Many other serious insect pests have a group of predators and parasites that help to keep the pest populations in check. We surveyed for parasites of rice water weevil adults in the spring, 1994. Ideally, for biological control to be most effective, the damaging stage of the pest should be attacked. Since rice water weevil larvae occur in flooded soils, this is going to be difficult. Biological control induced mortality of the eggs may be possible, but also difficult since the eggs are generally submerged. Therefore, we surveyed for parasites of spring generation of rice water weevil adults. Fifty rice water weevil adults were collected on each of 30 May, 6 June, and 10 June from the RES. The adults were held with rice leaves in the laboratory for 8 days at room conditions. Parasite emergence from the adults was monitored every 2 days. No parasite emergence was seen.

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CONCISE GENERAL SUMMARY OF CURRENT YEAR'S (1994) RESULTS:

L. D. Godfrey, A. T. Palrang, and A. A. Grigarick

RWW Control

Chemical control of rice water weevil (RWW) was studied at the Rice Experiment Station (RES). The effectiveness of Furadan 5G and six other insecticides (Furadan 4F, Fipronil, Karate 1E, Dimilin 25WP, Admire 2F, and a Rohm & Haas experimental compound) was compared. A total of 21 treatments were studied involving different rates, timing and methods of application. The experimental plots were evaluated for levels of adult weevil feeding, larval populations, and the effects of weevil injury on plant growth and yield. The materials were tested in aluminum rings with a natural infestation supplemented with field-collected adults. Furadan 5G, Furadan 4F (1.0 lb AI/ac), and Karate 1E reduced leaf scarring by over 90%. The remaining treatments reduced leaf scarring between 83% and 8%. RWW larval density was reduced by 65% by Furadan 5G. Two of the Fipronil treatments reduced larval density by 94%. Seven of the 21 treatments resulted in lower larval densities than resulted with Furadan 5G. Several of the chemical treatments had larval densities greater than in the untreated plots. All of the chemical treatments resulted in taller plants with more tillers; the treated plants had greater dry leaf and root weights. Grain yield was increased by each of the treatments with the exception of the Rohm & Haas compound. Furadan 5G produced the highest yield, however, several of the other treatments produced yields within 95% of the top yield.

Plant Response to RWW Injury

The effects of increasing densities of RWW were studied on 1) flooded M-202 rice, 2) flooded PI 506230 rice (a line being bred at the RES with tolerance to RWW feeding), and 3) drill-seeded M-202 rice. The studies were conducted in aluminum rings at the RES. Treatments of 0, 0.2, 0.4, 0.6 RWW adults per plant, and Furadan 5G (0.5 lb. AI/A) were tested. Adult feeding scars peaked at 73% in the flooded M-202 and at 64% in the PI 506230. However, feeding scars peaked at only 41% in the drill-seeded M-202. Larval densities peaked at 9 per plant in the water-seeded M-202 and at 8 in the PI 506230. Surprisingly, larval densities reached 9 per plant in the drilled M-202; this result contrasted with that of 1993 and was probably because a high number of adults were introduced into the drilled rings after they had been permanently flooded. RWW reduced tillering by ~27% in water-seeded M-202, by 8% in the PI 506230, and by ~6% in the drilled M-202. RWW infestation level had only a minimal effect on timing of panicle emergence; the greatest delay in heading was ~1 day, and occurred in water-seeded M-202 at the highest infestation level. Similarly, seeding method had no significant effect on heading date; drilled rice is initially delayed as it emerges through saturated soil, so it is difficult to interpret the slight difference that occurred in our study between the drilled and water-seeded plots. Grain yield was significantly reduced by RWW infestation in water-seeded M-202; yield reduction was ~25% at the medium (0.4) and high (0.6) infestation levels. The greatest percentage yield reduction in the PI 506230 treatments was ~12%. It does appear that this line does have tolerance to RWW at higher infestations, however, in test plots without weevil infestations, PI 506230 yielded less than M-202. Yield was not reduced by RWW infestation in the drill-seeded plots, in spite of the large larval densities observed earlier in the season.

RWW Biology

The RWW Spring Flight was slightly above average in 1994 as indicated by light traps placed with grower/cooperators in Butte/Glenn, Colusa and Sutter counties, and at the RES. The dates for completion of 95% of the spring flight ranged from 13 to 16 May at the Butte/Glenn, Colusa, and RES trap sites, which is a few days earlier than the long term (30 year) average. The traps used at the three non-RES sites were re-designed in 1994; the (average) total RWW catch per trap of 390 in 1994 is greater than the 199 average per trap catch from 1991 to 1993.

RWW Overwintering

A study on RWW overwintering biology was initiated in the fall of 1994. The majority of adults were found in root crowns within 1.5 inches of the soil surface. Surprisingly, a large number of weevils were found in cores removed from a water-saturated rice basin.

RWW Biocontrol

RWW adults were collected from rice fields and evaluated for parasites; no parasite activity was observed.