PROJECT NO. RP-3

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE

January 1, 1995 - December 31, 1995

PROJECT TITLE: Protection of rice from invertebrate pests.

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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 - Ring plots.

1.1.1) Evaluation of the efficacy of Furadan 5G, Furadan 4F, Fipronil, Karate 1E, Dimilin 25W, Admire 2F, and V-71639 0.83EC for controlling the rice water weevil.

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

1.2) Rice water weevil chemical control - Pinpoint flood conditions.

1.2.1) Evaluation of the efficacy of Dimilin 25W for controlling rice water weevil under pinpoint conditions.

1.3) Rice water weevil chemical control - Basin plots.

1.3.1) Evaluation of the efficacy of Dimilin 25W, Fipronil, Furadan 4F, and Furadan 5G for controlling a natural infestation of rice water weevil.

1.4) Rice water weevil chemical control - Grower field plots.

1.4.1) Evaluation of the efficacy of Dimilin 25W compared with Furadan 5G for controlling a natural infestation of rice water weevil in grower fields.

Objective 2: To revise the economic injury level of rice water weevil on the most widely used commercial variety, and to develop accurate, simplified sampling methods.

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

2.2) Examine the relationship between rice water weevil scar incidence, larval density, plant growth and grain yield under grower conditions.

2.3) Investigate the use of sticky traps for sampling adult rice water weevils.

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 Colusa and Sutter Counties.

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

3.3) Investigate the effects of temperature and photoperiod on the termination of winter diapause of rice water weevil adults.

SUMMARY OF 1995 RESEARCH BY OBJECTIVE:

Objective 1:

1.1) Chemical Control of Rice Water Weevil - Ring Plots

1.1.1 & 1.1.2) The efficacy of 6 chemical insecticide active ingredients and a total of 24 treatments was evaluated in a replicated field study. Numerous formulations and application timings were used. Several of these treatments were a continuation of the testing we did in 1994. The following treatments were evaluated:

Treatment	Rate (lbs. AI/A)	Timing	Treatment Date
1. Furadan 5G	0.50	Pre, incorporated	22 May
2. Furadan 4F	0.50	Pre, incorporated	22 May
3. Furadan 4F	1.00	Pre, incorporated	22 May
4. Furadan 5G	0.50	Post, 5 leaf stage	9 June
5. Furadan 4F	0.50	Post, 5 leaf stage	9 June
6. V-71639 0.83EC	0.11	Pre, incorporated	22 May
7. V-71639 0.83EC	0.11	Post, 3 leaf stage	5 June
8. Fipronil 1.5G	0.0125	Pre, incorporated	22 May
9. Fipronil 1.5G	0.025	Pre, incorporated	22 May
10. Fipronil 1.5G	0.0375	Pre, incorporated	22 May
11. EXP80658A	0.025	Seed treatment	24 May

Treatment List - 1995 (cont.)

12. EXP80658A	0.0375	Seed treatment	24 May
13. Fipronil 80WDG	0.025	Pre, incorporated	22 May
14. Fipronil 80WDG	0.0375	Pre, incorporated	22 May
15. Fipronil 1.5G	0.0375	Post, 3 leaf stage	5 June
16. Fipronil 80WDG	0.0375	Post, 3 leaf stage	5 June
17. Dimilin 25W	0.25	5 days after 50% emergence	7 June
18. Dimilin 25W	0.125	5 days after 50% emergence	7 June
19. Dimilin 25W	0.125+0.125	3 & 7 days after 50% emer.	5 & 9 June
20. Dimilin 25W	0.063	5 days after 50% emergence	7 June
21. Dimilin 25W	0.063+0.063	3 & 7 days after 50% emer.	5 & 9 June
22. Karate 1E	0.03	Post, 5 leaf stage	9 June
23. Admire 2F	0.25	Pre, incorporated	22 May
24. 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 24 May, 1995. The pre-flood applications were made on 22 May, the seed treatments were made on 24 May, the 3-leaf stage applications on 5 June, and the 5-leaf stage applications on 9 June. The Dimilin applications were made on 5 June, 7 June, and 9 June for the 3, 5, and 7 days after 50% rice emergence timings, respectively. 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, polymer, and product were placed into a plastic bag and shaken vigorously before planting. Rice stand was evaluated and adjusted to 96 plants per 8 ft^2 aluminum ring from 7-13 June. The natural rice water weevil infestation was supplemented with 6 adults placed into each ring on 12 June.

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

Sample Dates:

Seedling Vigor/Emergence: 7 June
Adult Leaf Scar Counts : 22 June
Larval Counts : 5-13 July, 21 July
Plant Growth Characteristics : 5-13 July, 21 July
Rice Yield : 10-11 October

Sample Methods:

Seedling Vigor/Emergence: stands rated before manual thinning on a 1-5 scale with
1 = very good stand (>150 plants)
3 = good stand (~100 plants)
5 = very poor stand (<20 plants)
Adult Leaf Scar Counts : percentage of plants with adult feeding scars on either of the two newest leaves (20 plants per ring)
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

Results:

The Rice Water Weevil (RWW) infestation in 1995 was comparable to that in 1994. The RWW flight at the RES was extremely high and a portion of the flight was after the plots were flooded. Therefore, we had a moderate natural infestation in the rings. In addition, we supplemented the natural infestation by adding additional weevils into the rings. Larval population density was similar in 1994 and 1995. The RWW did not, however, have as significant effect on plant growth in 1995 as in 1994. The unfavorable growing season, especially the cool, wet spring which delayed seeding, may have reduced the yield potential.

Emergence/Phytotoxicity

Based on a visual rating, stand establishment was delayed most noticeably in the EXP80658A treatments (Table 1). It is not uncommon for a Crustacean pest (crayfish) to infest a few rings and to inhibit stand establishment. This is usually accompanied by cloudy water and floating seedlings. However, in the EXP80658A treatments these conditions did not exist, but rather it appeared that the treatment inhibited seedling establishment. We did not, however, sample to verify the presence or absence of Crustacean pests.

Adult Leaf Scar Counts

RWW adult damage is generally insignificant in terms of rice plant growth and development. However, feeding scars are evaluated as a means to determine the effects of the treatments on adult density. A reduction in adult density generally corresponds to a decrease in larval density (the primary damaging stage). In 1995, the feeding scar data were collected after all the treatments had been applied. The Furadan 4F - 0.5 lb. AI/A treatment, Karate 1E , and the Fipronil 1.5G - postflood application were the most effective treatments (Table 1). These results are similar to the 1994 results.

Larval Counts

RWW larval counts were made twice during the season. Most individuals were second-third instars and third instar-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 (Table 2). Densities ranged from 0.0 to 5.2 larvae per plant in 5-13 July samples. The Furadan 5G, preflood Fipronil 1.5G and 80WDG (0.0375 lb. AI/A) and Karate treatments were the most effective on this date. However, several other treatments, including postflood Furadan 4F (0.5 lb. AI/A), preflood Fipronil 1.5G (0.0125 lb. AI/A), postflood Fipronil 1.5G and 80WDG (0.0375 lb. AI/A), and postflood Dimilin 25WP (0.25 lb. AI/A) also provided good to excellent control with larval densities ~1 per plant or less. On 21 July, the RWW immature density ranged from 0.1 to 4.8 per plant. The control seen with several treatments was less than in the first sampling date. This indicates that some products may be lacking the residual to control the late hatching eggs/larvae. The Fipronil 1.5G (0.0375 and 0.025 lbs. AI/A) treatments provided the best control (numerically).

Table 1. Stand rating evaluation and RWW adult leaf feeding scar data, 1995.

Treatment	Rate (lbs. AI/A)	Timing	Stand Rating(1-5)	% Scarred Plants
1. Furadan 5G	0.5	Pre, incor.	1.7 c	15.0 efghij
2. Furadan 4F	0.5	Pre, incor.	2.3 bc	38.8 ab
3. Furadan 4F	1.0	Pre, incor.	2.6 bc	33.8 bcd
4. Furadan 5G	0.5	Post, 5 leaf	2.3 bc	12.5 ghij
5. Furadan 4F	0.5	Post, 5 leaf	2.0 c	1.3 j
6. V-71639 0.83EC	0.11	Pre, incor.	2.0 c	31.3 bcde
7. V-71639 0.83EC	0.11	Post, 3 leaf	2.0 c	20.0 defghi
8. Fipronil 1.5G	0.0125	Pre, incor.	2.9 ab	53.8 a
9. Fipronil 1.5G	0.025	Pre, incor.	1.9 c	26.3 bcdefg
10. Fipronil 1.5G	0.0375	Pre, incor.	2.1 bc	21.3 cdefgh
11. EXP80658A	0.025	Seed Trt.	3.5 a	23.8 bcdefgh
12. EXP80658A	0.0375	Seed Trt.	2.9 ab	20.0 defghi
13. Fipronil 80WDG	0.025	Pre, incor.	2.1 bc	27.5 bcdefg
14. Fipronil 80WDG	0.0375	Pre, incor.	1.8 c	11.3 ghij
15. Fipronil 1.5G	0.0375	Post, 3 leaf	2.1 bc	8.8 hij
16. Fipronil 80WDG	0.0375	Post, 3 leaf	2.5 bc	18.8 defghi
17. Dimilin 25W	0.25	5 days after 50% emer.	2.1 bc	13.8 fghij
18. Dimilin 25W	0.125	5 days after 50% emer.	1.9 c	38.8 ab
19. Dimilin 25W	0.125+0.125	3 & 7 days after 50% emer.	2.3 bc	27.5 bcdefg
20. Dimilin 25W	0.063	5 days after 50% emer.	2.3 bc	37.5 abc
21. Dimilin 25W	0.063+0.063	3 & 7 days after 50% emer.	2.6 bc	30.0 bcdef
22. Karate 1E	0.03	Post, 5 leaf	2.3 bc	3.8 ij
23. Admire 2F	0.25	Pre, incor.	1.9 c	37.5 abc
24. Untreated	--	--	2.1 bc	31.3 bced

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Table 2. RWW immature density data from ring plots, 1995.

Treatment	Rate (lbs. AI/A)	Timing	RWW Immatures/Plant 5-13 July	21 July	Avg.
1. Furadan 5G	0.5	Pre, incor.	0.05 e	0.71 ghi	0.38
2. Furadan 4F	0.5	Pre, incor.	2.25 cd	1.55 defgh	1.90
3. Furadan 4F	1.0	Pre, incor.	1.24 cde	0.98 efghi	1.11
4. Furadan 5G	0.5	Post, 5 leaf	0.38 e	0.55 ghi	0.47
5. Furadan 4F	0.5	Post, 5 leaf	0.35 e	0.42 hi	0.38
6. V-71639 0.83EC	0.11	Pre, incor.	4.00 ab	3.14 bc	3.57
7. V-71639 0.83EC	0.11	Post, 3 leaf	2.63 bc	3.58 b	3.11
8. Fipronil 1.5G	0.0125	Pre, incor.	1.10 cde	0.78 ghi	0.94
9. Fipronil 1.5G	0.025	Pre, incor.	0.13 e	0.13 i	0.13
10. Fipronil 1.5G	0.0375	Pre, incor.	0.05 e	0.23 i	0.14
11. EXP80658A	0.025	Seed Trt.	1.25 cde	0.88 fghi	1.06
12. EXP80658A	0.0375	Seed Trt.	0.66 de	1.14 efghi	0.90

Table 2. cont.

Treatment	Rate (lbs. AI/A)	Timing	RWW Immatures/Plant 5-13 July	21 July	Avg.
13. Fipronil 80WDG	0.025	Pre, incor.	0.21 e	0.275 i	0.24
14. Fipronil 80WDG	0.0375	Pre, incor.	0.00 e	0.40 hi	0.20
15. Fipronil 1.5G	0.0375	Post, 3 leaf	0.35 e	0.51 ghi	0.43
16. Fipronil 80WDG	0.0375	Post, 3 leaf	0.43 e	0.65 ghi	0.54
17. Dimilin 25W	0.25	5 days after 50% emer.	0.73 de	1.13 efghi	0.93
18. Dimilin 25W	0.125	5 days after 50% emer.	1.05 cde	1.65 defg	1.35
19. Dimilin 25W	0.125+0.125	3 & 7 days after 50% emer.	1.30 cde	2.19 cde	1.74
20. Dimilin 25W	0.063	5 days after 50% emer.	2.39 bcd	2.38 bcd	2.38
21. Dimilin 25W	0.063+0.063	3 & 7 days after 50% emer.	0.65 de	2.02 cdef	1.33
22. Karate 1E	0.03	Post, 5 leaf	0.08 e	0.88 fghi	0.48
23. Admire 2F	0.25	Pre, incor.	5.19 a	4.83 a	5.01
24. Untreated	--	--	4.68 a	2.68 bcd	3.68

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Plant Growth Characteristics

Plant growth is a good measure of the immediate impact of RWW feeding.In 1995, there were no obvious trends in plant growth across the treatments. Treatments providing excellent larval control did not necessarily have larger plants than poor performing treatments. Again, this is indicative that the RWW feeding did not have substantial effects on the plant in 1995. This is in contrast with previous years.

Rice Yield

Rice grain yield was evaluated on 10-11 October. Grain yields in 1995 were reduced compared with 1994. In the Furadan 5G treatment (0.5 lb. AI/A preflood), the yields were 880.9 and 519.8 g/plot in 1994 and 1995, respectively (Table 3). In 1995, yields ranged from 366.7 to 550.2 g/plot. Numerically, yield was lowest in the Admire treatment and highest in the Dimilin 3 and 7 days after 50% emergence (0.063 lbs. AI/A) treatment.

1.2) Rice Water Weevil Chemical Control - Pinpoint Flood Conditions.

1.2.1) The efficacy of Dimilin insecticide was evaluated under pinpoint flood conditions. This material is applied postflood and it must be consumed by adult weevils to exert an effect. Since more rice foliage is exposed with pinpoint conditions, this may place more of the Dimilin on the plant leaves and available to the rice water weevils. Therefore, the activity of this insecticide may be improved with pinpoint conditions. The following treatments were tested (logistical considerations dictated that these treatments be separated from those under 1.1.1):

Treatment	Rate (lbs. AI/A)	Timing	Treatment Date
1. Dimilin 25W	0.125	5 days after 50% emergence	9 June
2. Dimilin 25W	0.125+0.125	pinpoint & 5 days after 50% emer.	5 & 9 June
3. Untreated	--	--	--

Table 3. Effects of RWW damage on rice grain yield from ring plots, 1995

Treatment	Rate (lb. AI/A)	Timing	Grain Yield (g/ring)	Estimated Grain yield (lbs./acre)
1. Furadan 5G	0.5	Pre, incor.	519.77 ab	6393.7
2. Furadan 4F	0.5	Pre, incor.	541.48 a	6660.7
3. Furadan 4F	1.0	Pre, incor.	463.70 ab	5703.8
4. Furadan 5G	0.5	Post, 5 leaf	489.01 ab	6015.3
5. Furadan 4F	0.5	Post, 5 leaf	506.10 ab	6225.5
6. V-71639 0.83EC	0.11	Pre, incor.	472.36 ab	5810.5
7. V-71639 0.83EC	0.11	Post, 3 leaf	451.59 ab	5554.9
8. Fipronil 1.5G	0.0125	Pre, incor.	505.05 ab	6212.6
9. Fipronil 1.5G	0.025	Pre, incor.	540.04 a	6643.0
10. Fipronil 1.5G	0.0375	Pre, incor.	513.93 ab	6321.8
11. EXP80658A	0.025	Seed Trt.	501.68 ab	6171.1
12. EXP80658A	0.0375	Seed Trt.	426.57 ab	5247.1
13. Fiponil 80WDG	0.025	Pre, incor.	486.61 ab	5985.7
14. Fipronil 80WDG	0.0375	Pre, incor.	514.79 ab	6332.4
15. Fipronil 1.5G	0.0375	Post, 3 leaf	447.95 ab	5510.2
16. Fipronil 80WDG	0.0375	Post, 3 leaf	538.69 a	6626.4
17. Dimilin 25W	0.25	5 days after 50% emer.	441.35 ab	5429.0
18. Dimilin 25W	0.125	5 days after 50% emer.	524.65 ab	6453.6
19. Dimilin 25W	0.125+0.125	3 & 7 days after 50% emer.	511.84 ab	6296.1
20. Dimilin 25W	0.063	5 days after 50% emer.	449.97 ab	5535.0
21. Dimilin 25W	0.063+0.063	3 & 7 days after 50% emer.	550.19 a	6767.8
22. Karate 1E	0.03	Post, 5 leaf	530.42 ab	6524.7
23. Admire 2F	0.25	Pre, incor.	366.71 b	4510.8
24. Untreated	--	--	510.98 ab	6285.5

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Testing was conducted with 'M-202' in 8 ft^2 aluminum rings at the Rice Experiment Station. The plots were flooded and seeded on 24 May, 1995. Water was removed on 5 June and the pinpoint Dimilin application was made. Water was returned to the plots on 9 June and the 5 days after 50% emergence Dimilin applications were made. The applications were made with a hand-held pump-up sprayer at 100 GPA. Rice stand was evaluated and adjusted to 90 plants per 8 ft^2 aluminum ring on 14 June. The natural rice water weevil infestation was supplemented with 6 adults placed into each ring on 14 June.

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

Sample Dates:

Seedling Vigor/Emergence: 7 June

Adult Leaf Scar Counts : 23 June

Larval Counts : 17-18 July, 24 July
Plant Growth Characteristics : 17-18 July, 24 July
Rice Yield : 18 October

The sample methods used were identical to those described above under 1.1.

Results:

A moderate larval infestation existed in this test. The pinpoint flood procedure may have itself provided some RWW control in this test. Since the weevils primarily infest flooded rice, if the field is not flooded during a key RWW flight period, this may reduce the infestation severity.

Adult Leaf Scar Counts

There were no significant differences in percentage scarred leaves (Table 4). The damage in the untreated was greater than 20%, which is generally considered the threshold value.

Larval Counts

RWW larval counts were made twice during the season. Most individuals were third instars and third instar-pupue at the first count and second counts, respectively. The population in the untreated averaged 1.6 RWW per plant (Table 4). This population would be classified as low to moderate. There were no significant differences among the treatments; however, the trends were suggestive of control with Dimilin. Numerically, the split treatment was better than the single application, which was better than the untreated.

Plant Growth Characteristics

In this test, there were no obvious trends in plant growth across the treatments. Treatments providing excellent larval control did not necessarily have larger plants than poor performing treatments. Again, this is indicative that the RWW feeding did not have substantial effects of the plant in 1995. This is in contrast with previous years.

Rice Yield

There were similarly no significant differences in rice grain yield (Table 5). However, the trends were similar to the trends in the larval data.

Table 4. RWW adult leaf feeding scar data and immature density data, 1995, pinpoint flood test.

Treatment	Rate (lbs. AI/A)	Timing	% Scarred Plants	RWW per Plant 17-18 July	RWW per Plant 24 July	RWW per Plant Avg.
1. Dimilin 25W	0.125	5 days after 50% emer.	25.0 a	0.75 a	1.18 a	0.97
2. Dimilin 25W	0.125+0.125	Pin point flood and 5 days after 50% emergence	8.8 a	0.55 a	0.35 a	0.45
3. Untreated	--	--	21.3 a	1.43 a	1.76 a	1.60

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Table 5. Effects of RWW damage on rice grain yield, 1995, pinpoint flood test.

Treatment	Rate (lbs. AI/A)	Timing	Grain yield (g/plot)	Estimated Yield (lbs./A)
1. Dimilin 25W	0.125	5 days after 50% emer.	483.2 a	4312.6
2. Dimilin 25W	0.125+0.125	Pin point flood and 5 days after 50% emergence	523.0 a	4667.8
3. Untreated	---	---	467.2 a	4169.8

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

1.3) Rice Water Weevil Chemical Control - Basin Plots.

1.3.1) The efficacy of Dimilin 25W, Fipronil, Furadan 4F, and Furadan 5G for controlling a natural infestation of RWW was evaluated in small basins. This study was designed to study treatments, promising in 1994 studies, under more realistic, grower conditions. These plots represent a second stage of testing. These small basin studies used larger plots, more commercial application methods, and natural RWW infestations compared with the 1994 ring studies. The ring studies are still useful for separating and screening numerous treatments. The following treatments were tested in the small basin studies:

Product	Rate (lbs. AI/A)	Timing
1. Furadan 5G	0.5	Pre, incor.
2. Furadan 5G	0.5	Post, 5 leaf stage
3. Fipronil 1.5G	0.025	Pre, incor.
4. Fipronil 80WDG	0.025	Pre, incor.
5. Fipronil 1.5G	0.025	Post, 3 leaf stage
6. Dimilin 25W	0.25	5 days after 50% emergence
7. Dimilin 25W	0.125 + 0.125	3 and 7 days after 50% emergence
8. Untreated	---	---

Testing was conducted within a 0.25 acre check in 10 feet x 20 feet basins of 'M-202' at the Rice Experiment Station. The plots were flooded and seeded on 24 May, 1995. The pre-flood applications were made on 22 May, the 3-leaf stage and 3 days after 50% emergence apstage plications on 5 June, the 5 days after 50% emergence application on 9 June, the 5-leaf applications on 12 June and the 7 days after 50% emergence application on 15 June. The liquid treatments were applied with a CO_2 sprayer at 31 GPA and the granular treatments were applied by hand with a grass seeder. A natural rice water weevil infestation was used in this test.

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

Sample Dates:

<u>Adult Leaf Scar Counts</u> : 9 June, 13 June
<u>Larval Counts</u> : 17-18 July, 24 July
<u>Plant Growth Characteristics</u> : 17-18 July, 24 July
<u>Rice Yield</u> : 16-18 October

Sample Methods:

The sample methods used were identical to those described under 1.1 and 1.2 with this exception. Rice yield was estimated by harvesting four 10.8 ft^2 areas and recovering the grain with a "Vogel" mini-thrasher.

Results:

Seedling establishment was good in this test and the rice water weevil infestation was moderate.

Adult Leaf Scar Counts

The Furadan treatments tended to have lower scar counts, but the differences were not large and were not consistently significant (Table 6).

Larval Counts

RWW larval counts were made twice during the season. Most individuals were third instars and third instar-pupue at the first count and second counts, respectively. The population decreased in the untreated from the first to second evaluation from 3.7 to 2.1 larvae per plant. This population would be classified as moderate. There were no significant differences among the 7 chemical treatments and all these were better than the untreated on the first date (Table 7). Numerically, the Furadan post-flood and Fipronil 1.5G treatments gave the best control. On 24 July, all treatments except the Dimilin 25W treatment (5 days after 50% emergence) were better than the untreated.

Plant Growth Characteristics

Plant growth is a good measure of the immediate impact of RWW feeding. In 1995, there were no obvious trends in plant growth across the treatments. Treatments providing excellent larval control did not necessarily have larger plants than poor performing treatments. Again, this is indicative that the RWW feeding did not have substantial effects of the plant in 1995. This is in contrast with previous years.

Rice Yield

There were similarly no significant differences in rice grain yield (Table 8). The best yielding treatment yielded ~730 lbs./A more than the untreated.

Table 6. RWW adult leaf feeding scar data, 1995, basin tests.

			% Scarred Plants	
Treatment	Rate (lbs. AI/A)	Timing	9 June	13 June
1. Furadan 5G	0.5	Pre, incor.	57.5 a	15.0 b
2. Furadan 5G	0.5	Post, 5 leaf stage	50.5 a	11.0 b
3. Fipronil 1.5G	0.025	Pre, incor.	74.5 a	47.5 a
4. Fipronil 80WDG	0.025	Pre, incor.	51.0 a	31.5 ab
5. Fipronil 1.5G	0.025	Post, 3 leaf stage	65.5 a	26.0 ab
6. Dimilin 25W	0.25	5 days after 50% emer.	56.0 a	32.0 ab
7. Dimilin 25W	0.125 + 0.125	3 and 7 days after 50% emer.	52.5 a	22.5 b
8. Untreated	---	---	62.0 a	27.0 ab

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Table 7. RWW immature density data, 1995, basin tests.

Treatment	Rate (lbs. AI/A)	Timing	RWW per Plant 17-18 July	24 July	Avg.
1. Furadan 5G	0.5	Pre, incor.	0.7 b	0.2 b	0.5
2. Furadan 5G	0.5	Post, 5 leaf stage	0.03 b	0.3 b	0.2
3. Fipronil 1.5G	0.025	Pre, incor.	0.2 b	0.1 b	0.6
4. Fipronil 80WDG	0.025	Pre, incor.	0.7 b	0.2 b	0.4
5. Fipronil 1.5G	0.025	Post, 3 leaf stage	0.2 b	0.0 b	0.1
6. Dimilin 25W	0.25	5 days after 50% emer.	1.1 b	1.5 a	1.3
7. Dimilin 25W	0.125 + 0.125	3 and 7 days after 50% emer.	0.6 b	0.6 b	0.6
8. Untreated	---	---	3.7 a	2.1 a	2.9

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

Table 8. Effects of RWW damage on rice grain yield, 1995, basin tests.

Treatment	Rate (lbs. AI/A)	Timing	Grain yield (g/plot)	Est. Yield (lbs./A)
1. Furadan 5G	0.5	Pre, incor.	846.5 a	7555.0
2. Furadan 5G	0.5	Post, 5 leaf stage	789.9 a	7049.9
3. Fipronil 1.5G	0.025	Pre, incor.	809.9 a	7228.3
4. Fipronil 80WDG	0.025	Pre, incor.	800.6 a	7145.3
5. Fipronil 1.5G	0.025	Post, 3 leaf stage	763.3 a	6812.4
6. Dimilin 25W	0.25	5 days after 50% emer.	818.4 a	7304.2
7. Dimilin 25W	0.125 + 0.125	3 and 7 days after 50% emer.	805.0 a	7184.6
8. Untreated	---	---	764.3 a	6821.4

Means within columns followed by the same letter are not significantly different; least significant differences test ($p<0.05$).

1.4) Rice Water Weevil Chemical Control - Grower Field Plots.

1.4.1) The efficacy of Dimilin 25W was studied compared with Furadan 5G (and with untreated plots) for controlling a natural infestation of RWW in grower fields in 1995. In cooperation with Uniroyal Chemical Co. personnel, four field sites was set-up under a Research Authorization/crop destruct scenario. Two of the sites were in Butte Co, one was in Sutter Co., and the final site was in Sutter Co. The standard preplant Furadan 5G application was used at all sites. The Dimilin application rates and timings differed slightly among the sites. Dimilin 25W (0.25 lb. AI/A) applied at 5 days after 50% plant emergence through water was tested at all sites. Lower rates and an alternate formulation were also evaluated at some sites. All Dimilin applications were made by air to ~1-2 acre plots at each location. The untreated areas were similarly sized.

The percentage scarred plants was sampled as previously described in all fields in June. Rice water weevil larval samples (using previously described procedures) were taken in mid-late July at a time when populations should be mostly large larvae and possibility some pupae. This timing was chosen so that late-deposited eggs would have hatched and because large larvae are more amenable to recovery with our sample processing system. Finally, grain yields were estimated by harvesting four 10.8 ft^2 areas and recovering the grain with a "Vogel" mini-thrasher.

The percentage scarred plants ranged from 13.8% to 95%. Overall, the percentage was slightly lower in the Furadan 5G treatment than in the other two treatments (Table 8). The 53.5% scarred plants in the untreated clearly exceeded the threshold of 10-20%. Larval densities ranged from 0 to 6.13 and, averaged over the sites, the densities were lower in the untreated than in the other two treatments (Table 8). This probably occurred because the larval population in the untreated areas declined over time as the high density consumed the majority of the root tissue. In the treatments, larval density was reduced by the toxicant and therefore the larvae were never in competition for food. This confounding result makes the larval data difficult to interpret. Grain yields were similar in the Furadan and Dimilin treatments (Table 8). The treatment areas yielded about 500 lbs/A more than the untreated areas. The lack of replication at each site may have hampered the results. Some yields may have been confounded with water level on that particular portion of the field, proximity to rice water weevil overwintering sites, soils, etc.

Table 8. Influence of treatments in grower field tests on average leaf damage, RWW larval density and grain yield.

Treatment	% Scarred Plants	RWW Per Plant	Grain yield (g/plot)	Estimated Yield (lbs./A)
1. Dimilin 25W*	57.3	2.0	827.8	7379
2. Furadan 5G**	45.1	1.7	836.1	7453
3. Untreated	53.5	1.3	780.5	6958

* Averaged over rates and formulations.

** Preplant incorporated at 0.5 lb. AI/A.

Objective 2:

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

2.1) Several levels of rice water weevil infestation were established in 8 ft^2 aluminum rings at the Rice Experiment Station on water-seeded 'M-202'. The goal of this study was to evaluate the influence of rice water weevil feeding on plant growth, development, and yield. This is the third year of this study. Although yield losses from rice water weevil have resulted during each year of the study, the magnitude of the yield losses have varied from year to year. This is indicative of the variable effects of rice water weevil on rice productivity. The environmental conditions and resulting rice plant vigor undoubtedly influence the pest-plant relationship. This report will describe the results from 1995 as well as briefly compare the results from the previous two years. In 1993 and 1994, we examined these interactions in 'M-202' water- and drill-seeded and in a water-seeded 'PI' line. In 1995, we concentrated only on water-seeded 'M-202', but examined more infestation levels of rice water weevil than in 1993-94.

Rice was seeded on 24 May. Rice stand was evaluated and adjusted to 96 plants per ring from 7 June to 13 June. The following treatments were established in the rings by adding the appropriate number of rice water weevils into each ring on 9 June, 12 June, and 19 June (33% of the total on each date):

1.) 0 RWW adults
2.) 5 RWW adults per ring (=0.05 adults per plant)
3.) 9 RWW adults per ring (=0.1 adults per plant)
4.) 18 RWW adults per ring (=0.2 adults per plant)
5.) 36 RWW adults per ring (=0.4 adults per plant)
6.) 54 RWW adults per ring (=0.6 adults per plant)
7.) Furadan 5G (0.5 lb. AI/A)
8.) 36 RWW adults per ring (=0.4 adults per plant)
    unsampled except for yield
9.) 36 RWW adults per ring (=0.4 adults per plant)
    uncovered control (with Furadan 5G [0.5 lb. AI/A])

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

Sample dates are as follows:
Adult scar counts: 9 June, 14 June, 19 June, 23 June, and 28 June
Larval counts: 26 June, 7 July, and 21 July
Plant physiology and growth characteristics: 26 June, 7 July, 21 July, 4 August, and 18 August
Plant maturity: 4-28 August
Rice yield: 12, 13 October

The sampling method consisted of the following:
Adult scar counts, larval counts, plant growth characteristics, and rice grain yield were determined as previously described. The following additional evaluations were done:
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.

Results:
Adult Feeding

The percentage of rice plants with RWW feeding scars (Fig. 1) varied according to the prescribed treatments. During the period of peak damage (14 June), percentage scarred leaves ranged from 8.3 to 89.2%. Leaf damage was highest in the 0.6 adults per plant treatment. Averaged over all sample dates, 9.8% and 70.0% of the plants were damaged in the 0 and 0.6 adults per plant treatments, respectively. The existing economic threshold, based on scar counts, is 10-20% damaged plants. Therefore, we had a excellent range of damage levels in this test.

Larval Density

RWW larval density (Fig. 2) was highest on 7 July with 18 larvae per plant as the peak sampled population. We obtained a range of larval densities through our infestation technique. There was a low background infestation in the 0 adults per plant treatment and the larval density gradually increased as the infestation regime increased. The highest larval population, both on 7 July and the seasonal average, was in the 0.4 rather than 0.6 adults per plant treatment. As we have seen in previous years, at very high infestation levels the larval survival and establishment is often poor. This probably occurs because of larval competition for food, i.e., roots. Under similar experimental conditions, the larval densities in 1995 were lower than in 1993 and higher than in 1994. Larval density in the 0.4 adults per plant treatment peaked at 18 larvae per plant and averaged 8.1 larvae per plant. The Furadan 5G treatment, with 0.4 adults per plant infestation, produced a high larval infestation (an average of 6.2 larvae per plant).

Plant Growth

Several plant growth parameters were evaluated in this study. Only a selected portion of these will be reported. RWW injury has been shown to reduce leaf area, plant height, root length, etc. However, most importantly, plant tillering is reduced by RWW feeding. The effect was severe in 1993 and only slight in 1994. In the 1995 study, the number of tillers per plant was severely reduced by RWW damage (Fig. 3). This largely accounted for the reduction in yield. On 26 June, when the larvae were first starting to feed on plant roots, there were no differences among the treatments in tillering. On 7 July, tillering was reduced by about ~30% in the two highest larval infestations. This date corresponded with the peak larval population density. The differences in tillering among the treatments were even more obvious on 21 July. Tillering was reduced in the 3 highest larval infestations with the most severe reduction being 45.7%. In addition, tillering was also increased by the Furadan 5G (with no RWW infestation) application compared with the other treatments.

Plant Physiology

Photosynthetic rates of rice plants were reduced by RWW injury during the period of peak feeding (7 July). For instance, rates of plants stressed by the 0.6 adults per plant treatment was reduced by ~20% compared with plants in the 0 adults per plant treatment (Fig 4). Rates in the 0.4 adults per plant treatments (with and without Furadan) were also depressed on this date. Concurrent with the cessation of damage (RWW pupation), the rates generally equilibrated among treatments. Through this research and other ongoing studies, the mechanisms of rice plant response to RWW injury can be determined. This knowledge can only aid in designing management programs for this pest.

Plant Maturity

Rice maturity, in terms of date when 50% of the panicles had emerged, was not significantly effected by RWW larval feeding. This is consistent with the 1993 and 1994 data. The dates of 50% panicle emergence ranged from 15 Aug. to 25 Aug., but there was no correlation with treatment.

Rice Grain Yield

Rice grain yield of 'M-202' (Fig. 5) was significantly reduced by RWW damage. Grain yield averaged 710 g/ring in the 0 and 0.05 adults per plant treatments and declined to 465 g/ring in the 0.4 and 0.6 adults per plant treatments. Yield in the Furadan 5G treatment (with no RWW infestation) was higher, by about 17.2%, than in the 0 adults per plant treatment. As with the tillering data, the Furadan treatment appeared to "stimulate" plant productivity. However, in the Furadan 5G + 0.4 adults per plant treatment, the Furadan did not protect the plant from yield loss. The yield was the same in the 0.4 adults per plant treatment (with and without Furdan 5G). The reasons for this difference are uncertain. Yields in the 0.4 adults per plant treatment (sampled and unsampled) were similar. This indicated that the coring and other "destructive" sampling had no effects on yield. On a percentage basis (Fig. 6), grain yields in 'M-202' were reduced by ~29.4% and 36.1% in the 0.4 and 0.6 adults per plant treatments, respectively. The yield reductions were less than those recorded in 1993, but more significant than in 1994. These data indicate that clearly RWW feeding reduces rice yield, but the magnitude of the plant response and yield loss varies from year-to-year. The plant growth vigor, resulting from environmental and edaphic conditions, and other factors undoubtedly influences this relationship. Further studies are needed to more fully define these effects.

2.2) Examine the relationship between rice water weevil scar incidence, larval density, plant growth and grain yield under grower conditions.

2.2) The study described under 2.1 has been extremely beneficial for quantifying the influence of rice water weevil damage on rice plant growth and yield. This information is needed for regulatory agencies, agrichemical companies, and for assisting growers in making management decisions. There is some artificiality in these data in that the study was conducted in ring plots. This was necessary to adequately control the infestation level. A portion of this work needs to be done in grower fields and that was the objective of this study. Quantifying the RWW - rice plant relationship in grower fields and modifying the sampling criteria for this pest may be even more important if registration of Furadan 5G is cancelled. Of the promising possible replacement compounds, two and possibly three of these compounds will be applied as a post-flood, as needed treatment rather than a preventative treatment. In addition, the cost of replacement materials may dictate they are applied only when required to prevent losses rather than preventatively.

The relationship among percentage scarred plants, RWW larval density, rice growth, and rice yield was studied in four grower fields (two in Butte Co., one in Sutter Co., and one in Colusa Co.). Previous research by Grigarick showed that RWW infestation declines from the edge of the levee into the rice check. Therefore, to establish different infestation levels, areas in untreated checks were located 5, 15, 25, 35, and 45 feet from the levee and marked. Four replicates of each distance were used at each site. The percentage scarred plants, RWW larval density, rice growth and rice yield, with methods previously described, were monitored at each location.

The percentage scarred plants generally declined from 5 to 45 feet from the levee (Table 8). However, the number of larvae per plant and grain yield did not differ across these treatments. Larval densities were slightly lower farthest from the levee, conversely yields were lowest nearest the levee. There have been several reports that rice water weevil infestations are generally more constant across the entire check than in past years. Research in the late 1970's showed the infestation were concentrated near the levee. The reason for this concentration near the levee was never defined. Perhaps some recent change in the water depth, rice varieties, pinpoint flood practices, or some other factor has changed the RWW distribution within a check. This is an area that may warrant further research.

Table 8. Percentage scarred plants, larval density, and rice grain yield from grower field tests, 1995.

Distance from Levee (feet)	% Scarred Plants	Larvae per Plant	Grain Yield (g/plot)	Estimated Yield (lbs./A)
5	56.9	1.5	687.0	6129
15	34.6	1.8	778.0	6941
25	27.4	1.4	785.0	7003
35	27.0	1.6	763.9	6815
45	7.0	0.9	778.8	6948

2.3) Investigate the use of sticky traps for sampling adult rice water weevils.

2.3) Sampling for rice water weevil infestations by determining the incidence of scarred plants is difficult and laborious. The goal of this project was to evaluate other sample methods. Traps of several types are used to sample many insects. In Japan, traps and bait plants are used to sample RWW adults. In this study, we studied the use of sticky traps for sampling RWW adults. Traps were placed at the Rice Experiment Station on 23 May and checked for RWW adults twice per week until ~20 June. Traps were placed on levees (except trt. 9) adjacent to rice fields used for our other studies, therefore, it was certain that RWW adults were flying in this area. Each trap treatment was replicated 4 times. The following trap designs were used:

1. 1 quart container - yellow; placed at 3 feet height; coated with Stickum®
2. 1 quart container - green; placed at 3 feet height; coated with Stickum®
3. 1 quart container - blue; placed at 3 feet height; coated with Stickum®
4. 1 quart container - silver; placed at 3 feet height; coated with Stickum®
5. 1 quart container - black; placed at 3 feet height; coated with Stickum®
6. 1 quart container - white; placed at 3 feet height; coated with Stickum®
7. 1 quart container - yellow; placed at 3 feet height; coated with Tanglefoot® Pest Barrier
8. 1 quart container - yellow; placed at 1 foot height; coated with Stickum®
9. 1 quart container - yellow; floating in check ~1 foot from levee; coated with Stickum®
10. plate trap - yellow; placed at 3 foot height; coated with Stickum®

The traps were not effective in capturing RWW adults. In total, less than 10 adults were captured during the season. The feasibility of traps for RWW will be re-evaluated.

Objective 3:

3.1) Evaluation of 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 Colusa and Sutter Counties.

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 1995, light traps were placed in 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 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 third 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 2 light traps used in 1995. Because of the trap designs, direct comparison of the flight data from the "standard" trap and the other traps is not appropriate.

Comparison of the 1995 light trap counts with those of previous years (Fig. 7), suggests that the 1995 flight was considerably greater in intensity than "average", based on 30 years of trap data. A total of 3,340 weevils were captured at Biggs compared with 1,832 last year. Flight magnitude at the other two sites was similar in 1994 and 1995. Light trap data indicate that the spring dispersal flight at the RES consisted of one large peak on 20 May and secondary peaks on 22 April and 25 May (Fig. 8). In Sutter Co., there was one flight peak on ~18 May. There were really no flight peaks at the Colusa Co. site; RWW adults were captured from 4 April to 1 June.

The date for completion of 95% of the flight was about 28 May. This compared with 16 May (1994), 15 May (1993), 7 May (1992), 30 May (1991), and 30 April (1990). Monitoring at different locations in the Sacramento Valley is providing a measure of the extent of variability in flight magnitude and timing. The use of planting date in 1995 to reduce RWW infestations was not really practical due to the delayed flight period.

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

3.2) RWW overwintering biology was studied in the fall 1994/winter 1995. Soil and root crown cores were collected at two depths, surface to 1.5 inches and 1.5 to 3 inches deep, from these four locations: 1.) south facing levee, 2.) north facing levee, 3.) in the basin, and 4.) margin between roadway and field basin. RWW adults were recovered by a soil washing/flotation technique. Samples were taken in mid November, January, February, and March.

The majority of the RWW adults were concentrated in the top 1.5 inches of the soil/root crown area. Low numbers of adults were found between 1.5 to 3.0 inches. Among the four locations, the most weevils were found on the north-facing levee and field margin (Fig. 9). However, a surprising high number of weevils was found in the field basin. This is particularly surprising because there was standing water in the basin from January to March. The density of RWW adults declined from November to March (Fig. 10). This probably represents natural mortality of RWW during the overwintering period.

3.3) Investigate the effects of temperature and photoperiod on the termination of winter diapause of rice water weevil adults.

3.3) The ability to break the winter diapause of the rice water weevil would be beneficial to allow further investigations of this pest during the winter. This pest naturally goes into diapause (hibernation) from September to about March/April. RWW collected while in diapause are inactive, i.e., non-reproductive, even in warm temperatures. A laboratory study was conducted in 1994-95 to attempt to define the conditions needed to terminate the diapause. Previous research at UC-Davis, and elsewhere, on diapause termination has been inconclusive and attempts to break the diapause have been generally unsuccessful.

RWW adults were collected in December, January, February, and March from a rice field in Sutter County. These weevils were returned to UC-Davis and exposed to various temperature/light/plant substrate conditions within ~1 ft^3 plastic boxes. About 30 adults were placed into each of 4 replicates within each treatment. The following conditions were tested:

1.) 18 hr. light : 6 hr. dark; 80.6^{0}F; with Dallis grass
2.) 18 hr. light : 6 hr. dark; 60^{0}F; with Dallis grass
3.) ambient conditions; with Dallis grass
<u>December samples only</u>
4.) 24 hr. dark; 46^{0}F; with Dallis grass for 30 days; then moved to 18 hr. light : 6 hr. dark; 80.6^{0}F; with Dallis grass

The diapause state of the weevil adults was monitored in two ways. Periodically, flooded rice plants were placed into each box and removed about 3 days later. The young rice plants were intended to serve as egg-laying host material for any weevils which may have terminated diapause and reached reproductive maturation. These plants were processed and the number of RWW eggs in the stem tissue was counted. Secondly, RWW adults were removed from each treatment at biweekly intervals and the condition of the flight muscles and reproductive structures examined. Developed flight muscles or ovaries are each indicative of diapause termination.

Sample evaluation and data analysis are ongoing. Eggs were initially found on 3 March, but the effects of the treatments are still being evaluated.

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Palrang, A. T. and L. D. Godfrey. 1995. Evaluation of insecticides for rice water weevil control in California, 1994. Arthropod Management Tests. 20: 227-228.

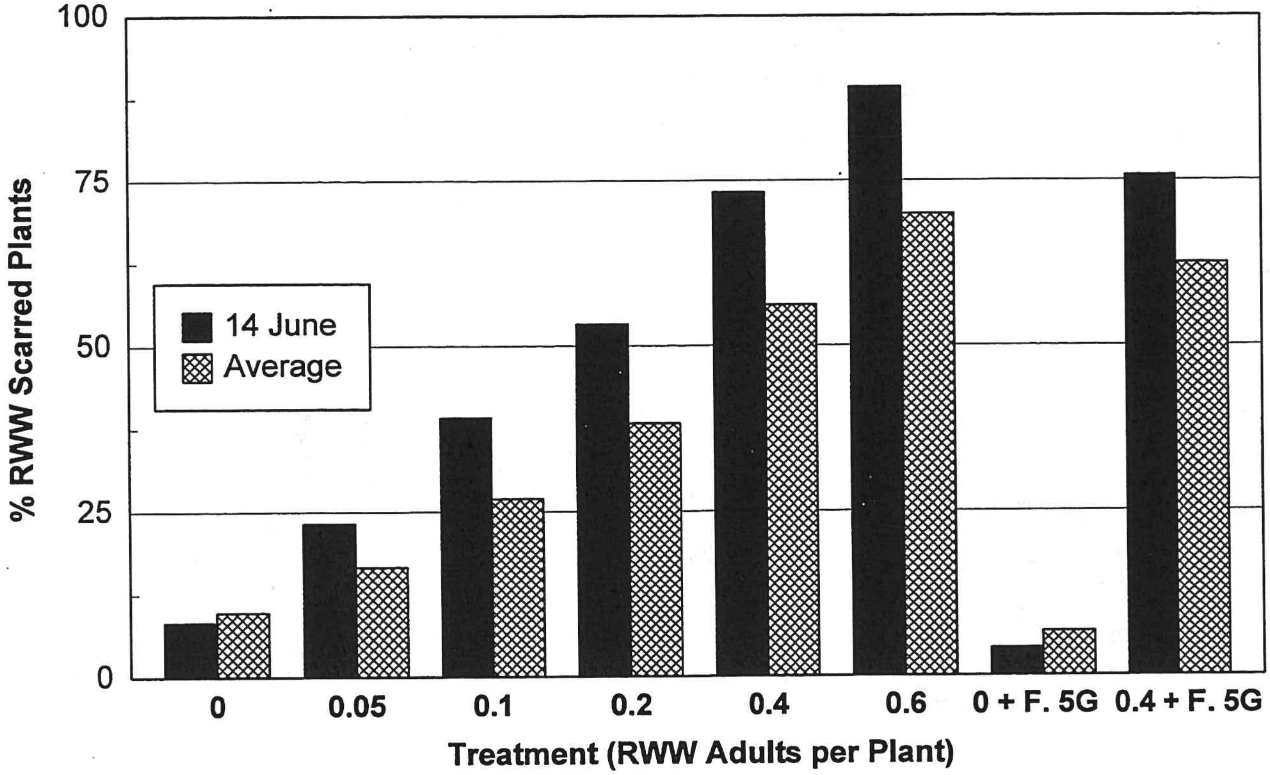

100
75
50
25
0
% RWW Scarred Plants
14 June
Average
0
0.05
0.1
0.2
0.4
0.6
0 + F. 5G
0.4 + F. 5G
Treatment (RWW Adults per Plant)

Fig. 1

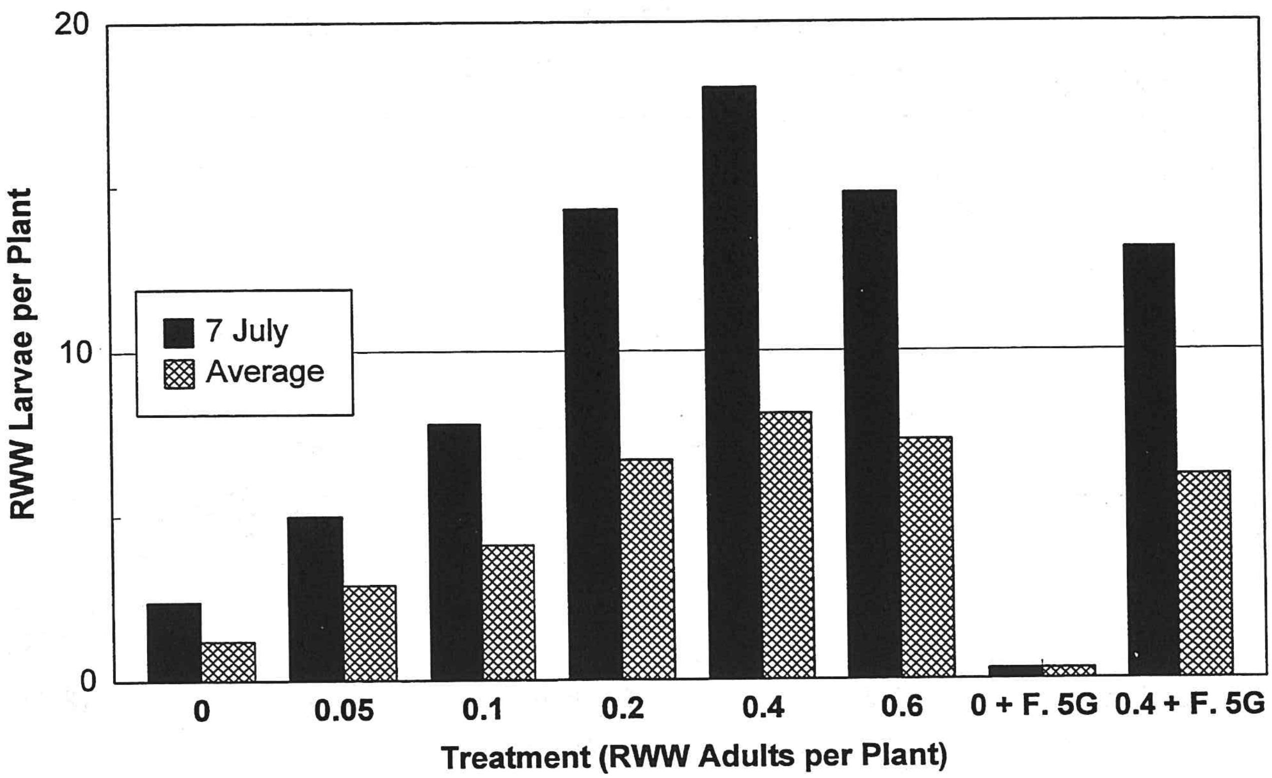

20
10
0
RWW Larvae per Plant
7 July
Average
0
0.05
0.1
0.2
0.4
0.6
0 + F. 5G
0.4 + F. 5G
Treatment (RWW Adults per Plant)

Fig. 2

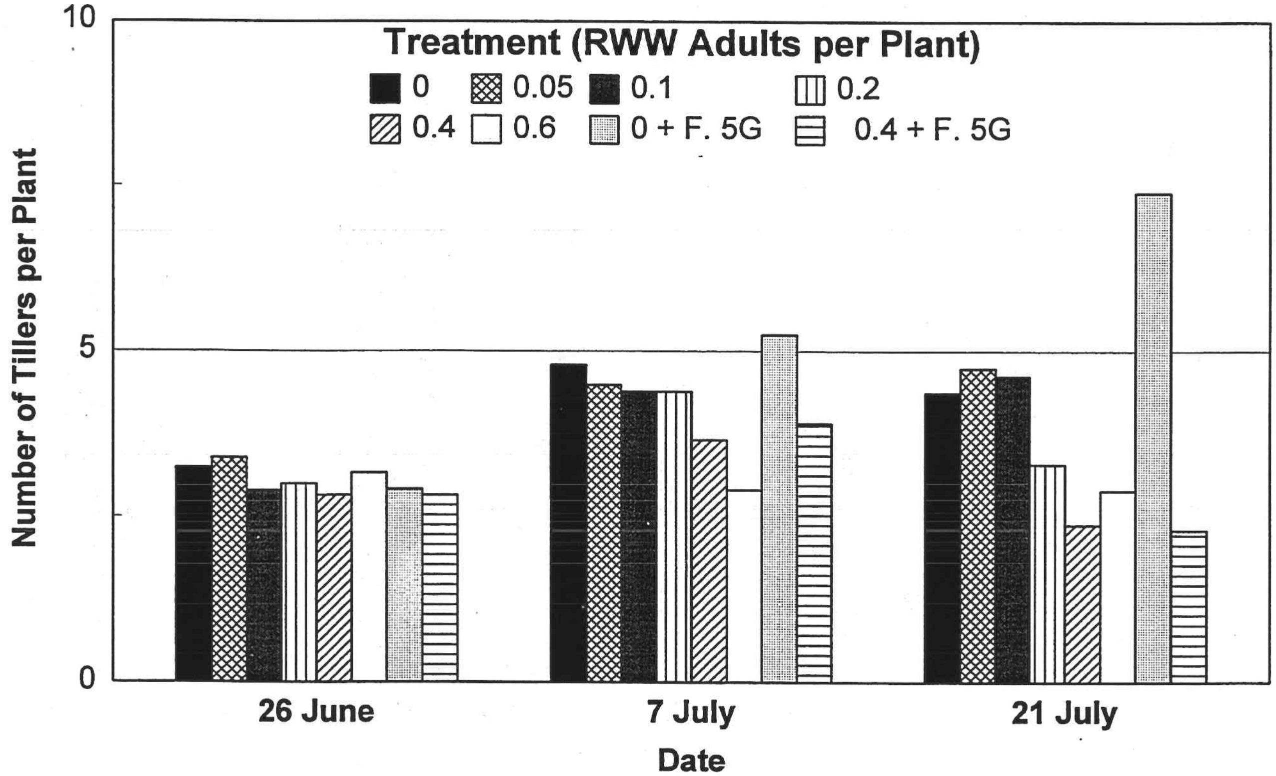

Treatment (RWW Adults per Plant)
0
0.05
0.1
0.2
0.4
0.6
0 + F. 5G
0.4 + F. 5G
10
5
0
Number of Tillers per Plant
26 June
7 July
21 July
Date

Fig. 3

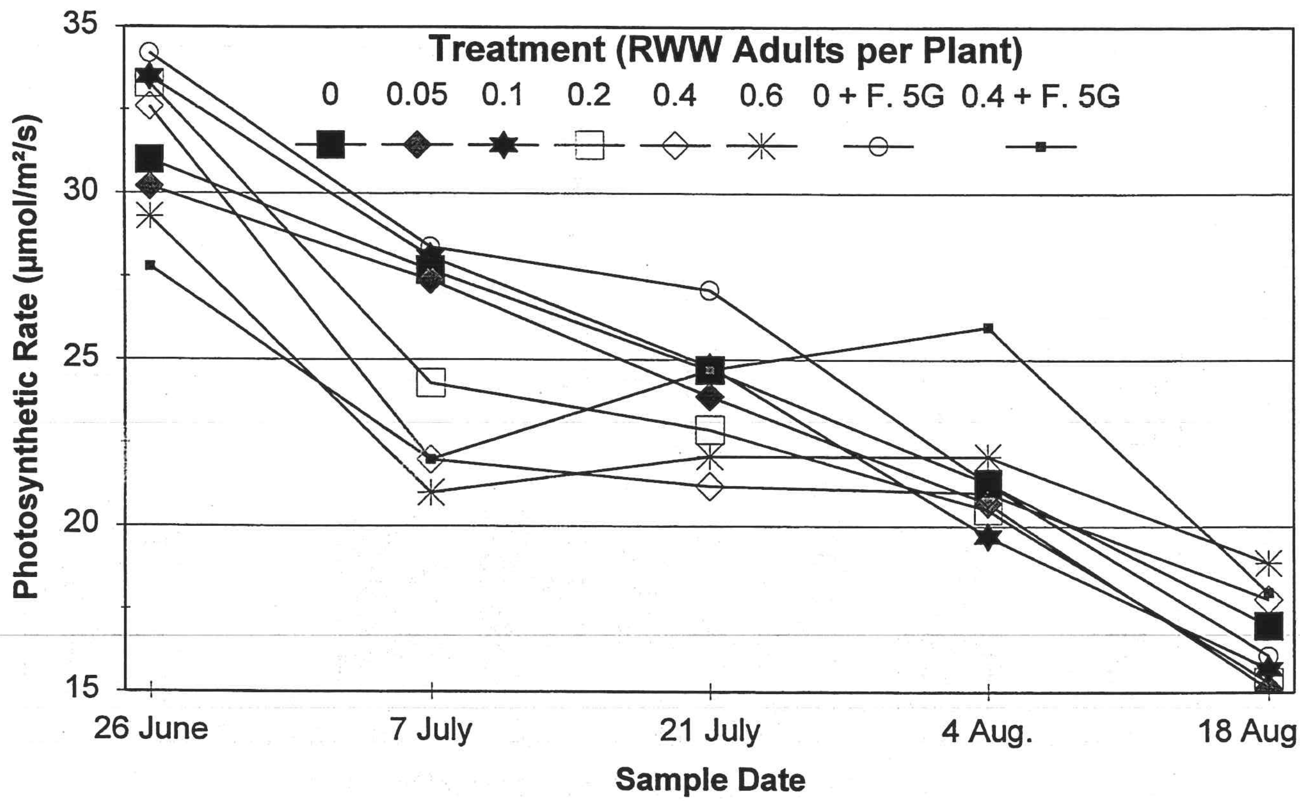
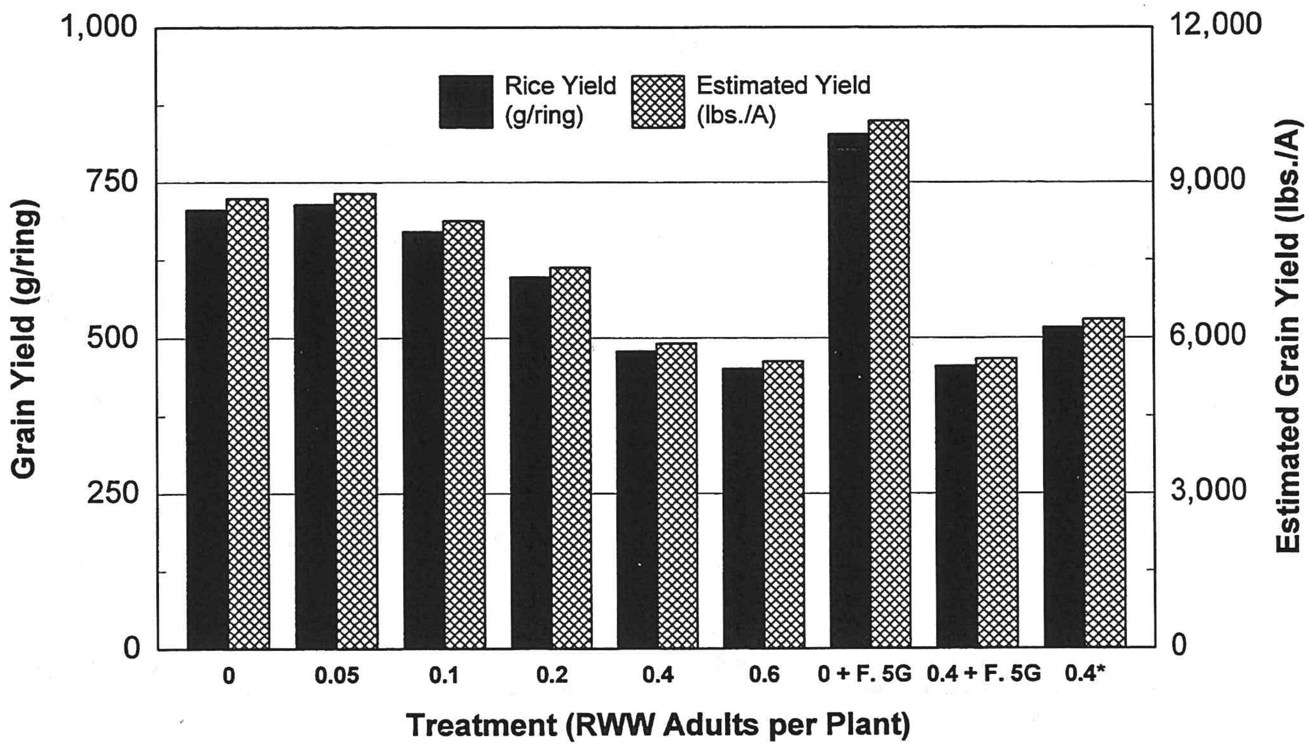
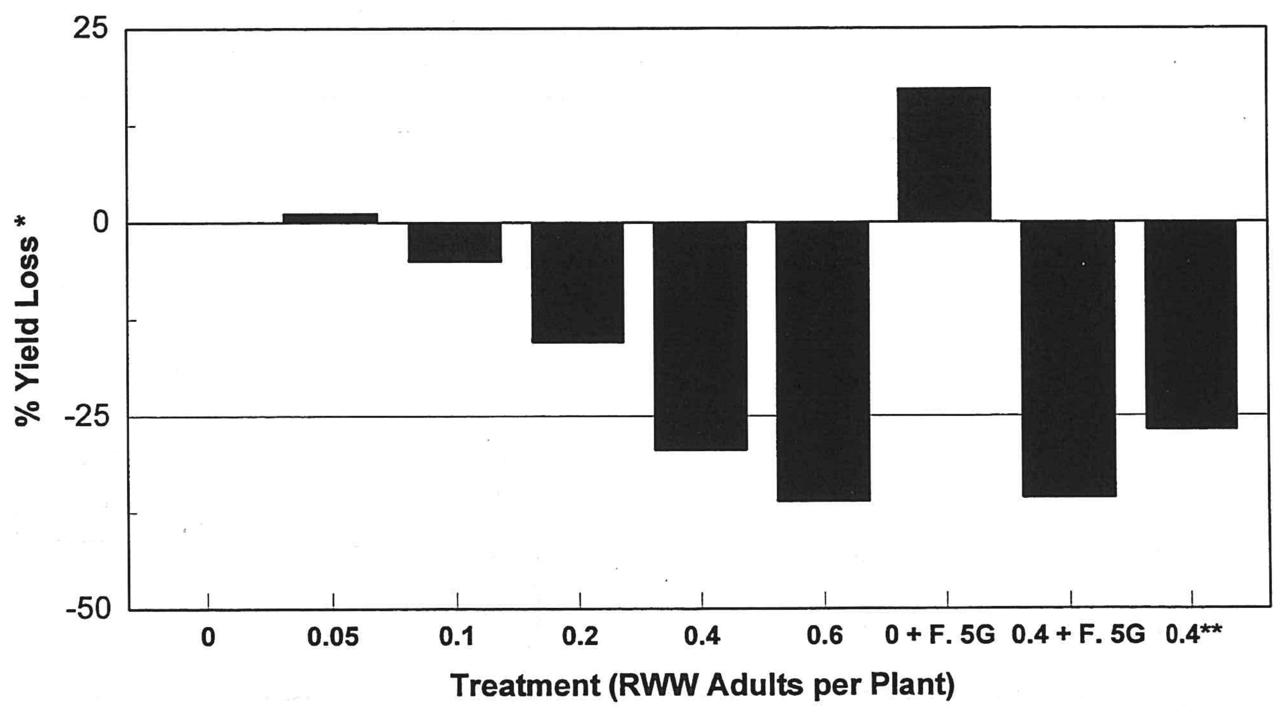

Treatment (RWW Adults per Plant)
0
0.05
0.1
0.2
0.4
0.6
0 + F. 5G
0.4 + F. 5G
35
30
25
20
15
Photosynthetic Rate (µmol/m²/s)
26 June
7 July
21 July
4 Aug.
18 Aug.
Sample Date

Fig. 4



* Unsampled except for yield

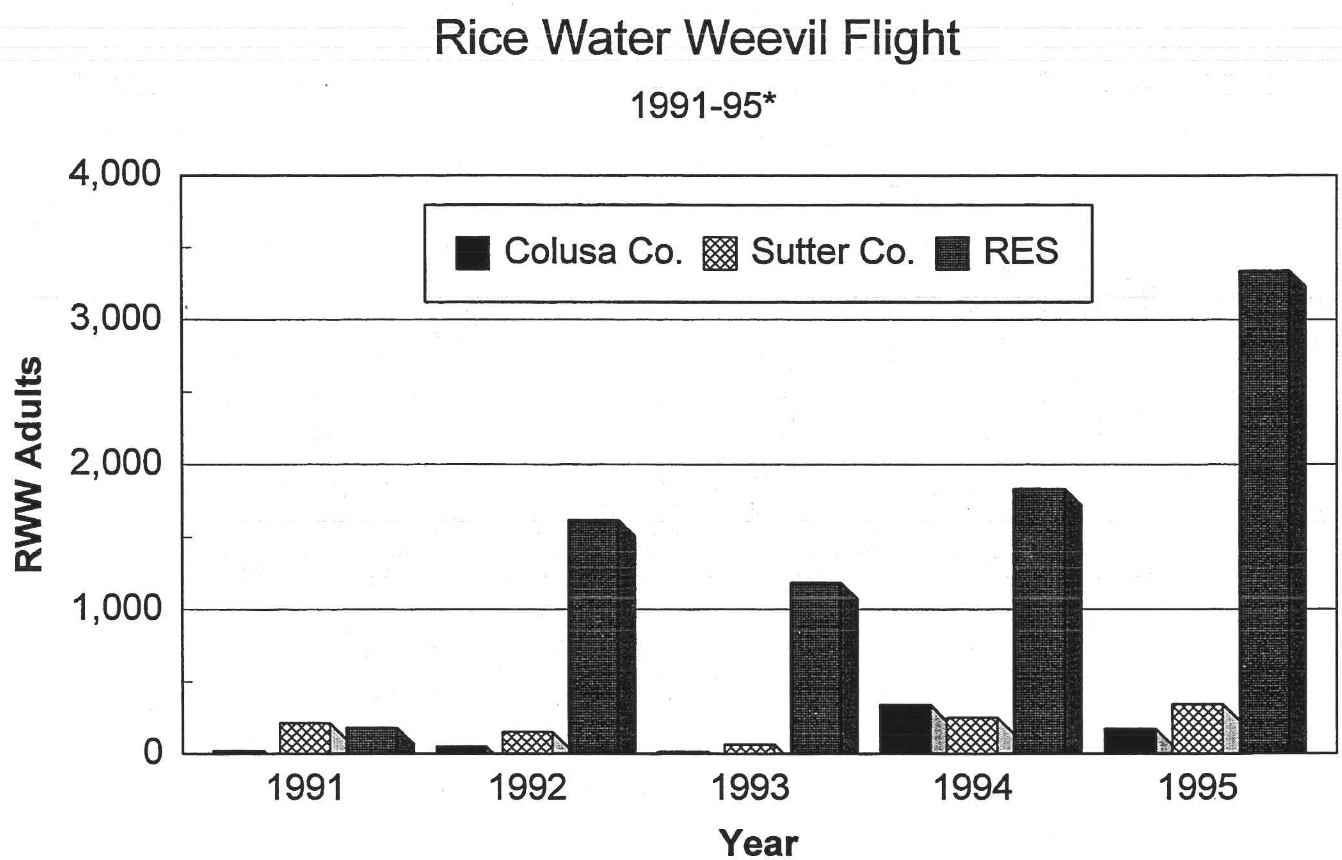
Fig. 5



* Compared with 0 adults per plant treatment

** Unsampled except for yield

Fig. 6



* April - June

Fig. 7

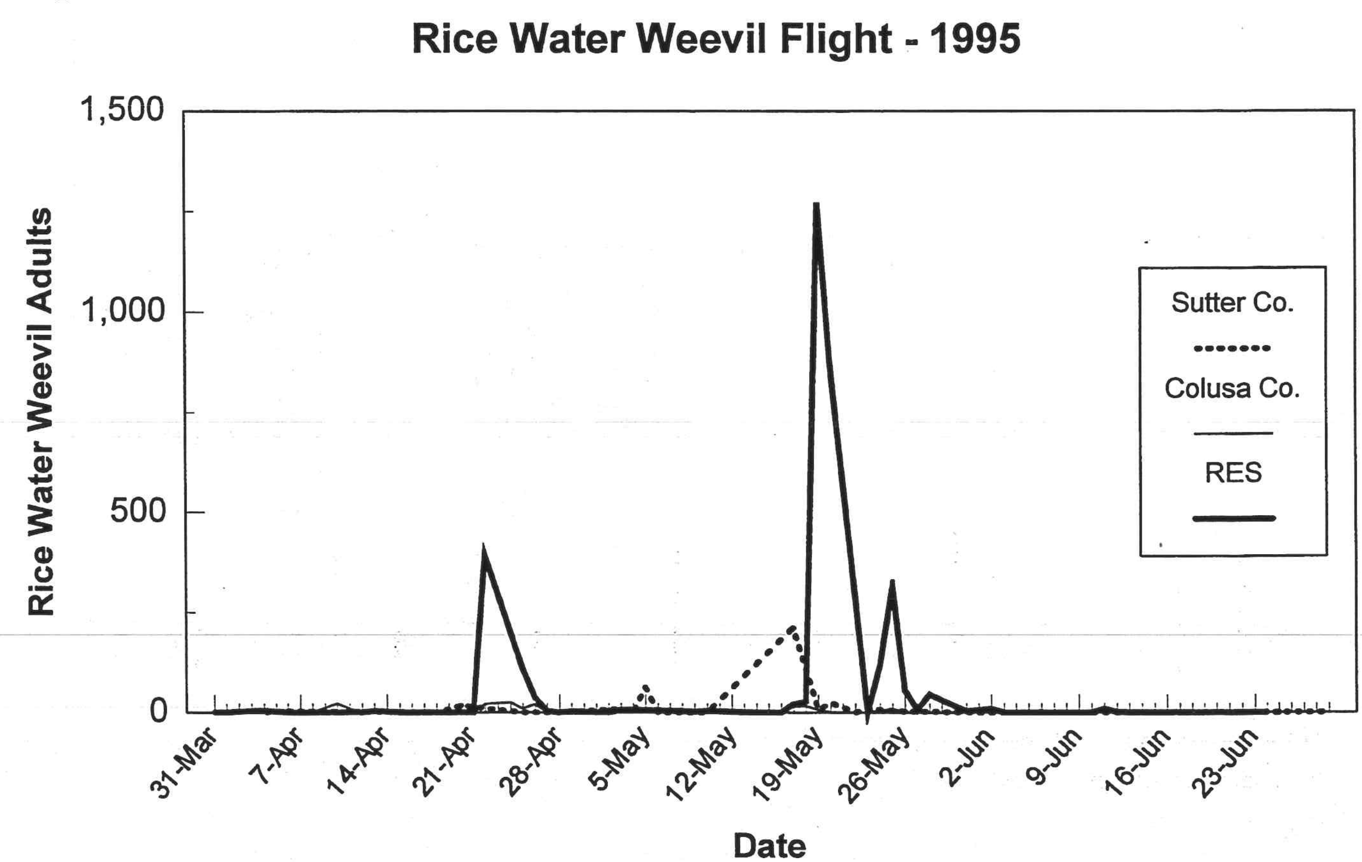
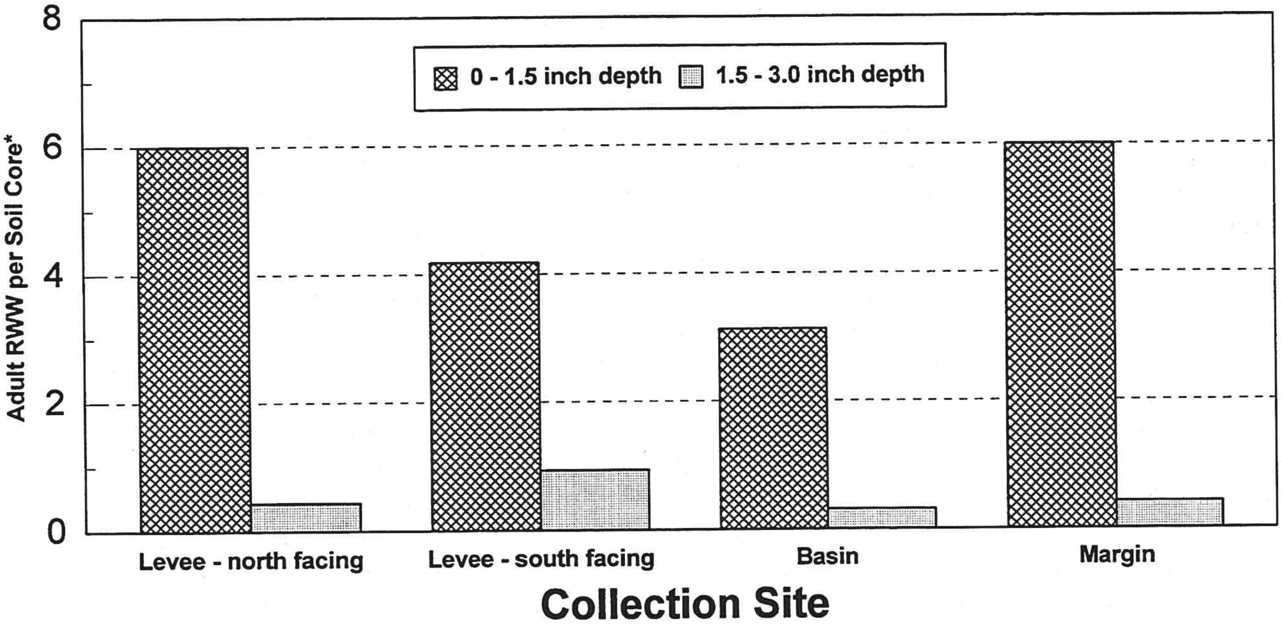


Fig. 8

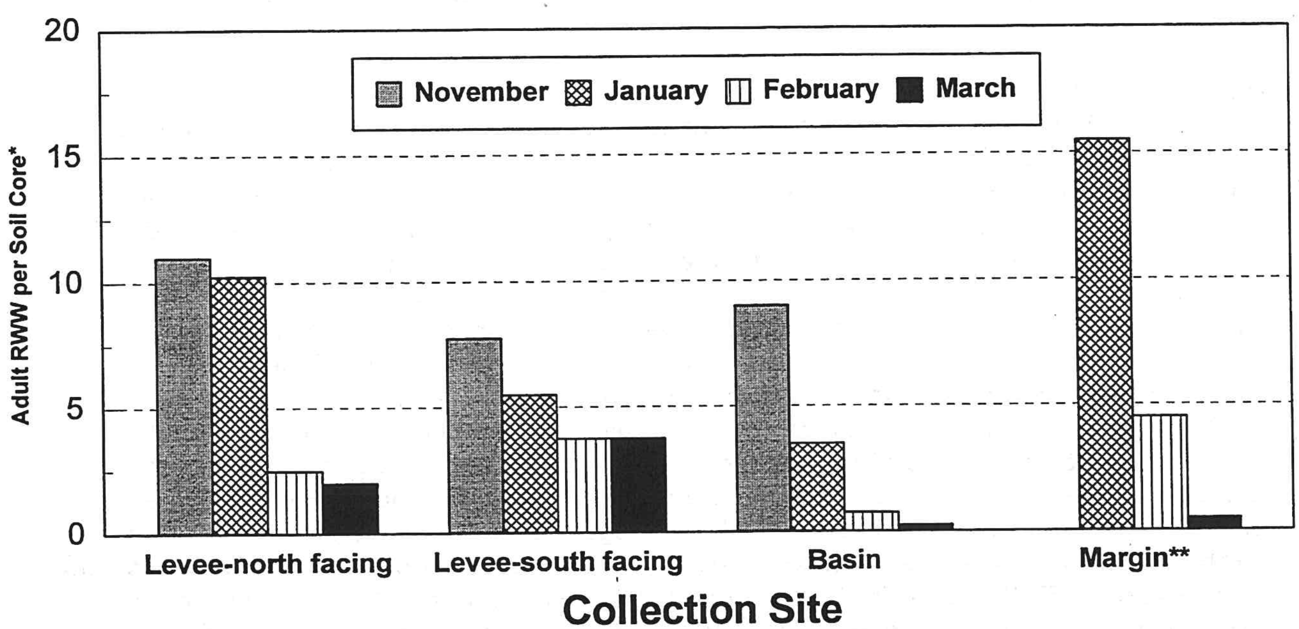
Rice Water Weevil Overwintering Abundance from Fallow Rice Fields in the Sacramento Valley, 1994-1995.



* soil cores measured approximately 4 inches diam. x 1.5 inches high
cores were collected in November, January, February, & March

Fig. 9

Rice Water Weevil Overwintering Abundance from Fallow Rice Fields in the Sacramento Valley, 1994-1995.



* soil cores measured approximately 4 inches diam. x 3 1/4 inches deep
** margin not sampled in November

Fig. 10

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S (1995) RESULTS:

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

Rice Water Weevil Control

Rice water weevil (RWW) management with insecticides was evaluated in three studies at the Rice Experiment Station and in 4 grower field sites. The efficacy of 6 chemical insecticide active ingredients (carbofuran, dimilin, fipronil, imidacloprid, lambda-cyhalothrin, and V-71639) and a total of 24 treatments was screened in ring plots in a replicated field study. Numerous formulations and application timings were used. Many of the treatments were an continuation of the 1994 testing. A natural RWW infestation was supplemented with field-collected adults placed into each ring. The percentage of plants with RWW feeding scars, RWW larval densities, plant growth, and grain yield, as well as phytotoxicity results, were recorded from all treatments. The Furadan 5G, preflood Fipronil 1.5G and 80WDG (0.0375 lb. AI/A) and Karate treatments were the most effective for larval control. However, several other treatments, including postflood Furadan 4F (0.5 lb. AI/A), preflood Fipronil 1.5G (0.0125 lb. AI/A), postflood Fipronil 1.5G and 80WDG (0.0375 lb. AI/A), and postflood Dimilin 25W (0.25 lb. AI/A) also provided good to excellent control with larval densities ~1 per plant or less. There was not a consistent yield response to the treatments in 1995; overall rice yields were lower in 1995 than in 1994. The efficacy of Dimilin was evaluated under pinpoint flood conditions. Larval control in these conditions was equal or slightly better than with a continuous flood system. The most promising treatments from the 1994 ring plot tests were evaluated in 1995 in small basins. RWW larval control with Furadan 5G (preplant and postflood), Fipronil 1.5G (preplant and postflood), Fipronil 80WDG (preplant), and Dimilin (postflood) was comparable and all treatments had significantly fewer larvae than in the untreated. Finally, the efficacy of Dimilin was compared with Furadan 5G, and an untreated, at four grower field sites. Both treatments were applied with commercial equipment. Overall, grain yields were similar with the Dimilin and Furadan treatments, and both yielded about 500 lbs./A better than the untreated. There was considerable variation among the four field sites.

Plant Response to Rice Water Weevil Injury

Two studies were conducted towards this objective. First, several levels of rice water weevil infestation were established to evaluate the influence of larval feeding on plant growth, development, and yield of 'M-202'. In the third year of this study, yield losses from rice water weevil have resulted during each year; however, the magnitude of the yield losses have varied from year to year. This is indicative of the variable effects, influenced by environmental conditions and resulting rice plant vigor, of rice water weevil on rice productivity. Larval population densities ranged from 1.8 to 18.0 larvae per plant in 1995. Several plant growth parameters were effected by larval injury. Tillering was reduced in the three highest larval infestations with the most severe reduction being 45.7%. The reduction in tillering largely accounted for the yield reduction. Rice maturity, in terms of date when 50% of the panicles had emerged, was not significantly effected by RWW larval feeding. This is consistent with the 1993 and 1994 data. Rice grain yield of 'M-202' was significantly reduced by RWW damage. Grain yield averaged 710 g/ring (=about 8700 lbs./A) in the uninfested and low infestation treatments and declined to 465 g/ring (=about 5700 lbs./A) in the high RWW infestation treatments. Therefore, grain yield was reduced by about one-third by the highest infestation densities. In a second study, the relationship between rice water weevil leaf scarring incidence, larval density, plant growth, and grain yield was examined under grower conditions. These data are needed to validate the information from the previous study (controlled conditions) and, in total, to re-evaluate the economic threshold for RWW on rice. The relationships among these variables in grower fields were poor and need to be further evaluated.

Rice Water Weevil Sampling

Sampling for rice water weevil infestations by determining the incidence of scarred plants is difficult and laborious. The goal of this project was to evaluate the use of sticky traps for sampling RWW adults. Several trap colors, types, and heights were studied. RWW capture was poor with all traps tested.

Rice Water Weevil Flight

Light traps were placed in Colusa and Sutter counties with grower cooperators, as well as at the Rice Experiment Station in Butte county, to monitor RWW flight in 1995. The 1995 flight was considerably greater in intensity than "average", based on 30 years of trap data. A total of 3,340 weevils were captured at the RES compared with 1,832 in 1994. Light trap data indicate that the spring dispersal flight at the RES consisted of one large peak on 20 May and secondary peaks on 22 April and 25 May. The date for completion of 95% of the flight was about 28 May. This compared with 16 May (1994), 15 May (1993), 7 May (1992), 30 May (1991), and 30 April (1990). The use of planting date in 1995 to reduce RWW infestations was not really practical due to the delayed flight period.

Rice Water Weevil Overwintering

RWW overwintering biology was studied in the fall 1994/winter 1995. This pest spends the winter in a diapause (inactive) state. Samples taken during the overwintering period showed that the majority of the RWW adults were concentrated in the top 1.5 inches of the soil/root crown area. Low numbers of adults were found between 1.5 to 3.0 inches. The most weevil adults were found on the north-facing levee and field margin; however, a surprising high number of weevils was found in the field basin (even though there was standing water in the basin from January to March). The density of RWW adults declined from November to March, probably representing natural mortality of RWW during the overwintering period.

Rice Water Weevil Diapause

The ability to break the winter diapause of the rice water weevil would be beneficial to allow additional laboratory/greenhouse investigations of this pest during the winter. A laboratory study was conducted in 1994-95 to attempt to define the conditions needed to terminate the diapause. RWW adults were field-collected in December, January, February, and March and exposed to various temperature/light/plant substrate conditions in the laboratory. Sample evaluation and data analysis are ongoing.