ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE

January 1, 1992 - December 31, 1992

PROJECT TITLE: Protection of rice from invertebrate pests.

PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:
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LEVEL OF 1992 FUNDING: $28,236

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION:

Objective 1: **The recognition of physical and biological factors that result in fluctuation and movement of pest populations that cause economic injury to rice plants.**

1.1) To determine seasonal trends (timing and magnitude) in the flight activity of the Rice Water Weevil (RWW) at the Rice Experiment Station (RES) at Biggs, and in Butte, Colusa, and Sutter Counties.

Objective 2: **To determine the most effective control of rice invertebrate pests while maintaining environmental quality compatible with the needs of society.**

2.1) **Rice water weevil - chemical control.**

2.1.1) To evaluate the effectiveness of two experimental Rhone-Poulenc compounds, at various rates, in controlling the RWW.

2.1.2) To evaluate the effectiveness of the flowable formulation of carbofuran at two rates, for control of the RWW.

2.2) **Rice water weevil - biological control.**

2.2.1) To evaluate the effectiveness of an entomopathogenic fungus in controlling the RWW.

2.3) **Rice water weevil - cultural control.**

2.3.1) To determine the effect of delayed planting on RWW infestation level. Butte, Colusa and Sutter Counties.

2.3.2) To determine the effect of drill seeding on pest population levels and damage compared to conventional water seeded culture. RES

2.3.3) To determine the role of levee vegetation on RWW infestation. Butte, Colusa, Sutter Counties.

2.4) **Rice water weevil - economic injury level.**

2.4.1) To evaluate the rice plant physiological response to adult and larval weevil injury. RES

SUMMARY OF 1992 RESEARCH BY OBJECTIVE:

Objective 1:

1.1) 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 1992, light traps were placed in Butte, Colusa and Sutter counties, as well as at the RES in Butte county, in order to measure variability in weevil flight among these areas. The Butte site was approximately 5 miles east of Glenn, on the border of Butte and Glenn counties, at the Thompson Ranch. The Colusa site was four miles east of Maxwell at the Dennis Ranch. The Sutter site was about four miles south of Nicolaus at the Scheidel Ranch. A fourth trap was placed at the RES to provide continuation of the light trap record that began in 1962. The trap at the RES was an older "standard" model, and was different from the other three light traps used in 1992. Direct comparison of the magnitudes of the RES flight data with the other three locations is not appropriate due to the difference in trap design. However, a comparison of the 1992 RES trap counts with those of previous years (based on the same trap design), suggests that this year's flight was slightly greater in intensity than "average", based on 30 years of trap data.

Table 1. Light trap counts for the Rice Water Weevil (*Lissorhoptrus oryzophilus*) - 1992.

Date off	BUTTE[a]	COLUSA[b]	SUTTER[c]	R.E.S.	Accumulated D-D[d]
4/10	0	0			91
4/11	61	7			91
4/12	0	0			91
4/14	0	0			96
4/15	15	0			98
4/17	0	0	0	2	104
4/18	0	0	0		108
4/19	0	0	0		114
4/21	196	12			124
4/22	5	0	31		126
4/23	4	0	0		130
4/24	1	0	0	71	136
4/25	57	0			144
4/26	10	0	58	1300+	150
4/27	0	0	0	10	159
4/28	5	0	40	3	170
4/29	117	0	1	1	177
4/30	0	0	0		181
5/1	8	0	0	47	188
5/2	1	3	1	136	199
5/3	23	3	5	10	213
5/4	101	7	4[e]	3	229
5/5	117	0	2	1	245
5/6	266[e]	10	0	3	255
5/7[c]	1	2	0	0	266
5/8	66	2[e]	0	2	279
5/9[c]	3	0	6	0	292
5/10[c]	0	0	0	0	305
5/11	0	3	0		314
5/12	0	0	0		321
5/13[c]	0	0	1		328
5/14[c]	2	0	0	1	337
5/16[c]	0	1	0	6	353
5/18[c]	0	0	0	3	371
5/21[c]	0	0	1	2	395
5/22			2	16	405
5/24	2	0	0	1	435
5/27		1	0	901[e]	482
5/29	0	0	0	0	503
5/31	0	0	0	0	536
6/1	0	0	0	0	553
	TOTAL: 1059	TOTAL: 51	TOTAL: 152	TOTAL: 2519	

[a] Thompson ranch, approximately 5 miles east of Glenn
[b] Dennis ranch, approximatey 4 miles east of Maxwell
[c] Scheidel ranch, approximately 4 miles west of Pleasant Grove
[d] Degree-Days starting date = 1/1/92, Minimum threshold = 63^0, Durham weather station
[e] date on which 90% of flight was completed

A total of 2,519 weevils were captured at Biggs, compared with 1,059 in Butte county, 51 in Colusa county and 152 in Sutter county. The spring dispersal flight consisted of three to five peaks, depending on trap location. Two of these peaks showed relatively close agreement across the four sampling locations. The first peak occurred between April 19-26 with the accumulation of 130 day-degrees and maximum temperatures rising to the mid 80's. This was followed by cooler temperatures and/or windier conditions until May 2 when maximum temperatures rose to the high 90's, and approximately 225 day-degrees had accumulated. The second area-wide flight peak began at this time and extended until about May 6. An early flight peak occurred on April 11 at the Butte and Colusa sites, with the accumulation of 90 day-degrees. The traps at the other two sites were not yet operational at this early date. The flight period ended between May 22 and May 27 at the four locations. The approximate average date for completion of 95% of the flight was May 10, which is quite early based on a 30 year average.

With the majority of the flight having occurred before May 15 this year, later planted rice fields should have been subjected to reduced infestation by flying adults. In fact, fields which were monitored in late May and early June, for the time of planting study, generally had infestation levels below the economic threshold. Of 15 fields planted after May 23, only 20% developed weevil infestations which surpassed the economic threshold. This contrasts with the 15 fields planted before May 23, in which 13 of them (or 87%) developed economic infestations. The correlation of light trap catches with commercial field flooding should be continued to better understand the relationship between weevil flight period, flooding date, and field infestation. Monitoring at different locations in the Sacramento Valley will provide a measure of the extent of variability in flight magnitude and timing.

Objective 2:

2.1) Rice water weevil - chemical control.

2.1.1 and 2.1.2) Two experimental Rhone-Poulenc compounds (both from a new class of chemical insecticides) and the flowable formulation of Furadan were evaluated for control of the RWW in a replicated field experiment at Biggs RES. Furadan 5G was included as a standard for comparison. Plots consisted of M-202 rice enclosed by aluminum rings that encompassed ca. 8 ft^2. All materials were applied on May 8, before flooding. The plots were seeded on 11 May.

The rice stand was evaluated on 27 May and adjusted to 64 plants per 8 ft^2 ring. The natural rice water weevil infestation was supplemented with 30 adults, collected from wild rice and placed into each ring; 15 weevils on 27 May and 15 weevils on 3 June.

Sample dates were as follows:
- Adult scar counts: 27 May, 3 June, 10 June, and 17 June.
- Larval counts and Plant Growth Characteristics: 7 to 15 July
- Rice yield: 23 September

The sampling method consisted of:
- Adult scar counts:
  percentage of plants with adult feeding scars on either of the two newest leaves (20 plants per plot)
- Larval counts:
  50 in^3 soil core (containing one plant) processed by washing/floatation method
- Plant Growth Characteristics:
  plant height, root length, number of leaves, number of tillers, and leaf and root dry weights were recorded on plants sampled from 7 to 15 July
- Rice yield:
  entire plots hand-cut and grain recovered with a "Vogel" mini-thrasher

During the sampling period [Table 2], 'RHONE-POULENC Experimental 1' (R-P #1) consistently significantly reduced the percentage of plants with feeding scars. This product apparently has either systemic properties or some contact activity in the water in order to kill the adults feeding on the foliage. 'RHONE-POULENC Experimental 2' (R-P #2) had no effect on adult feeding. Furadan® 5G and Furadan® 4F (1.00 lb. AI/A) also generally reduced adult feeding severity compared with the untreated.

Table 2. Control of Rice Water Weevil with Several Selected Insecticides

Treatment	Rate (lb. AI/A)	% of Plants with Adult Feeding Scars 3 June	10 June	17 June	# Immatures/ Plant 7-15 July
Untreated	---	96.3a	93.8a	63.8a	3.5ab
Furadan® 4F	0.50	78.8abc	78.8ab	45.0a	4.9a
Furadan® 4F	1.00	77.5bc	58.8bc	13.8b	2.8ab
Furadan® 5G	0.50	73.8cd	61.3bc	16.3b	2.2b
R-P #2	0.025	97.5a	93.8a	57.5a	2.2b
R-P #2	0.050	95.0ab	95.0a	46.3a	1.3bc
R-P #1	0.050	48.8d	52.5b	13.8b	0.2c

Means within columns followed by the same letter are not significantly different (DMRT, $P < 0.05$).

Larval densities ranged from 0.2 to 4.9 larvae per plant [Table 2]. The highest densities, numerically, were found in the Furadan® 4F (0.50 lb. AI/A) treatment. R-P #1 significantly reduced larval numbers (a 94.3% reduction compared with the untreated). Furadan® 5G and both rates of R-P #2 significantly reduced larval densities compared with the highest density, but not compared with the untreated. R-P #2 (0.025 lb. AI/A) performed equal to Furadan® 5G and R-P #2 (0.05 lb. AI/A) performed somewhat better than the standard.

Table 3. Growth Characteristics of Plants Treated with Selected Insecticides for Control of Rice Water Weevil

Treatment	Rate (lb. AI/A)	Plant Ht.(in.)	Root Len.(in.)	Num. of Tillers	Leaf Wt.(gm.)*	Root Wt.(gm.)*
Untreated	---	44.0b	13.7b	3.7a	21.6b	11.1a
Furadan® 4F	0.50	54.9a	18.1ab	6.1a	32.3ab	17.6a
Furadan® 4F	1.00	58.3a	19.3ab	6.3a	32.6ab	14.9a
Furadan® 5G	0.50	62.3a	21.7a	6.1a	42.6ab	19.2a
R-P #2	0.025	59.8a	21.0a	5.6a	46.4a	14.9a
R-P #2	0.05	58.8a	22.1a	5.5a	34.3ab	12.6a
R-P #1	0.05	62.6a	21.0a	6.2a	40.1ab	13.3a

Means within columns followed by the same letter are not significantly different (DMRT, $P < 0.05$).

*per 10 plants.

All treatments resulted in larger plants [Table 3], but significant differences were not obtained for all parameters. Plant height, for example, was increased in all treatments compared with the untreated; however, no obvious trends were seen among the treatments. The treatments had no effects or noticeable trends on root weight.

Table 4. Rice Grain Yield of Plants Treated with Selected Insecticides for Control of Rice Water Weevil

Treatment	Rate (lb. AI/A)	Rice Yield (grams/ring)	Rice Yield (lbs./acre)
Untreated	---	389.5d	5030.6d
Furadan® 4F	0.50	513.3c	6625.5c
Furadan® 4F	1.00	552.1bc	7130.1bc
Furadan® 5G	0.50	633.7ab	8183.7ab
R-P #2	0.025	541.0bc	6987.1bc
R-P #2	0.05	577.1abc	7453.0abc
R-P #1	0.05	674.4a	8709.3a

Means within columns followed by the same letter are not significantly different (DMRT, $P < 0.05$).

Rice grain yield [Table 4] was significantly affected by the treatments. Yield in the untreated was lowest and averaged about 60% of that in the best treatment. Yields in the R-P #1, R-P #2 (0.05 lb. AI/A), and Furadan® 5G treatments were the highest. Intermediate yields were obtained in the R-P #2 (0.025 lb. AI/A) and Furadan® 4F (1.00 lb. AI/A) treatments.

2.2) Rice water weevil - biological control.

2.2.1) Microorganisms (bacteria, fungi, and viruses) are used to control several insect pests. Many advancements have been made in recent years in the toxicity of these organisms to insects and in the formulation of microorganisms into insecticides. The fungus *Beauveria bassiana* has shown promise for the control of several soil-borne insect pests. In a greenhouse study conducted at UC-Davis, a granular formulation of this product was tested for the control of rice water weevil larvae. The granules were applied to potted, flooded rice plants.

Table 5. Control of Rice Water Weevil Larvae and Growth Characteristics of Plants Treated with a Microbial Insecticide

Treatment	Rate	Num. of Larvae	Plant Ht.(in.)	Root Len.(in.)	Num. of Tillers	Root Wt. (gm.)[c]
Untreated	---	17.8	44.6	16.4	2.7	1.3
B. bassiana[a]	9.7×10^6 CFU[b]	15.0	46.1	20.5	3.0	1.4
B. bassiana	9.7×10^7 CFU	15.6	46.8	17.0	2.9	1.4
B. bassiana	9.7×10^8 CFU	13.4	47.1	21.2	3.0	1.8

[a] *Beauveria bassiana*
[b] per gram soil.
[c] per 4 plants.

These results show potential for *Beauveria bassiana* as a control agent for rice water weevil larvae (Table 5). Problems arose with forming a suspension of the formulation with water, therefore the rates used may have been lower than intended. However, the highest rate of fungi provided about 30% rice water weevil larval control. Perhaps, more importantly, the treated plants had larger roots, more tillers/leaves, and were taller than the untreated plants. These trends, which indicate some larval control and less larval-induced stress to the plant with the biological insecticide, warrant additional research in this area.

2.3) Rice water weevil - cultural control.

2.3.1) <u>DELAYED FLOODING/PLANTING</u>

Delayed flooding/planting until after peak weevil flights may present opportunities to avoid or reduce weevil infestations. In 1990, later flooding resulted in lower infestation levels. Moreover, fields flooded on or after May 13-15 had infestation levels that were near or below the control action guideline (20% of plants with leaf scars). The benefit of delayed planting was more variable in 1991, probably due to the relatively late weevil flight period that year.

Extensive sampling was conducted during 1992 in Sacramento Valley fields, planted at approximately weekly intervals from 4/14 through 6/27, to determine the relationship between flooding date and infestation level. This procedure was followed in Butte, Sutter and Colusa Counties. Scar counts (100 plant sample along each margin ca. 5' from the margin) were taken on two dates (one week interval between samples) when the rice was at the 4-7 leaf stage. The number of plants with scars on either of the two newest leaves was determined.

Figure 1. Delayed Planting to Reduce RWW Infestation.
Butte County, CA. 1992

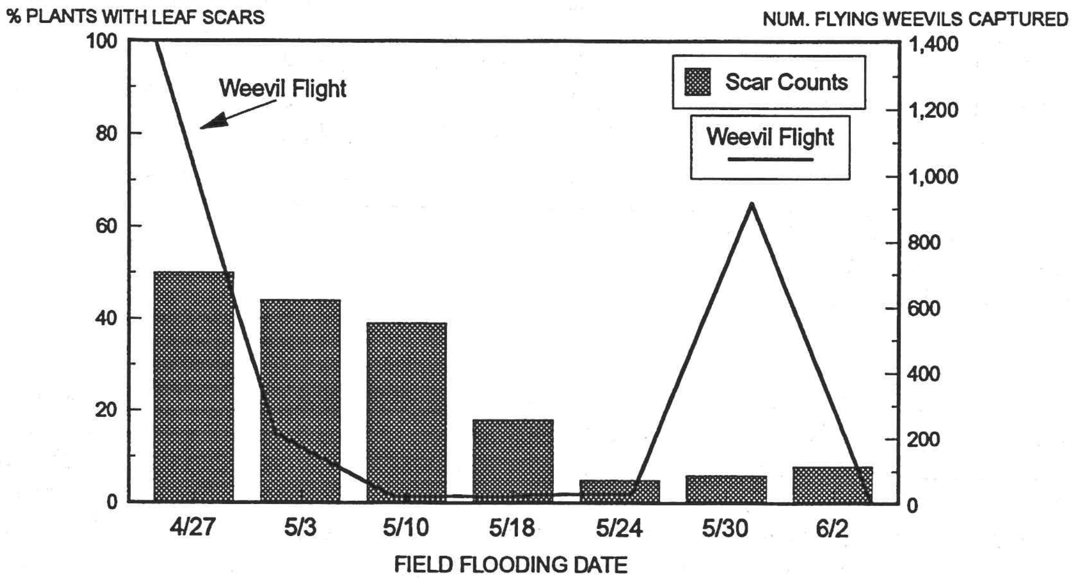


Figure 2. Delayed Planting to Reduce RWW Infestation.
Colusa County, CA. 1992

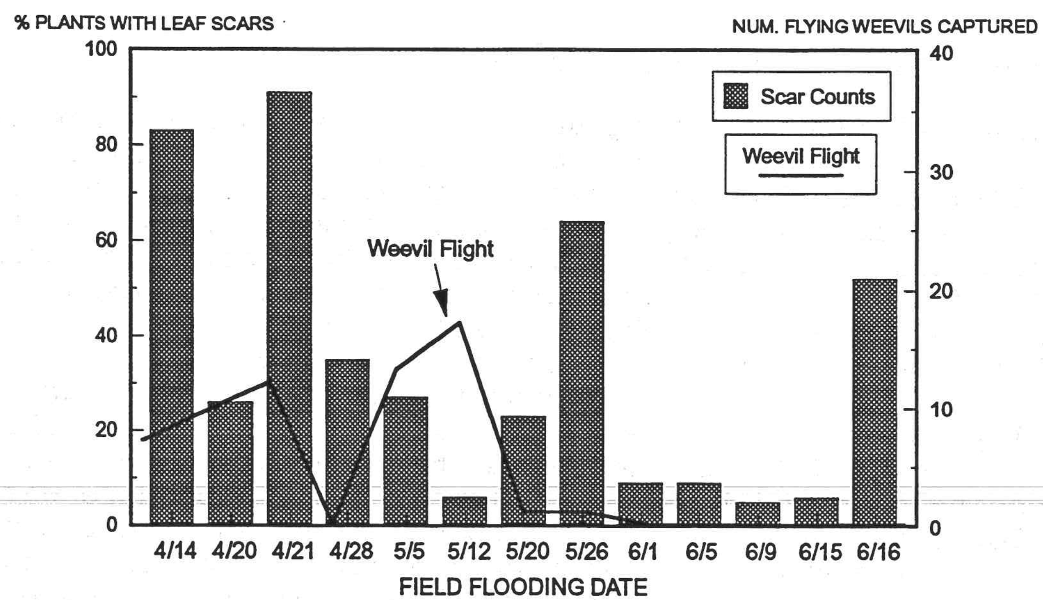
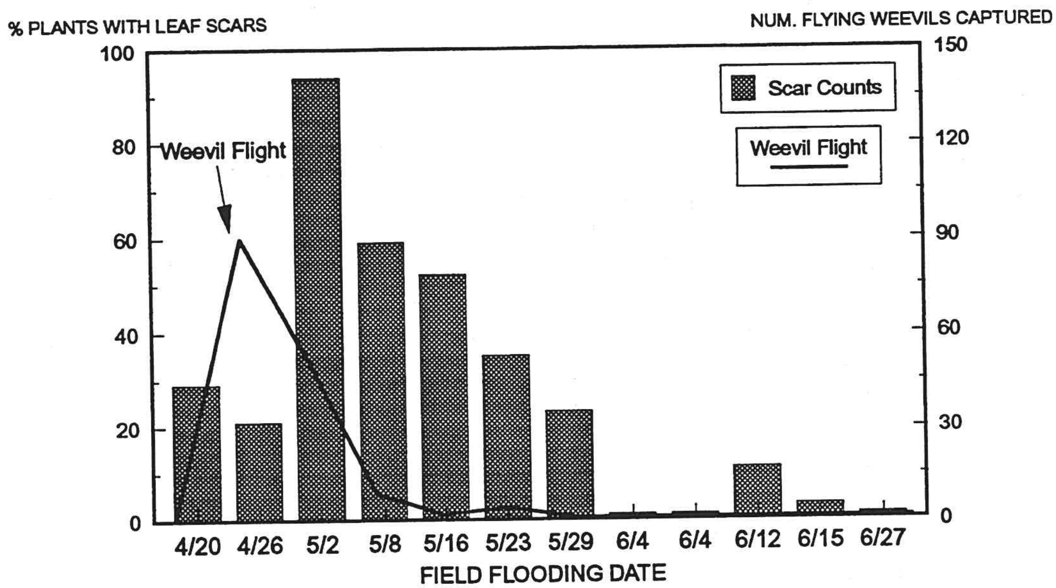


Figure 3. Delayed Planting to Reduce RWW Infestation.
Sutter County, CA. 1992



In 1992, delayed planting generally resulted in lower weevil infestations with the exception of two fields in Colusa county which were planted on 5/26 and 6/16 (Fig. 1-3). Both of these fields had weedy levees, and were located adjacent to heavily vegetated natural areas. Each of these conditions seems to contribute to increased weevil abundance, and may explain the unexpectedly high weevil counts in the two Colusa fields mentioned above.

These results support those found in 1990, and indicate that in years with earlier than average weevil flight periods, fields that are planted in late May or June can be expected to have weevil infestations below the economic threshold. The occasional exception to this rule indicates that infestation levels are influenced by factors other than date of planting. Vegetative condition of levees and adjacent areas appears to be one of these additional factors in field infestation.

Delayed planting is associated with a reduction of yield, due to rice physiology and limitations in variety type, as well as to a later harvest period. These costs, however would probably be less than the savings gained, in terms of reduced weevil injury, in an early flight year like 1992.

2.1.2) DRILL SEEDING

Drill seeding offers a means of eliminating or reducing damage by tadpole shrimp, other aquatic invertebrate pests and possibly, the RWW. With respect to the RWW, the later date at which the continuous flood is applied with drill-seeding probably functions much like delayed flooding/planting with probable lower infestation levels. Further, in drill-seeded rice the plants are older and more vigorous when the weevil infestation occurs (after the continuous flood is applied). Research has shown that older plants are much better able to withstand weevil damage. Thus, we would expect the injury by the RWW to be less in drill-seeded than water-seeded rice.

The effect of drill seeding on weevil infestation was evaluated in a field experiment at the RES. Experimental design was randomized complete block with four treatments and four replications. Plot size was 20' by 150'.

TREATMENTS were:

1. Drill seeded
   - A. treated with carbofuran
   - B. untreated
2. Water seeded
   - A. treated with carbofuran
   - B. untreated

'M-202' was seeded as follows:

Drill seeded[DS] @ 120 lbs/ac on 9 May.
flushed 16 May & 27 May;
permanent flood went on 5 June.
Water seeded[WS] @ 150 lbs/ac on 18 May.

Fertilization was as follows:

DS: 77 lbsN/ac postplant, 80 lbsN/ac postflood
WS: 137 lbsN/ac postplant, 40 lbsP_2O_5

Herbicides were applied:

DS: Ordram @ 5 lb/ac postfld (5 June), Ordram @ 4 lb/ac + Londax @ 1 oz/ac on 12 June
WS: Ordram @ 4 lb/ac + Londax @ 1 oz/ac on 30 May

Sampling consisted of:

3 June & 5 June - 1st adult scar count
19 June - 2nd adult scar count
16 July - immature 'core' count

Sampling methods:

A. Scar counts (50/check) taken in both treatments 2 days prior to placing the permanent flood on the drill seeded plots; and again approximately two weeks later. Stand density measurements done at the same time.
B. Core sampling for larval recovery and plant measurements. Ten cores per paddy @ ca. 7 weeks post-plant; (DS ca. 2 to 4 weeks behind WS in oviposition timing).
C. Harvest by combine for yield data.

Table 6. Comparison of weevil infestation levels in drill and water seeded rice, with and without carbofuran. Biggs, CA 1992.

	% rice plants with feeding scars		# immatures/plant
Water mgmt.	**3 June**	**19 June**	**16 July**
Drill seeded[a]	15a	20	1.1a
Water seeded	49b	20	2.6b
Furadan			
Treated[b]	26a	14	1.0a
Untreated	43b	26	2.8b
Drill seeded[a]			
with Furadan[b]	11	20	0.4
w/o Furadan	19	21	1.8
Water seeded			
with Furadan[b]	37	8	1.5a
w/o Furadan	61	31	3.7b

Paired means within columns followed by different letters are significantly different (SNK test, P<0.05).

[a] water seeded planted on May 17;
drill seeded planted on May 9;
1st flush on May 16,
2nd flush on May 27;
permanent flood applied June 5, 1992

[b] treated with carbofuran at 0.5 lbs AI/ac.

Excessive early weed growth in the drill-seeded plots complicated the scar count evaluations. Weeds constituted ca. 92% of the total stand in the drilled plots on June 3, with sprangletop and watergrass being the predominant species. Weed counts were not done on June 19, however a rough estimate of weed level was recorded [scale: non-weedy(1), slightly weedy(2), moderately weedy(3), and very weedy(4)]. The average weed level estimate on June 19 for all of the drill plots was 3.125 (on the 1-4 scale). In contrast, seven of the eight continuous flood plots were 'non-weedy' with an average weed level of 1.125.

Rice density in the drilled plots averaged 8 plants per square foot over both sample dates. This contrasts with the continuous flood plots which had an average rice density of 27 plants per square foot.

In evaluating the weevil counts in the drilled plots one should consider possible interactions from the weed species present, as well as the low ratio of rice plants to weeds. If either the sprangletop or watergrass had other than a neutral effect (i.e. attracting or repelling flying weevils, ovipositing weevils, or larvae) than these data may not represent actual differences between drill seeding and continuous flood seeding.

Adult RWW feeding was 70% lower in the drill-seeded plots compared to the water seeded plots, during the early, non-flood period (Table 6). This difference had disappeared by June 19, after two weeks of continuous flood in the drill plots. These results support earlier findings (by L. Hesler) that adult feeding activity on rice is significantly reduced in the absence of standing water, but resumes with application of continuous flood. Drill seeding resulted in 58% lower larval infestations.

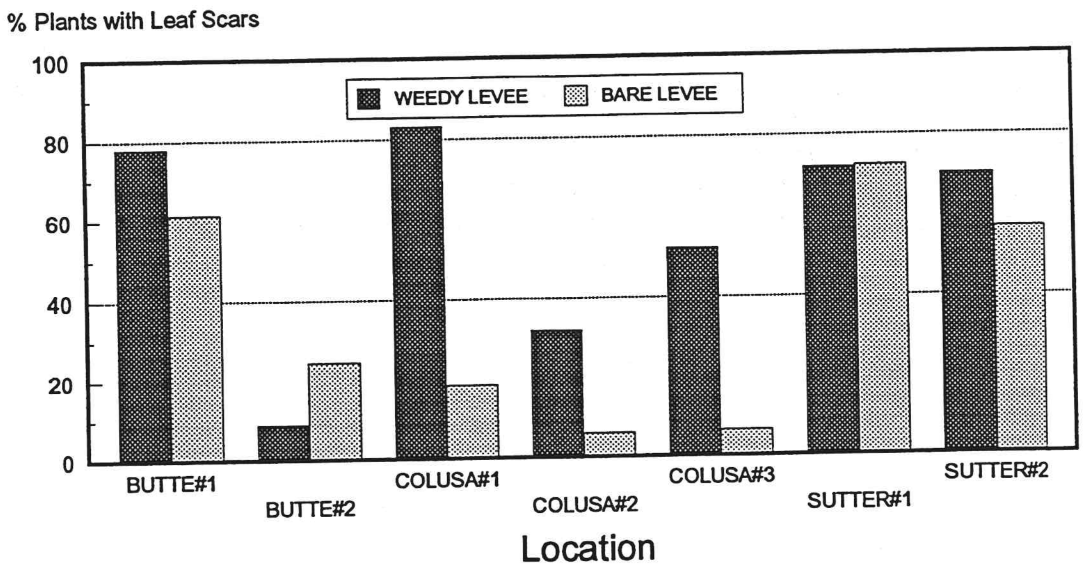
Furadan reduced adult feeding by 40% (June 3) and 46% (June 19), and larval infestation by 64% (Table 6). The reduction in immatures by Furadan was similar to that achieved by drill seeding. It was interesting to note that Furadan sharply reduced larval infestation within the drill seeded plots (Table 6), and resulted in the lowest weevil level of the four treatment combinations.

The applicability of these results to commercial scale drill seeding is not clear due to the unusually high weed levels, however drill seeding does appear to be a potential cultural tactic against the RWW.

2.1.3) REMOVAL OF BORDER VEGETATION

Removing weeds and debris from levees and field margins that may serve as overwinter refuges or attract weevils during the spring flight, may help reduce field infestation levels. The relationship between levee vegetation and weevil infestation was evaluated by sampling in paired fields at seven locations. One field of each pair had weedy levees while the other had bare levees. Scar counts (100 plant sample along each margin ca. 5' from the margin) were taken on two dates, 7 days apart, with the plants at the 4-7 leaf stage. The number of plants with scars on either of the two newest leaves were determined. Data from the two sampling dates were combined to obtain the average percentage of plants with scars for a particular levee type-location. Scar counts showed that lower infestation levels were associated with bare levees compared to weedy levees at five of seven locations in 1992 (Figure 4).

Figure 4. Levee Vegetation: Influence on RWW infestation - 1992



Removal of border vegetation continued to show promise this year. It appears to offer benefit in the majority of fields irrespective of weevil flight timing and planting date. The exceptions that were noted in Butte Co. in 1990 and 1992, Sutter Co. in 1991 and 1992 need additional study.

2.4) **Rice water weevil - economic injury level.**

A field study was conducted at the RES to evaluate the influence of stress from rice water weevil on rice plant photosynthesis and biomass accumulation and to compare these data with plants treated with Furadan® 5G. Plants produce energy through the photosynthesis process. Therefore, for an insect pest to reduce plant growth and yield, corresponding negative effects on photosynthetic rate, and other parameters correlated with plant function, should be seen. By understanding how rice plants respond to this injury, we may be able to design novel control measures for this pest, and this information may be useful to plant breeders.

Rice plants within a one acre check at the RES were caged (two per cage) at emergence from the water, and the following treatments were established on the plants:

1.) Uninfested
2.) 5 rice water weevil adults per cage
3.) 10 rice water weevil adults per cage
4.) 15 rice water weevil adults per cage
5.) 30 rice water weevil larvae per cage
6.) Furadan® 5G (0.5 lb. AI/A)

Adults were confined on the plants with the cages and allowed to lay eggs. Each treatment was replicated four times.

Rice plant photosynthetic rate was evaluated with a portable photosynthesis instrument. Measurements were made on 10 June, 17 June, 1 July, 14 July, and 29 July. The first date was before rice water weevil egg hatch, whereas the last date was after rice water weevil larval feeding on rice roots had been completed. On the last three sampling dates, rice plants from all treatments were returned to the lab, and leaf area, leaf dry weight, root dry weight.

Table 7. Photosynthetic Rate of Plants Stressed by Injury from Rice Water Weevil.

	Photosynthetic Rate (μmol/m²/sec)				
Treatment	10 June[a]	17 June	1 July	14 July	29 July
Untreated	23.8	23.9	30.6	22.5	30.0
Furadan®5G[b]	23.4	26.7	27.8	23.7	27.6
5 adults/cage	20.4	13.7	20.6	16.3	22.6
10 adults/cage	17.6	16.7	21.7	16.1	22.6
15 adults/cage	22.3	12.8	21.0	15.6	26.4
30 larvae/cage	24.7	19.0	21.5	21.9	24.3

[a] primarily leaf-feeding damage.
[b] (0.50 lb. AI/A)

Injury from rice water weevil larvae influenced the photosynthetic rate, i.e., energy producing mechanisms, of sampled rice plants (Table 7). On 10 June, the damage was primarily leaf-feeding and there was no effect on the plants. The damage severity was about 15% leaf defoliation. On the subsequent sampling dates, the infested plants had photosynthetic rates about 25-30% lower than the uninfested plants. This time period encompasses the period of maximum feeding by rice water weevil larvae. Plants treated with Furadan® 5G had photosynthetic rates similar to the uninfested plants.

Table 8. Plant Growth Characteristics of Plants Stressed by Injury from Rice Water Weevil.

	1 July		14 July		29 July	
Treatment	Leaf Area[a]	Root Wt.[b]	Leaf Area	Root Wt.	Leaf Area	Root Wt.
Untreated	205.9	0.393	690.3	2.04	331.2	1.87
Furadan 5G[c]	246.8	0.479	673.8	2.83	387.2	1.06
5 adults/cage	141.3	0.184	378.1	1.61	219.5	0.64
10 adults/cage	162.3	0.217	332.1	0.90	250.0	0.88
15 adults/cage	98.7	0.172	491.1	1.39	227.6	1.22
30 larvae/cage	107.8	0.243	147.7	0.78	281.2	0.89

[a] mm^2
[b] mm^2
[c] (0.50 lb. AI/A)

Plants stressed by rice water weevil larval feeding generally had smaller leaf area values and smaller root weights than uninjured plants (Table 8). The Furadan® 5G treatment generally resulted in plants that were larger than the plants from the uninfested treatment, although rice water weevil damage was nil in both treatments. Based on larval density estimates, larval counts did not differ among the three infestation rates (5, 10, and 15 adults/cage), but density in infested plots was higher than in uninfested plots. Larval density averaged 3.2 larvae per 50 in^3 soil core.

PUBLICATIONS OR REPORTS:

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CONCISE GENERAL SUMMARY OF CURRENT YEAR'S (1992) RESULTS:
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Pest Biology

THE SPRING MIGRATORY FLIGHT OF THE RICE WATER WEEVIL (RWW) was monitored by light traps in Butte/Glenn, Colusa, and Sutter Counties and at the RES. This monitoring was in conjunction with cultural management practices and the annual monitoring of flight at the RES. There was a high degree of variability in both flight intensity and timing among traps (Table 1).

Earliest recorded flight ranged from April 11-22 at the four sites. The earliest peaks ranged from April 21-24. Several peaks occurred for each site during April and May that sometimes coincided, but may have been 1-4 days apart. Ninety per cent of the flight was completed by May 3 at the Sutter site, by May 6 at the Butte/Glenn site and by May 11 at the Colusa site. A late strong flight at the RES delayed the 90 % level to May 27. The flight period totals by site from highest to lowest were RES, Butte/Glenn, Sutter, and Colusa. The comparison among years of RWW flight based on the RES trap (averaging flight data from the previous 30 years) indicated 1992 was a moderately heavy flight year.

The use of light traps to indicate potential for RWW infestation and as a tool for cultural management by way of avoidance through choice of planting date still shows promise. However, the variability noted in flight between areas shows the need for spring flight to be monitored locally rather than regionally unless reasons for the variability can be explained and forecasted.

RWW Chemical Control

THE FLOWABLE FORMULATION OF FURADAN AND TWO EXPERIMENTAL CHEMICALS FROM RHONE-POULENC were tested against adults and/or larvae.

The effectiveness of Furadan 5G (0.5 lbs. AI/A) and Furadan 4F (0.5 and 1.0 lbs. AI/A) and two experimental granular insecticides on the RWW were evaluated at the RES (Tables 2-4). All materials were applied pre-flood in aluminum rings. The natural infestation was supplemented with 30 adult/ring from May 27-June 3. Over five sampling dates from May 27-June 23, the percentage of untreated plants with feeding scars on the two newest leaves averaged 60%. The granular Furadan and high rate of flowable Furadan reduced the adult feeding to 37 and 32%, respectively. One of the experimental compounds reduced adult feeding to only 27% of the plants; however, the other product was ineffective against adult feeding. The untreated averaged 3.5 larvae per core compared with 2.2 larvae in the Furadan 5G treatment. The Furadan 4F provided intermediate control. Both of the experimental insecticides provided larval control equal or better than the standard Furadan 5G, with the best treatment resulting in only 0.2 larvae per core. These products are both several years from possible registration, but their new chemistry does appear promising.

Biological Control

The Fungus *Beauveria bassiana* has shown promise for the control of several soil-borne insect pests. In a greenhouse study conducted at UC-Davis, a granular formulation of this product was tested for the control of RWW larvae. The granules were applied to potted, flooded rice plants. The highest rate of fungi provided about 30% larval control (Table 5). In addition, the treated plants had larger roots and more tillers/leaves than the untreated plants. These preliminary results, which indicate some larval control and less larval-induced stress to the plant with this biological insecticide, warrant additional research.

Cultural Control

RWW INFESTATION IN RELATION TO FLOODING/PLANTING DATE was evaluated in Butte, Colusa, and Sutter Counties based on planting dates ranging from April 14 to June 27 (Figs. 1-3). Delayed planting generally resulted in lower weevil infestations with the exception of two fields in Colusa County which were planted on May 26 and June 16. These results showed less variability than 1991 and support the findings of 1990. The results indicate that in years with earlier than average weevil flight periods, fields that are planted in late May or in June can be expected to have weevil infestations below the economic threshold. The occasional exception to this rule indicates that infestation levels are influenced by factors other than date of planting. Vegetative condition of levees and adjacent areas appears to be one of these additional factors in field infestation.

LEVEE VEGETATION MANAGEMENT. The effect of vegetation removal on the selection of a field by the RWW was studied for the third year. Paired comparisons (bare levees vs. levees with vegetation) were made in seven areas in three counties (Fig. 4). Five of the seven comparisons showed significantly higher weevil infestations in fields with vegetation on the levees. A reversal was again noted in one comparison which is unexplained.

RICE WATER WEEVIL ACTIVITY ON DRILL SEEDED AND WATER SEEDED RICE, each treated and untreated with Furadan, were compared at the RES. The delayed flooding of drill seeded rice, and greater level of plant growth at the time of weevil oviposition have the potential to reduce the severity of an RWW infestation compared to water seeded rice. In such a comparison it was difficult to isolate the interacting factors of the greater pressure of weed species in the drill seeded plots, the fewer plants in the drill seeded plots, and their effect upon RWW activity.

Adult RWW feeding was 70% lower in the drill seeded plots compared to the water seeded plots, during the early, non-flood period (Table 6). This difference had disappeared after two weeks of continuous flood in the drill plots. This supports earlier findings that adult feeding activity on rice is significantly reduced in the absence of standing water, but resumes with application of continuous flood. Drill seeding resulted in 58% lower larval infestations, presumably because of this delay in flood.

Furadan reduced adult feeding by 40% at the early count and by 46% at the later count, and reduced larval infestation by 64%. The reduction in larvae by Furadan was similar to that achieved by drill seeding. Notably, Furadan sharply reduced larval infestations within the drill seeded plots , and resulted in the lowest weevil level of the four treatment combinations.

The applicability of these results to commercial scale drill seeding is not clear due to the unusually high weed levels encountered, however drill seeding does appear to be a potential cultural tactic against the RWW.

<u>Rice Water Weevil Economic Injury Level</u>

Preliminary studies were undertaken to evaluate rice plant response to RWW feeding to assist in developing potential control measures and provide information that may be useful to plant breeders.

Studies were initiated that caged three rates of adults and one rate of larvae, and compared them with an untreated control and a Furadan treatment. The results (Tables 7 and 8) showed the infested plants to have a reduction in photosynthetic rate of about 25-30% less than the uninfested plants during the period of maximum larval feeding. Plants stressed by RWW larval feeding generally had smaller leaf area values and smaller root weights than uninjured plants. The Furadan treatment generally resulted in plants that were larger than the plants from the uninfested control, although RWW damage was nil in both treatments.