PROJECT NO. RP-3

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE

January 1, 1998 - December 31, 1998

PROJECT TITLE: Rice protection from invertebrate pests.

PROJECT LEADER AND PRINCIPAL UC INVESTIGATOR:
L. D. Godfrey, Extension Entomologist/ Associate Entomologist;
T. D. Cuneo, Post-Graduate Researcher;
Department of Entomology, One Shields Avenue,
University of California, Davis 95616

LEVEL OF FUNDING: $ 49,810

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION:

Objective 1: Evaluate the most effective control of rice water weevil with three insecticides that are proceeding toward registration (compared with Furadan ® 5G whose registration is scheduled for cancellation) 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 ®, Icon ®, Dimilin ®, and Warrior (Karate ®) for controlling the rice water weevil.

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

1.1.3) Compare efficacy of various formulations of new chemical, experimental products for controlling rice water weevil.

1.2) Rice water weevil control with new biorational products - Ring plots.

1.2.1) Evaluation of the efficacy of a bacterial based product, Novodor ™ (*Bacillus thuringiensis tenebrionis*), and a fungal product, Mycotrol ™ (*Beauveria bassiana*) for controlling rice water weevil.

1.2.2) Evaluation of application timing on the efficacy of Novodor and Mycotrol for rice water weevil control.

1.3) Rice water weevil chemical control - Grower field plots/ EUPs.

1.3.1) Evaluation of the efficacy of Dimilin 2L compared with Furadan 5G for controlling a natural infestation of rice water weevil in grower fields.

1.3.2) Evaluation of the efficacy of Icon 70 FS compared with Furadan 5G for controlling a natural infestation of rice water weevil in grower fields.

1.3.3) Evaluation of the efficacy of Warrior (Karate) 2EC compared with Furadan 5G for controlling a natural infestation of rice water weevil in grower fields.

1.3) Rice water weevil chemical control - Greenhouse studies.

1.3.1) Re-evaluate the influence of Dimilin 25W on rice water weevil to determine the number of days of activity following exposure.

1.3.2) Evaluate the influence of Novodor, a new biorational product, on rice water weevil to determine efficacy.

Objective 2: To evaluate the physical and biological factors that result in fluctuation and movement of populations of the rice water weevil so as to better time control options, such as insecticide applications.

2.1) Examine the influence of winter flooding on rice water weevil populations.

2.2) Investigate timing of rice water weevil oviposition in water-seeded, continuously flooded rice fields.

Objective 3: Monitor the movement of rice water weevil populations that result in economic injury to rice plants.

3.1) Monitor seasonal trends (timing and magnitude) in the flight activity of the rice water weevil at the Rice Experiment Station near Biggs with a black-light trap.

3.2) Monitor the timing and movement of rice water weevil with paper, colored sticky traps.

SUMMARY OF 1998 RESEARCH BY OBJECTIVE:

Objective 1:

1.1) Chemical Control of Rice Water Weevil - Ring Plots

1.1.1, 1.1.2 & 1.1.3) The efficacy of 26 treatments was evaluated in a replicated field study at the Rice Experiment Station (RES) in Biggs, CA. These treatments encompassed 8 chemical insecticide active ingredients. Three of the materials are in the registration process as replacements for Furadan 5G. Each treatment was replicated four times. Numerous formulations and application timings of the 8 active ingredients were used. Several of these treatments were a continuation of the testing we did in 1997 to further refine the timing and formulation of applicable products. The following treatments were evaluated:

Treatment	Rate (lbs.ai/acre)	Timing	Treatment Date
1. Furadan 5G	0.5	PPI	26 May
2. Dimilin 2L	0.063	5 d aft 50% emg	17 June
3. Dimilin 2L	0.094	5 d aft 50% emg	17 June
4. Dimilin 2L	0.125	5 d aft 50% emg	17 June
5. Dimilin 2L	0.188	5 d aft 50% emg	17 June
6. Dimilin 2L	0.125	50% rice emerg.	12 June
7. Dimilin 2L	0.125	first emg	11 June
8. Dimilin 2L	0.125	10 d aft 50%	22 June
9. Dimilin 2L	0.125	15 d aft. 50%	26 June
10. Mustang 1.5EW	0.03	3-5 leaf	17 June
11. Mustang 1.5EW	0.05	3-5 leaf	17 June
12. Mustang 1.5EW +oil	0.03 + 1 qt/ac	3-5 leaf	17 June
13. Decis 180EC	0.022	3 leaf	17 June
14. Decis 180EC	0.025	3 leaf	17 June
15. Warrior 2EC	0.03	3 leaf	17 June
16. Exp80698A	0.037	dry seeded	27 May
17. Exp80698A	0.05	water-soaked	27 May
18. CGA-293343 2G	0.18	PPI	26 May
19. Icon 70 FS	0.0325	PPI	26 May
20. Icon 70 FS	0.0325	postflood	17 June
21. Exp61685A 0.83EC	0.20	PPI	26 May
22. Exp61685A 0.83EC	0.20	postflood	17 June
23. USA 1	0.10	emg + 4-5 d aft	11&15 June
24. USA 1	0.20	emg + 4-5 d aft	11&15 June
25. Icon 2.5EC	0.05	PPI	26 May
26. Untreated	---	--	---

Testing was conducted with 'M-202' in 8 ft^2 aluminum rings at the Rice Experiment Station. The plots were flooded on 26 May (pm) and seeded on 27 May, 1998. The application timings were as follows:

26 May (am), pre-flood applications
11 June, first emergence
12 & 17 June, 50% emergence,
17 June, 5 to 7 days post emergence applications, 3 leaf stage
17 June, 5 days after 50% emergence applications
22 June, 10 days after 50% emergence applications
26 June, 15 days after 50% emergence applications

Granular treatments were applied with a "salt-shaker" granular applicator and liquid treatments were applied with a CO_2 pressurized sprayer at 18 GPA. Rice stand was evaluated and adjusted to 96 plants per 8 ft^2 aluminum ring on 22 June. The natural rice water weevil infestation was supplemented with 10 adults placed into each ring on 10 June and 5 adults each ring on 16 June. The following sample dates and methods were used for this study:

Sample Dates:

Emergence/ Seedling vigor: 17 June
Adult Leaf Scar Counts: 22 & 26 June
Larval Counts: 8 & 14 July
Plant Growth Characteristics: 8 & 14 July
Rice Yield: 29 September

Sample Methods:

Seeding Vigor/ Emergence:
1 = very poor stand (<20 plants)
3 = good stand (~100 plants)
5 = very good stand (>150 plants)

Adult Leaf Scar Counts: percentage of plants with adult feeding scars on either of the two newest leaves (50 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-thresher.

CHM Ring Study Results:

Rice Emergence

Early season growth was hindered by cool conditions and the seedlings were quite etiolated, but outgrew this symptom as the weather improved. No phytoxicity was seen from any treatment. The seedling establishment was slightly lower with the dry-seeded EXP80698A treatment; this probably reflected the non-standard seedling method (Table 1).

Adult Leaf Scar Counts

Adult leaf-scar damage normally is insignificant in terms of rice plant growth and development. Although, feeding scars are evaluated as a means to determine the effects of the treatments on adult density. In 1998, the feeding scar data were collected after all of the treatments were applied. Several treatments showed a marked effect on adult feeding. These were Mustang 1.5EW + oil at 0.03 (3-5 leaf), CGA293343 2G (PPI), EXP61685A 0.83E (postflood, 3-leaf), and USA 1 (0.1 & 0.2 ai/ac). All four treatments had scores that were below 10% scarring (Table 1). Adult mortality from the post-flood treatments is expected since the insecticide is sprayed on to the exposed RWW adults, adult mortality is the mode of action for

Mustang. All treatments, except for Dimilin, significantly reduced the percentage scarred plants. Dimilin, acting as an ovicide, does not directly kill RWW adults.

Larval Counts

RWW larval counts were made twice during the season. Most individuals were second and third instars and third instar and pupae at the first count and second counts, respectively. For both sample dates (8 & 14 July), counts in all chemical treatments were significantly lower than the untreated control rings which averaged at 5.3 and 11.6 RWW per core, respectively. In the 8 July samples, densities ranged from 0 to 5.3 RWW per core. Twenty treatments averaged below the economic threshold of 1.0 larva per plant (Table 2) for the first sample date. Treatments that averaged below Furadan 5 G at 0.60 RWW per core were Dimilin 2L, 0.125 (1st emg & 50 % emg), Mustang 1.5EW, 0.03 & 0.05 (3-5 leaf), Mustang 1.5 EW + oil, 0.03 + 1 qt/A (3-5 leaf), Decis 180EC (1.5 lb), 0.022 & 0.025 (3 leaf), Warrior 2EC, 0.03 (3 leaf), Exp80698A, 0.037 (dry seeded) & 0.05 (water-soaked), CGA-293343, 2 G, 0.18 (PPI), Icon 70 FS, 0.0325 (PPI & postflood), Exp61685A, 0.83 EC, 0.20 (PPI), USA 1 0.10 & 0.20 (emg + 4-5 d aft) and Icon 2.5EC, 0.05 (PPI). Dimilin 2 L, 0.125 & 0.188 (5 d aft 50 % emg) were at 0.80 RWW per core. On 14 July, the RWW immature densities ranged from 0 to 11.6 RWW per core. On the average 19 treatments were below 1 larva per core. Furadan 5G averaged at 3.0 RWW per core, above the allowed economic threshold and was much higher than the first sample date indicating a decrease in efficacy. Overall, Furadan was the only treatment that showed a marked difference between the larval counts from the first to the second sample date.

Plant Growth Characteristics

Plant growth is a good measure of the immediate impact of RWW feeding. The 1998 field season quantification of plant growth characteristics is still on-going in the laboratory.

Rice Yield

Rice yield was evaluated on 29 September. Grain yields were similar in comparison with the 1997 results. The yields in the untreated rings were 983.2 g/plot in 1997 and 976.8 g/plot in 1998. This was less than 1 % difference. In the Furadan 5G (0.5 lb. AI/A pre-plant incorporated) treatment, the yields were 1015.5 g/plot and 1170.0 g/plot in 1997 and 1998, respectively (Table 3). In 1998, yields ranged from 808.3 to 1235.5 g/plot. Yield was lowest in the Dimilin 2 L, 0.125 (10 d aft 50% emg) plots and highest in the Icon 70 FS, 0.0325 (PPI) treatment. Similarly in 1997 study, this same Icon treatment exhibited the highest results at 1308.1 g/plot.

1.2) Rice Water Weevil Control with Biorationals - Ring Plots

1.2.1) The efficacy of two biorationals was studied in a replicated field study. Bacterial and fungal compounds appear to have the most promise and several companies are developing these materials as insecticides. The efficacy of Novodor (Abbott Laboratories) and Mycotrol (Mycotech Inc.) was evaluated in comparison to Furadan 5G and untreated control rings. The ring studies, are always the first step in the screening process of new materials and are useful for screening numerous treatments. If a product shows good potential for management of rice water weevil then it will be tested in a larger basin study at the Rice Experiment Station and/or at a grower field site.

Testing was conducted with 'M-202' in 8 ft^2 aluminum rings at the Rice Experiment Station. The plots were flooded on 26 May (pm) and seeded on 27 May, 1998. The liquid treatments were applied with a CO_2 sprayer at 18 GPA and the granular Furadan was applied by hand with a "salt shaker applicator". Two installments of RWW adults were added to the rings, first ten on 10 June, second five adults on 16 June.
The following treatments and application timings were used in these ring studies:

Treatment	Rate (ai/acre)	Timing	Appl. Date
1. Furadan 5G	0.5 lbs	PPI	26 May
2. Novodor	4 qts	PPI	26 May
3. Novodor	4 qts	3 leaf	17 June
4. Novodor	4 qts	5 leaf	22 June
5. Novodor	4 qts	3 + 5 leaf	17, 22 June
6. Mycotrol	2 qts	PPI	26 May
7. Mycotrol	3 qts	3 leaf	17 June
8. Untreated	-----	-------	----

Sample Dates & Sample Methods:
Same as in 1.1.1

Biorational Ring Study Results:

Scar Counts/Stand Ratings

Greenhouse studies (1994) conducted with Mycotrol showed good adult activity; work with Novodor in 1998 (1.3.2) showed potential to control RWW larvae. Plant stand ratings on 17 June were good at ~ 100 (rank ~ 3.0) plants per ring (Table 4). Adult leaf scarring ranged from 18 to 86 % for the 1st date and 0 to 67 % on the 2nd. The lowest treatments being Mycotrol 2 qts & 3 qts/acre (PPI & 3 leaf). The highest percentage of scar counts, for both dates, was the Novodor 4 qts/acre (PPI) treatment and the untreated control rings at 86 & 62 % and 73 & 67 % respectively (Table 4).

Larval Counts

The larval counts ranged on 8 July from 1.35 RWW per core for Furadan 5G to 7.20 per core for the untreated rings (Table 4). Therefore, all rings averaged higher than the 1.0 RWW per plant economic threshold. Even though the numbers were higher than the economic threshold, 75% of the treatments were significantly lower than the untreated rings, indicating some activitity either by killing the RWW adults or larvae. On the 2nd coring date (14 July), the counts ranged from 1.70 for Furadan to 12.0 RWW per core for untreated rings. Here again, with the exception of Novodor (PPI & 3 leaf), 65% of the treatments were significantly lower than the untreated rings. The best Novodor and Mycotrol treatments averaged 79% and 75% RWW control respectively, compared with 83% control with the standard Furadan. Therefore control with the biologicals was very similar to that of Furadan (Fig. 1).

Rice Yields

Average yields (Table 5) in the biorational ring study ranged from the lowest at 697.8 g/plot in the Mycotrol, 3 qts (3 leaf) to the highest at 1101.9 g/plot in Novodor, 4 qts (3 + 5 leaf). The average for the untreated control and Furadan 5G rings were 904.9 g/plot and 1026.8 g/plot, respectively. Further testing is recommended to re-evaluate these results.

1.3) Rice Water Weevil Chemical Control - Grower Field Plots/ EUPs.

The efficacy on RWW of Dimilin 2L, Warrior (Karate) 2EC and Icon 70FS was studied in comparison with standard pre-plant Furadan 5G (and untreated plots) in grower fields in 1998. In cooperation with Uniroyal Chemical Co. (Dimilin), Zeneca Ag. Products (Warrior), and Rhone-Poulenc Ag. Products (Icon) personnel, 11 field sites were set-up under an Experimental Use Permit. Five of the sites were in Butte Co., two in Sutter Co., two in Placer Co., one in Colusa Co., and one in Yuba Co. Border versus full-basin treatments of Dimilin and Warrior were examined at six and four sites, respectively. At each site, the respective treatments were applied to borders only (~50 ft) or entire basins of several acres within individually leveed plots. The percentage scarred plants was sampled as previously described in all fields in June. Most sampling was concentrated ~ 10 feet from the levee so as to have the highest RWW densities. For the border treated areas, an additional sampling site was placed at ~ 60 feet from the first flag in an untreated area to examine for differences between full treated basins and borders treated only. Rice water weevil larval samples (using previously described procedures) were taken in June and July at a time when populations were mostly large larvae and some pupae. This timing was chosen so that late-deposited eggs would have hatched. In addition, larger larvae are easier to recover with our sample processing methods. Lastly, grain yields were estimated by hand harvesting four 10.8 ft^2 areas per plot and recovering the grain with a "Vogel" mini-thresher. In addition to the hand-harvest yields, machine harvest yields were taken at the Icon and Dimilin (5 of 6) study sites. The field site locations, treatments, seeding, application, and sampling dates were as follows:

County	Study	Seeding	Application*	Scar Counts	1st Cores	2nd Cores	Hand Harvest	Machine Harvest
Sutter	**Dimilin**	18-May	12-Jun	15-Jun	2-Jul	13-Jul	18-Sep	20-Sep
Placer	"	18-May	8-Jun	11-Jun	1-Jul	16-Jul	22-Sep	25-Sep
Yuba	"	21-May	9-Jun	11-Jun	29-Jun	10-Jul	24-Sep	30-Sep
Butte	"	8-Jun	26-Jun	29-Jun	17-Jul	22-Jul	21-Oct	26-Oct
Butte	"	13-Jun	1-Jul	9-Jul	20-Jul	23-Jul	9-Oct	10-Oct
Butte	"	26-May	15-Jun	19-Jun	15-Jul	21-Jul	9-Oct	10-Oct
Sutter	**Icon**	27-May	23-May	15-Jun	1-Jul	13-Jul	23-Sep	7-Oct
Butte	"	10-Jun	6-Jun	29-Jun	9-Jul	17-Jul	13-Oct	19-Oct
Colusa	**Warrior**	2-May	21-May	16-Jun	24-Jun	6-Jul	2-Oct	10-Oct
Yuba	"	21-May	4-Jun	9-Jun	29-Jun	10-Jul	28-Sep	30-Sep
Butte	"	17-May	4-Jun	5-Jun	29-Jun	9-Jul	21-Sep	23-Sep
Placer	"	25-May	6-Jun	10-Jun	30-Jun	10-Jul	na**	5-Oct

*All Dimilin 2L (8, 12 & 16 oz) applications were broadcast with a fixed-wing aircraft; Furadan 5G treatments were pre-plant incorporated; Icon 70 FS was applied as pre-plant with a ground applicator; Warrior 2 EC was applied with a fixed-wing aircraft.
** Grower harvested before hand harvest samples could be taken.

1.3.1) The efficacy of Dimilin 2L at three rates (8, 12, 16 oz/acre) and two types of applications (basin & border) was studied in comparison to Furadan 5G (and to untreated plots). The Dimilin application rates and timings were similar among the six study sites. In contrast to the 1997 grower field study, border treatments were added in 1998. Therefore, in addition to the sample sites 10 feet flag from the levee, the border treated fields had a sample site at 60 feet from the first. For the border treatments, this site was located in an untreated area to compare the differences between the border treatments and the full-basin treatments.

Over all the sites the percentage scarred plants ranged from 2.3% for Furadan to 64.5% for the Dimilin (8+8oz) border treatment (Table 6). The scarred plants in the untreated exceeded the threshold of 10-20% at 33.0%. Larval densities ranged from 0.24 RWW per core for Furadan to 2.60 for a Dimilin (12 oz) border treatment. However, the (12 oz) border treatment was only studied at one site in Butte county which had a high number of RWW in all treatments. Averaged over all the sites, the remaining Dimilin treatments were lower than the economic threshold of 1 RWW larva per plant and below the untreated fields at 1.23. Over all the Dimilin treatments the (16 oz) border treatment averaged the lowest at 0.46 larva per core; Dimilin (8 oz) full-basin was second lowest at 0.65.

Averaged overall in 1998, none of the hand-harvested grain yields for the Dimilin treatments were higher than the Furadan 5G treatment (Table 6). However, three of the six Dimilin treatment (8 oz-full, 12 oz-border and 16 oz-full) hand yields exceeded the untreated plots. Only five of the six Dimilin sites were machine harvested and out of these, in 4 of the 5 sites, Dimilin yielded more grain than the untreated areas and were greater than or comparable to the Furadan fields. The averaged results from the machine harvested areas showed that no Dimilin treatments were higher than the Furadan and only two Dimilin yields were higher than the untreated plots.

Larval control with Dimilin for all three rates in 1998 was greater than in 1997; however, grain yields were lower. Better larval control could be attributed to application timing (in 5 of 6 sites). Lower grain yields most likely had to do with delayed planting because of adverse weather (El Niño) conditions in the spring. As has been mentioned before, timing is critical for postflood treatments just as Dimilin, and as we have discovered by oviposition studies (1994-1998; 2.2), RWW commence laying eggs as early as the 2-leaf stage and are the most prolific at about the 4-leaf stage. Even with the delayed growing season, Dimilin did provide good protection of yield in 1998 (Fig 2).

1.3.2) The efficacy of Icon 70FS was studied in comparison to Furadan 5G (and to untreated plots). All applications were made preplant. All Icon applications were made by ground sprayer to ~ 4 acre plots. The untreated areas were similarly sized. A Furadan comparison was examined at only one site in 1998.

The percentage scarred plants ranged from 2.0 to 45.5% (Table 7). The lower result represents two fields, one with Icon 70FS and the other with Furadan 5G. The highest result was from an untreated field. The percentage averaged for the Icon 70 FS treatments was only 4.5% (Table 8). Overall, the average percentage in the Icon treatments was slightly higher than in the Furadan treatment. The 32.5% scarred plants in the untreated exceeded the threshold of 10-20%. Average larval densities ranged from 0.2 for Furadan to 2.35 (Table 7) per core for the untreated, and averaged over the two sites, the density was 0.3 in the Icon treatment (Table 8). Rice water weevil larval densities in the Icon treatments were comparable to the Furadan 5G treatments and much lower than the untreated plots. All chemical treated areas had lower RWW per core when compared to the untreated plots. Therefore, the larval densities were reduced by the both of the insecticides.

The average, hand-harvested yield for Icon, at one site (Butte Co.) was lower than the Furadan 5G but higher than the untreated plot (Table 7). The average yield from the machine-harvested Icon areas was higher than the Furadan 5G plot and untreated plots. Averaged for both sites, the machine-harvested Icon yields were higher than Furadan at 8156 lbs/ac but lower than the untreated plots (Table 8). Because of an unusually wet spring, overall in 1998, rice yields were affected (i.e., generally lower) by delayed planting dates. The (machine-harvested) Icon treated areas yielded on average about 500 lbs./A more than Furadan 5G and 200 lbs./A less than the untreated areas.

Icon has consistently provided outstanding larval control in our past studies both as a preplant material and also used postflood. It also shows potential as a seed treatment.

1.3.3) The efficacy of Warrior 2EC was studied in comparison to Furadan 5G (and to untreated plots). The Warrior application rates were similar among the four study sites. All Warrior applications were made by air to borders (~50 ft) only or to entire basins over several acre plots within individual-leveed checks. The untreated areas were similarly sized.

The percentage scarred plants in the tests ranged from 4.5 to 62.5%. These two results were recorded from Warrior full-basin and untreated plots, respectively. The percentage averaged for the Warrior 2EC treatments was 21.6% for full-basin and 11.9% for border treatments (Table 9). Overall, the average percentage in the Warrior treatments was higher than in the Furadan treatments but much lower than the untreated. The 43.8% scarred plants in the untreated exceeded the threshold of 10-20%. Larval densities per core ranged from 0 to 3.45, and averaged over the sites, the density was lowest (0.06/core) in the Warrior full-basin treatment (Table 9). All treatments had larval densities lower than the untreated plots at 1.76 RWW per core which exceeds the economic threshold. In addition, at all sites with a Furadan comparison, the Warrior treatments performed better in reducing the numbers of RWW larvae (Fig. 3). This was most likely due to better postflood application timing (2-4 leaf stage) of Warrior in 1998.

Machine yields were not done at the Warrior sites. Average hand yields for Warrior were lower than the Furadan yields but higher than the untreated plots (Table 9). Overall, Warrior treatments yielded on average about 1200 lbs./ac less than Furadan 5G and 800 lbs./ac more than the untreated areas.

1.4) Greenhouse studies

1.4.1) In 1998, a greenhouse study was continued to evaluate the activity of Dimilin. This was a continuation of the 1996-97 study detailed in the 1996 report. The study was designed to examine how many hours of feeding is necessary to exert an effect on the adults and the number of days after exposure that Dimilin exerts an effect on RWW oviposition. There were two experiments performed.

Rice plants were grown in a UC-Davis greenhouse in 32 oz. plastic cups within soil from the RES. Once the plants reached the 3 to 4-leaf stage, the appropriate Dimilin treatments were applied, the plants were caged, and field-collected RWW adults were introduced. The introduction and removal of the adults were manipulated so that the above objectives could be addressed. Plants/soil was processed and RWW larvae counted. For the experiment designed to evaluate how long the RWW adults need to feed in order to be affected by the chemical, our 1998 results confirmed that as little as 4 hrs is necessary to exert an effect on RWW oviposition. Results for the experiment, on the number of days after exposure that Dimilin exerts an effect, are presently being analyzed.

1.4.2) A new biorational product was studied in the greenhouse in 1998. Novodor (*Bacillus thuringiensis tenebrionis*, Btt) was evaluated to observe its efficacy on adult feeding, mortality, and oviposition.

Rice plants were grown in a UC-Davis greenhouse as in the above Dimilin experiments. There were two experiments. In one, the plants were sprayed with Novodor (4 qt/ac, 20GPA) and then allowed to dry. Field collected adults were introduced and allowed to feed and oviposit for 48 h. The adults were then removed and feeding scars were counted for each pot. The removed adults were then housed on healthy plants for several days to access mortality. In the second experiment, Novodor was sprayed onto the plant foliage 48 h before the adults were allowed to feed to evaluate efficacy of Novodor. After the 48 h period, the adults were introduced to oviposit for 48 h. Again, they were removed and scar and larval counts accessed. Untreated plants were used as controls in all trials. Plants/soil were processed and RWW larvae counted.

For the first experiment (in early spring) there was no apparent effect on adult feeding or mortality associated from the Novodor treatment. However, the average number of RWW immatures in the Novodor treated pots were clearly different and lower (i.e., 0 vs. 38) from the numbers in the untreated control pots. Unfortunately, the late spring trial for this first experiment gave a different result, with no significant differences between the number of RWW in the treated and untreated pots. In Experiment 2 (sprayed 48 h before oviposition), there was no difference in the number of RWW between treatments. Further testing is recommended, analyses are pending for these experiments.

Objective 2: To evaluate the influence the physical and biological factors that result in fluctuation and movement of populations of the rice water weevil so as to better time control options, such as insecticide applications.

2.1) Examine the influence of winter flooding on rice water weevil populations.

Winter Flooding

The influence of winter-flooding on rice water weevil populations was examined at three locations. However, some compromises were made at each location. High winter and spring precipitation resulted in most rice fields being "winter-flooded". Scarred plant and larval data were collected as previously described. In addition, rice water weevil oviposition was monitored 2 to 3 times per week from ~14 to ~30 days after seeding. Seedlings (40/date) were collected and held in the laboratory until newly hatched larvae appeared. These larvae were counted to estimate oviposition timing and magnitude.

Studies were conducted at the straw management study site near Maxwell (Colusa County). We have been collecting data at this location for the past 4 years and the winter-flooding has consistently reduced rice water weevil larval densities. In 1998, we sampled the winter-flooded versus non-flooded main plots (Fig. 4). Unfortunately, the entire site was flooded from 3 to 17 February 1998. This undoubtedly influenced the results in 1998 as there were no significant differences between the two treatments (in fact the results were the opposite of previous years) (Table 10). Egg density, incidence of scarred plants, and larval numbers were actually slightly higher in the winter-flooded compared with the non-flooded. In addition, the straw management site in Butte Co. (RES) was similarly sampled. Very few RWW were found at this site probably because of the late seeding date (late June).

The final comparison was in grower fields in Sutter County. Two nearby fields were used, but the planting dates were 14 days apart because of the unfavorable spring for planting. The winter-flooded field had less oviposition and slightly lower percentage scarred plants compared with the non-flooded field (Table 11). The abnormal rice water weevil flight timing and infestation method may have influenced the 1998 results for this objective. A more favorable year in terms of weather will allow us to make more progress towards this objective.

2.2) Investigations of timing of rice water weevil oviposition in water-seeded, continuously flooded rice fields.

Oviposition Study

The pattern of RWW egg-laying is important for determining the timing of post-flood applications. Dimilin and Warrior have no activity on RWW larvae and must be applied before significant egg deposition. With pre-flood treatments, the precise timing of egg-laying is unimportant. RWW oviposition was monitored in 1998 in 11 grower rice fields. Seedlings were collected 2-3 times per week and taken to the laboratory to determine the incidence of RWW eggs. Water depth, days after seeding, and rice leaf stage were also recorded and considered in relation to egg deposition. RWW egg incidence was not related to water depth. Egg deposition started as early as the 1-2 leaf stage and peaked from the 3-4 leaf stages (Fig. 5). Some oviposition occurred as late as the 7 leaf stage, but this was very low. Egg-laying continued for 4 to 27 days (from initiation to conclusion) depending on the site. Looking at days after seeding, most eggs were deposited from 9 to 32 days after seeding (Fig. 6). This is, of course, dependent on the environmental conditions and how fast the plants grow. Again, some eggs were deposited as soon as 9 days after rice seeding and as late as 39 days after seeding. Additional analyses needs to be done to see what factors influence the length of the ovipositional period. The pattern of oviposition varied significantly over the 12 fields examined. For instance, the fields with the shortest and longest period of egg-laying are depicted in Fig. 7. Over about the same 3-4 week period, egg-laying in one field took place at a constant rate from the 1 to 6 leaf stage whereas in another field egg-laying was completed from the 2 to 4 leaf stages. With a 27 day ovipositional period, a short-lived treatment such as Warrior would not persist long enough to prevent late oviposition. This as well as the timing of the initiation of egg-laying will be critical for the efficacy of post-flood treatments.

Objective 3:

3.1) Evaluation of the movement of RWW populations that result in economic injury to rice plants. Monitor seasonal trends (timing and magnitude) in the flight activity of the RWW.

The timing of RWW adult flight in the spring has been monitored for several years with a black light trap. Monitoring weevil flights is important to determine the levels and intervals of peak flight periods which provides important baseline data on the timing and intensity of the spring weevil flight.

In 1998, readings were taken from the light trap housed at the Rice Experiment Station (RES) in Butte Co. This trap is used to provide a continuation of the light trap RWW record that began in 1962. Peak flights in 1998 occurred at the RES on 21 April and 28 to 30 April (Fig. 8). The last major peak was on 28 April. April 29 marked the completion of over 90% of the weevil flight at the RES. A total of 1206 weevils were captured in 1998 at the RES. This was about 53% lower than the number caught in 1997. The location of the trap and protocol has been exactly the same over this period.

The flight timing in 1998 (date of 90% flight completion) was about a month earlier when compared to 1997; in addition, the number was much (~50%) lower (Figs 8 & 9). The period of flight (capture of weevils) in 1998 was about 2 weeks longer than in 1997, and ran from 17 April to 1 June. Looking at the past five rice seasons (1994 to 1998), there was an increasing trend in numbers of RWW captured from 1994 to 1996, but the number dropped in 1997 to ~2500 in 1998 to ~1200 (Fig. 10). Compared to 1997, spring of 1998 was much wetter and still cool. Wet, cooler temperatures may have increased overwintering adult mortality and delayed the emergence of RWW adults from overwintering and therefore the occurrence of the 1998 spring flight.

3.2) Monitoring movement of adult RWW with colored sticky traps.

Paper sticky traps were placed at two field sites (Colusa & Butte counties) in order to evaluate their utility in monitoring the seasonal flight and/or movement of emerging overwintering adults during early spring 1998. Two sets each of yellow and white paper traps (dish and cone-shaped) were painted with Tanglefoot® and placed in grower fields on levees ~ 8 inches off the ground immediately after flooding and rice seeding. They were monitored twice per week (until 3-leaf stage) for RWW activity and number of adults were tallied. No adults were found on any of the eight sticky traps at either site. These sticky traps are used in the southern rice states for monitoring RWW populations; RWW in California are not captured by these traps.

PUBLICATIONS OR REPORTS:

Cuneo, T. D. and L. D. Godfrey. 1998. Effect and efficacy of Dimilin on rice water weevil, *Lissorhoptrus oryzophilus* (Coleoptera: Curculionidae), greenhouse studies in California. J. Econ. Entomol. (in review)

Cuneo, T. D. and L. D. Godfrey. 1998. Rice water weevil biology: Implications for improved management. Rice Technical Working Group Report (in review), p 40.

Cuneo, T. D., L. D. Godfrey and C.C. Baca. 1998. Optimizing efficacy of new rice water weevil management tools- 1997-98. Calif. Rice Experiment Station Field Day Report. pp 4-6.

Cuneo, T. D. and L. D. Godfrey. 1998. Rice water weevil management with insecticides - changes for 1999? Calif. Rice Experiment Station Field Day Report. pp 47-50.

Godfrey, L. D., T. D. Cuneo, C. L. Alexander and C. C. Baca. 1998. Rice water weevil flight and oviposition timing: Keys to managing this pest with postflood treatments. Calif. Rice Experiment Station Field Day Report. pp 8-9.

Godfrey, L. D. and T. D. Cuneo. 1997. Annual report comprehensive research on rice, RP-3.

Godfrey, L. D., T. D. Cuneo. 1998. 29th Annual report to the California rice growers. Protection of rice from invertebrate pests.

Godfrey, L. D. and P. L. Tocco. 1998. Metabolic and biochemical effects of rice water weevil feeding on rice. Rice Technical Working Group Report (in review), p 40.

PROJECT NO. RP-3

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S (1998) RESULTS:

Larry D. Godfrey and Terry D. Cuneo

Research was conducted in 1998 on important aspects of rice water weevil (RWW) biology and on management (cultural and chemical) of this insect pest. Significant progress was made on all objectives. Preplant applications of Furadan® 5G are the standard method of controlling rice water weevil in California; application is generally made only to the field borders. Registration of this insecticide is scheduled for cancellation. This has hastened the need for additional insecticidal products, refined cultural controls, and knowledge of rice water weevil biology.

Chemical Controls: Three products, Dimilin® 2L, Warrior® 2EC, and Icon® 70FS are in the registration pipeline. Dimilin and Warrior are applied post-flood over the field. These products were evaluated in grower field tests at 11 locations within 2-10 acre plots. A key question regarding these products is if they will provide efficacious rice water weevil control when applied only to the borders of the field compared with applications to the entire basins. Economic RWW populations generally only occur in the first 30-50 feet of the field adjacent to the levees. Averaged over six locations, rice water weevil larval populations averaged 1.23 per core sample (untreated), 0.24 (Furadan standard), 0.60 (Dimilin full basin), and 1.30 (Dimilin border treatment). The border treatment average was high due to a high RWW density at one site and late Dimilin application. Without this one site the average for the border treatments was 0.66 RWW per core. The border treatment was made to ~50 feet of the field against the levees. Machine yields for these treatments averaged 6556 (Dimilin-full), 6092 (Dimilin-border), 6946 (Furadan), and 6532 (untreated) lbs per acre. For the other prospective rice water weevil post-flood product (Warrior), studies were conducted in four grower field locations. Averaged over these four sites, untreated basins averaged 1.7 larvae per core sample compared with 0.06 for the Warrior full basin treatment. The border Warrior treatment was comparable with 0.08 rice water weevil per core. Furadan resulted in 0.3 rice water weevil per core. Yield data were 6161 (untreated), 6970 (Warrior-full), 6854 (Warrior-borders), and 8173 lbs per acre for Furadan. Icon (pre-plant incorporated) was tested in two grower fields; results showed effective rice water weevil control. Therefore, all three products successfully controlled this pest in 1998 testing; preliminary results indicate that borders treatments are also effective. At a Butte county location, Icon treatments averaged 0.2 RWW per core compared with 2.4 and 0.1 for the untreated and Furadan, respectively. In addition, at this site, Icon plots yielded more than the untreated and similar to Furadan.

Additional products were tested in small plot (8 ft^2 ring) studies. Two pyrethroid products, three experimental numbered compounds (all preplant), and Icon seed treatments were examined. These products provide flexibility and a backup position for registration. Several of these treatments provided excellent RWW control with RWW numbers ranging from 0 (Decis & Mustang) to 0.4 (Exp80698-seed treated). The influence of application timing on Dimilin 2L efficacy was additionally studied. Applications at first rice emergence through water, 50% emergence, and 5 days after performed much better (0.1 & 0.4 RWW per core) than 10 and 15 days after 50% emergence (3.4 & 3.3 RWW per core). Results were similar to 1997 with slightly less activity early and more activity later in 1997. With the exception of five treatments (< 20%), 20 treatment grain yields exceeded the untreated control rings. Finally, the efficacy of biological, biorational products on rice water weevil was evaluated in ring plots. A bacteria, Novodor® (*Bacillus thuringienisis_tenebrionsis*), and a fungus, Mycotrol® (*Beauveria bassiana*) were evaluated. Novodor (applied at the 3 and 5 leaf stages) and Mycotrol (3 leaf stage) gave 77 and 74%, respectively, control compared with 83% control for Furadan. Novodor was also evaluated in a greenhouse study and shows promise for effective RWW larval control. Further testing is recommended.

Rice Water Weevil Biology: The Entomology program at UC-Davis in conjunction with the staff of the Rice Experiment Station have monitored RWW adult flight at the RES for the last ~35 years. Compared with 1997, the RWW flight in 1998 was lower in number (~2500 RWW captured in 1997 compared with ~1085 captured in 1998) and earlier in terms of timing (90% of the RWW had flown by May 6 in 1997 compared with April 29 in 1998). This trend for lower numbers continues that seen since 1996 when ~5500 adults were collected. The record number of RWW collected is 60,000+ in 1969. The effects of 'El Niño' on RWW flight in 1998 was significant. RWW adults fly predominantly in the evenings and require warm (~75 - 80^0F), calm evenings. In 1998, these conditions did not occur until April 19-22 and April 26-30. Flight peaks for RWW were April 27, 28, and 29. Therefore, this accounted for the adults "waiting" to fly until these conditions existed in late April. However, little to no rice was planted by this period. Weed growth on the levees was substantial and the adults probably survived on these weeds until the rice was planted. At this time, the weevils probably crawled into the fields as they are thought to not be able to continue to fly.

The pattern of RWW egg-laying is important for determining the timing of post-flood applications. Since Dimilin and Warrior have no activity on RWW larvae, they must be applied before significant egg deposition. Egg deposition started as early as the 1-2 leaf stage and peaked from the 3-4 leaf stages. Some oviposition occurred as late as the 7 leaf stage, but this was very low. On average, most eggs were deposited from 9 to 32 days after seeding. There was significant variation in egg-laying from field to field. Over about the same 3-4 week period, egg-laying in one field took place at a constant rate from the 1 to 6 leaf stage whereas in another field egg-laying was completed from the 2 to 4 leaf stages. With a 27 day ovipositional period, a short-lived treatment such as Warrior would not persist long enough to prevent late oviposition. This as well as the timing of the initiation of egg-laying will be critical for the efficacy of post-flood treatments.

Cultural Controls: Previous small plot research has shown that lower rice water weevil larval populations occur during the growing season in areas that were winter-flooded compared with non-flooded areas. This research in 1998 was extended to larger plots and to grower fields. The unfavorable winter and spring conditions greatly compromised this objective. Most rice fields were flooded to some extent during the winter of 1998. Three locations were examined. At one location, there were no differences in rice water weevil adult feeding incidence, oviposition, or larval densities between the winter-flooded and non-flooded. At a Sutter County grower field site, there was a tendency for a lower rice water weevil infestation in the winter-flooded site than the non-flooded field, but the data were inconclusive.

Table 1. Chemical control ring stand rating evaluation and RWW adult leaf scar data, 1998.

Treatment	Rate (lbs.AI/A)	Timing	Rating	% Scarred Plants
1. Furadan 5G	0.5	PPI	3.5	19.5 de
2. Dimilin 2L	0.063	5 d aft 50% emg	4.0	52.0 ab
3. Dimilin 2L	0.094	5 d aft 50% emg	3.8	62.0 a
4. Dimilin 2L	0.125	5 d aft 50% emg	3.3	33.5 b-d
5. Dimilin 2L	0.188	5 d aft 50% emg	3.8	56.5 ab
6. Dimilin 2L	0.125	50% rice emerg.	3.8	47.0 a-c
7. Dimilin 2L	0.125	first emg	3.8	65.5 a
8. Dimilin 2L	0.125	10 d aft 50%	3.8	61.0 a
9. Dimilin 2L	0.125	15 d aft. 50%	3.8	71.0 a
10. Mustang 1.5EW	0.03	3-5 leaf	4.0	12.0 de
11. Mustang 1.5EW	0.05	3-5 leaf	3.5	13.5 de
12. Mustang 1.5EW +oil	0.03 + 1 qt/ac	3-5 leaf	3.5	7.0 de
13. Decis 180EC	0.022	3 leaf	4.0	10.5 de
14. Decis 180EC	0.025	3 leaf	3.8	17.5 de
15. Warrior 2EC	0.03	3 leaf	4.0	12.0 de
16. Exp80698A	0.037	dry seeded	2.4	14.0 de
17. Exp80698A	0.05	water-soaked	3.5	26.5 c-e
18. CGA-293343 2G	0.18	PPI	3.8	7.5 de
19. Icon 70 FS	0.0325	PPI	3.5	20.5 de
20. Icon 70 FS	0.0325	postflood	3.8	13.5 de
21. Exp61685A 0.83EC	0.20	PPI	3.5	16.5 de
22. Exp61685A 0.83EC	0.20	postflood	3.8	10.5 de
23. USA 1	0.10	emg + 4-5 d aft	4.3	7.0 de
24. USA 1	0.20	emg + 4-5 d aft	4.0	5.0 e
25. Icon 2.5 EC	0.05	PPI	3.8	11.0 de
26. Untreated	---	--	4.0	71.5 a

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

Table 2. Chemical control ring RWW immature density data, number of RWW per core, 1998.

Treatment	Rate (lbs.AI/A)	Timing	Mean RWW/Core		
			8 July	14 July	Avg./ Core
1. Furadan 5G	0.5	PPI	0.60 c	3.00 b	1.8
2. Dimilin 2L	0.063	5 d aft 50% emg	1.55 c	1.25 bc	1.4
3. Dimilin 2L	0.094	5 d aft 50% emg	3.55 b	2.70 b	3.1
4. Dimilin 2L	0.125	5 d aft 50% emg	0.80 c	0.05 c	0.4
5. Dimilin 2L	0.188	5 d aft 50% emg	0.80 c	0.30 c	0.6
6. Dimilin 2L	0.125	50% rice emerg.	0 c	0.20 c	0.1
7. Dimilin 2L	0.125	first emg	0 c	0.05 c	0
8. Dimilin 2L	0.125	10 d aft 50%	3.50 b	3.30 b	3.4
9. Dimilin 2L	0.125	15 d aft. 50%	3.40 b	3.10 b	3.3
10. Mustang 1.5EW	0.03	3-5 leaf	0.20 c	0.20 c	0.2
11. Mustang 1.5EW	0.05	3-5 leaf	0.05 c	0 c	0
12. Mustang 1.5EW +oil	0.03 + 1 qt/A	3-5 leaf	0.10 c	0.15 c	0.1
13. Decis 180EC	0.022	3 leaf	0.15 c	0 c	0.8
14. Decis 180EC	0.025	3 leaf	0 c	0.05	0
15. Warrior 2EC	0.03	3 leaf	0 c	0 c	0
16. Exp80698A	0.037	dry seeded	0.10 c	0 c	0.1
17. Exp80698A	0.05	water-soaked	0.50 c	0.30 c	0.4
18. CGA-293343 2G	0.18	PPI	0.10 c	0.20 c	0.2
19. Icon 70 FS	0.0325	PPI	0 c	0 c	0
20. Icon 70 FS	0.0325	postflood	0.30 c	0.15 c	0.2
21. Exp61685A 0.83EC	0.20	PPI	0.05 c	0.05 c	0.1
22. Exp61685A 0.83EC	0.20	postflood	1.25 c	1.00 bc	1.1
23. USA 1	0.10	emg + 4-5 d aft	0.10 c	0.05 c	0.1
24. USA 1	0.20	emg + 4-5 d aft	0.20 c	0.15 c	0.2
25. Icon 2.5 EC	0.05	PPI	0 c	0 c	0
26. Untreated	---	--	5.30 a	11.60 a	8.5

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

Table 3. Chemical control rings, effects of RWW damage on rice grain yield, 1998.

Treatment	Rate (lbs.AI/A)	Timing	Grain Yield* (g/ring)	Est. Yields (lbs/acre)
1. Furadan 5G	0.5	PPI	1170.0 a-c	14032.3
2. Dimilin 2L	0.063	5 d aft 50% emg	1199.7 ab	14387.9
3. Dimilin 2L	0.094	5 d aft 50% emg	1110.2 a-c	13315.1
4. Dimilin 2L	0.125	5 d aft 50% emg	1170.9 a-c	14043.1
5. Dimilin 2L	0.188	5 d aft 50% emg	940.2 c-e	11275.9
6. Dimilin 2L	0.125	50% rice emerg.	1036.2 a-e	12427.8
7. Dimilin 2L	0.125	first emg	951.6 b-e	11412.6
8. Dimilin 2L	0.125	10 d aft 50%	808.3 e	9694.4
9. Dimilin 2L	0.125	15 d aft. 50%	1101.7 a-d	13213.7
10. Mustang 1.5EW	0.03	3-5 leaf	1093.6 a-d	13116.0
11. Mustang 1.5EW	0.05	3-5 leaf	853.9 de	10240.8
12. Mustang 1.5EW +oil	0.03 + 1 qt/A	3-5 leaf	1011.1 a-e	12125.9
13. Decis 180EC	0.022	3 leaf	999.0 a-e	11981.5
14. Decis 180EC	0.025	3 leaf	1062.4 a-d	12742.3
15. Warrior 2EC	0.03	3 leaf	1036.1 a-e	12426.7
16. Exp80698A	0.037	dry seeded	1083.3 a-d	12991.9
17. Exp80698A	0.05	water-soaked	1115.8 a-c	13382.4
18. CGA-293343 2G	0.18	PPI	1079.6 a-d	12947.6
19. Icon 70 FS	0.0325	PPI	1235.5 a	14818.1
20. Icon 70 FS	0.0325	postflood	1151.4 a-c	13808.8
21. Exp61685A 0.83EC	0.20	PPI	1123.7 a-c	13476.5
22. Exp61685A 0.83EC	0.20	postflood	1133.0 a-c	13588.1
23. USA 1	0.10	emg + 4-5 d aft	971.0 b-e	11645.8
24. USA 1	0.20	emg + 4-5 d aft	1171.3 a-c	14047.3
25. Icon 2.5 EC	0.05	PPI	1148.6 a-c	13775.7
26. Untreated	---	--	976.8 b-e	11715.5

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

*Yields corrected to 14% moisture.

Table 4. Biorational ring study: Stand evaluation, adult leaf scar data and RWW density, 1998.

Treatment	Rate (ai/acre)	Timing	Stand Rating	% Scars 22 June	26 June	Avg. RWW/core 8 July	14 July	Total Avg/core
1. Furadan 5G	0.5 lb	PPI	3.0	37	29	1.35 c	1.70 c	1.50
2. Novodor	4 qts	PPI	2.6	86	62	4.30 b	9.95 ab	7.13
3. Novodor	4 qts	3 leaf	3.3	61	33	4.35 b	8.35 ab	6.35
4. Novodor	4 qts	5 leaf	3.1	81	47	4.50 ab	5.40 bc	4.95
5. Novodor	4 qts	3+5 leaf	3.1	62	29	2.10 bc	2.35 c	2.23
6. Mycotrol	2 qts	PPI	2.9	18	0	2.60 bc	2.40 c	2.50
7. Mycotrol	3 qts	3 leaf	3.3	21	3	2.00 bc	2.90 c	2.45
8. Untreated	-----	-----	3.1	73	67	7.20 a	12.00 a	9.60

Means within columns followed by same letter are not significantly different; least significant differences test ($\rho \leq 0.05$).

Table 5. Biorational ring study: effects of RWW damage on rice grain yield, 1998.

Treatment	Rate (ai/acre)	Timing	Average Grain Yield* (g/ring)	Average Estimated Yields (lb/acre)
1. Furadan 5G	0.5 lb	PPI	1026.8 a	12314.5
2. Novodor	4 qts	PPI	931.9 ab	11176.2
3. Novodor	4 qts	3 leaf	938.9 ab	11260.9
4. Novodor	4 qts	5 leaf	859.5 ab	10308.1
5. Novodor	4 qts	3+5 leaf	1101.9 a	13215.7
6. Mycotrol	2 qts	PPI	871.1 ab	10447.2
7. Mycotrol	3 qts	3 leaf	697.8 b	8368.7
8. Untreated	-----	-----	904.9 ab	10852.3

Means within columns followed by same letter are not significantly different; least significant differences test ($\rho \leq 0.05$).

*Yields corrected to 14% moisture.

Table 6. Overall average RWW per core, scarred plants, estimated hand and machine yields - grower fields, Sacramento Valley, Dimilin 2L 1998.

Treatment	% Scarred Plants	Avg. RWW per core	Hand Yields (lb/ac)*	Machine Yields (lb/ac)*
Dimilin (8 oz)-full	34.6	0.65	6303.7	6786.2
Dimilin (8+8oz)-border	64.5	0.85	4051.9	5704.0
Dimilin (12 oz)-full	22.4	0.79	5970.3	5945.8
Dimilin (12 oz)-border**	53.0	2.60	6325.1	6182.0
Dimilin (16 oz)-full	25.8	0.35	7121.2	6934.5
Dimilin (16 oz)-border	48.0	0.46	5852.9	6389.3
Furadan 5G	2.3	0.24	7421.9	6945.7
Untreated	33.0	1.23	6276.8	6532.2

* Yields corrected to 14% moisture.

**Treatment only at one of the six sites, not legitimate to compare directly with other treatments.

Table 7. Average number RWW per core, scar counts, rice grain yield - grower fields, Sacramento Valley, Icon 70 FS 1998.

County Site Treatment	15-Jun % Scarred Plants	1-Jul RWW per core	13-Jul RWW per core	RWW ave/core	23-Sep Hand** Est. Yield (lbs./A)	7-Oct Machine Est. Yield (lbs./A)**
Sutter						
Untreated	19.50	0.40	2.35	1.38	8950	9152
Icon 70FS	7.00	0.00	0.85	0.43	7310	8418
Furadan 5G*	na	na	na	na	na	na
County Site Treatment	**29-Jun % Scarred Plants**	**9-Jul RWW per core**	**17-Jul RWW per core**	**RWW ave/core**	**13-Oct Hand Est. Yield (lbs./A)**	**19-Oct Machine Est. Yield (lbs./A)**
Butte						
Untreated	45.50	1.40	3.25	2.35	7962	7689
Icon 70FS	2.00	0.30	0.15	0.23	9195	7893
Furadan 5G	2.00	0.00	0.20	0.10	9418	7647

* Grower did not apply Furadan treatment at this site

**Yields corrected to 14% moisture.

Table 8. Overall site average % scarred plants, RWW per core and hand & machine grain yields - grower fields, Icon 70 FS 1998.

Treatment	% Scarred Plants	RWW per core	Hand Est. Yields* (lbs/ac)	Machine Est. Yields* (lbs/ac)
Icon	4.5	0.33	8252	8156
Furadan	2.0	0.00	9418	7647
Untreated	32.5	1.90	8456	8420

*Yields are corrected to 14% moisture.

Table 9. Overall average RWW per core, scarred plants, estimated hand harvests - grower fields, Sacramento Valley, Warrior 2 EC 1998.

Treatment	% Scarred Plants	Avg. RWW per core	Hand Yields*
Warrior- full	21.6	0.06	6970.3
Warrior- borders	11.9	0.08	6853.5
Furadan 5G	15.3	0.31	8173.3
Untreated	43.8	1.76	6161.0

*Yields are corrected to 14% moisture.

Table 10. Scar incidence and larval density data from straw management study - Colusa County.

Treatment	Eggs Deposited (8 to 29 June)[A]	Percentage of Scarred Plants	Rice Water Weevil per Core Sample
Winter-flooded	101	22.3	6.3
No winter flood	79	32.7	2.2

[A] 12 to 33 days after seeding; total of 6 sample dates.

Table 11. Scar incidence and larval density data from winter-flooding study - Sutter County.

Treatment	Eggs Deposited[A]	Percentage of Scarred Plants	Rice Water Weevil per Core Sample
Winter-flooded	6	12.6	NA
No winter flood	21	16.7	0.7

[A] Total of 4 sample dates.

Rice Water Weevil
1998 Biorational study (RES)

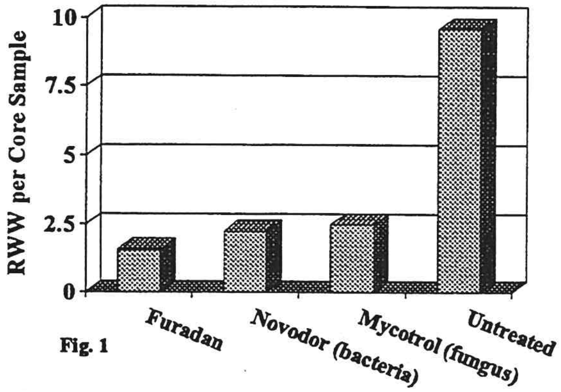


Fig. 1

Rice Water Weevil
Dimilin - 1998 Grower Field Tests

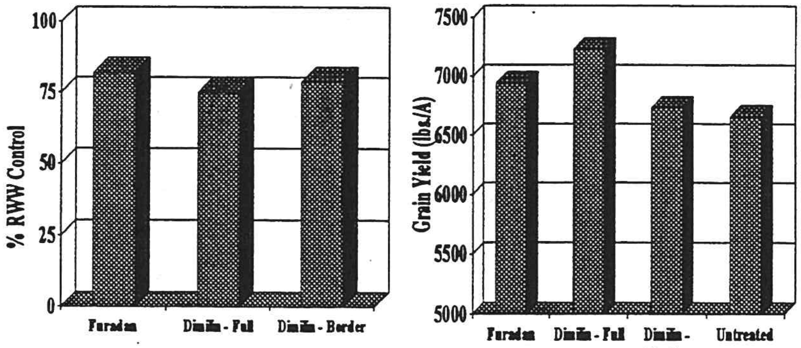


Fig. 2

Rice Water Weevil

Warrior - 1998 Grower Field Tests

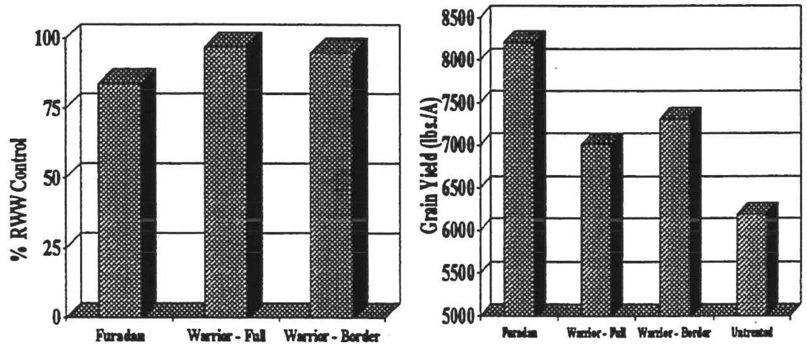


Fig. 3

Direct comparisons difficult; not all treatments at all sites

Influence of Straw Management Treatments on RWW Larval Density - 1995 to 1998

Average of 4-year Study: Effect of Winterflooding

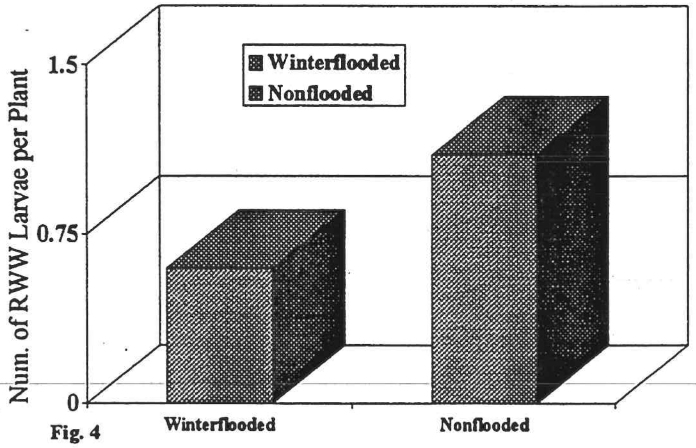


Fig. 4

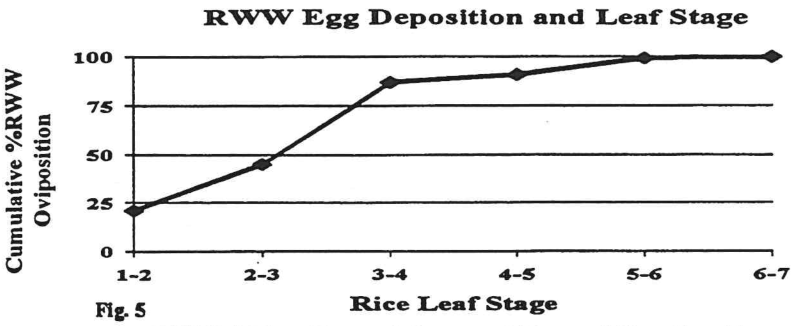


Fig. 5

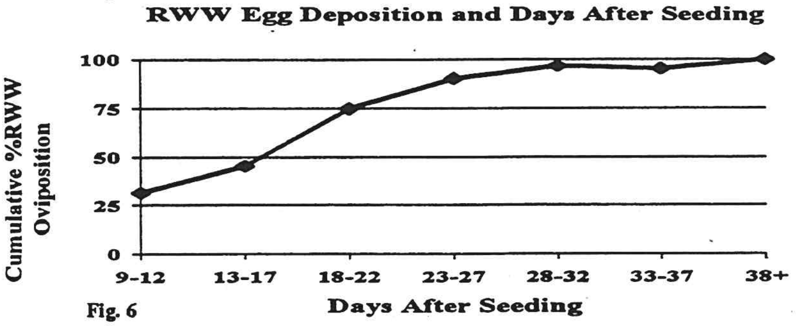


Fig. 6

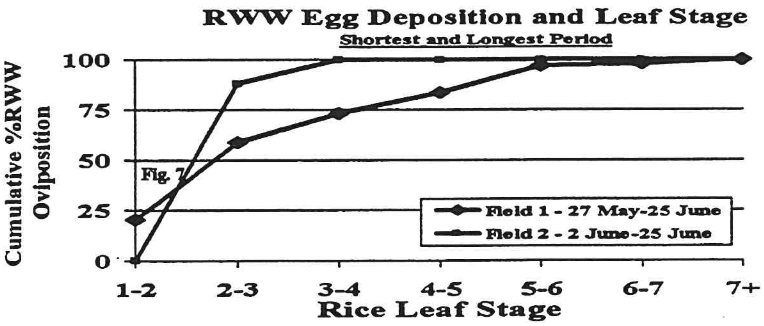
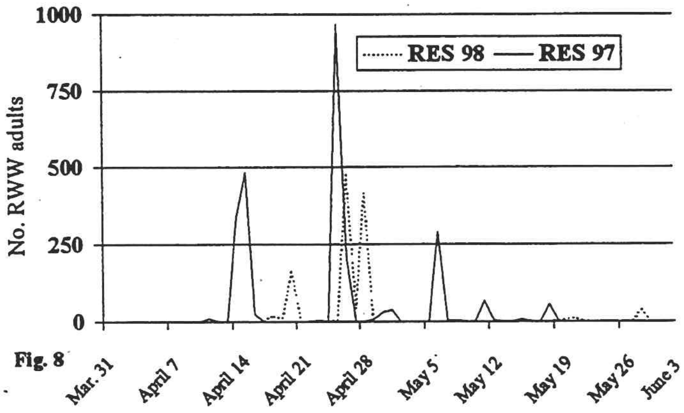
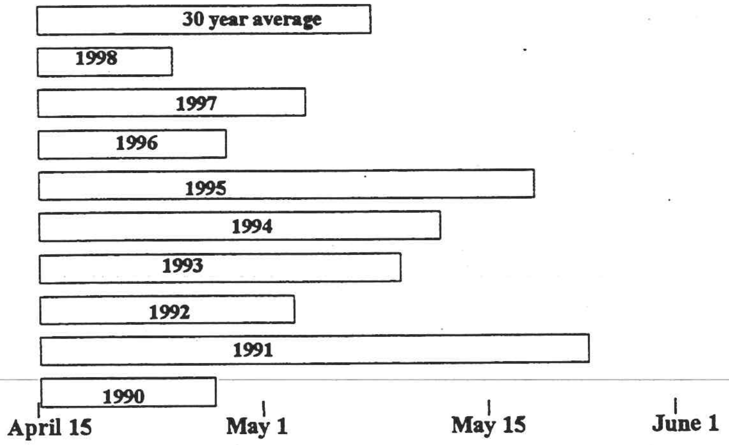


Fig. 7



Rice Water Weevil Flight 1997 & 1998
Rice Experiment Station, Biggs, CA

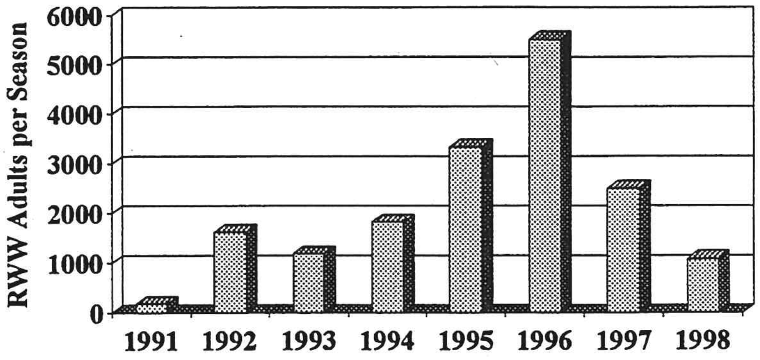
Fig. 8



Rice Water Weevil Flight Period - Rice Expt. Station
Completion of 90% of Flight *

Fig. 9

* based on black light trap captures



Rice Water Weevil Spring Flight - 1991-98
Rice Experiment Station, Biggs, CA

Fig. 10