Project No. RP-3

COMPREHENSIVE RESEARCH ON RICE
ANNUAL REPORT

January 1, 1986 -December 31, 1986

PROJECT TITLE: Protection of rice from invertebrate pests.

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LEVEL OF 1986 FUNDING: $39,635.

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

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

1) A continuing survey of rice water weevil and armyworm adults was made with a light trap at Biggs to determine flight periods from April to July (infestation flights).

2) Plastic Pane Traps and Sticky Traps were placed in three fields at Biggs for comparison with the Light Trap and to determine possible relationships of water weevil flights to postflood insecticide applications.

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

1) Rice water weevil - chemical control.

a) Preplant applications of carbofuran granules at 1 lb. ai/acre, incorporated and surface applied, were made at Biggs to determine efficacy on the rice water weevil and observe the effect upon caged mallards.

b) Postflood applications of Alsystin and diflubenzuron were made at several rates within a single paddy at Biggs.

c) Postflood applications of Alsystin and diflubenzuron were made at several rates and times in replicated paddies with separate water management at Biggs. Treated plants and water were taken to Davis for greenhouse studies with controlled weevil infestations. Natural infestations and artificial infestations in rings were used for evaluations at Biggs. The effect of Alsystin on non-target species was also monitored at Biggs.

d) Field evaluations at Biggs and greenhouse studies at Davis were made with the experimental chemicals CMI 8501 and 8601 as postflood applications. These chemicals have an insecticidal activity similar to that of the synthetic pyrethroids with low hazard to mammals and a low fish toxicity compared with other pyrethroids.

e) Greenhouse evaluations with the experimental chemicals SC-0567 (an organophosphate) and PP993 (a pyrethroid) as preplant, preflood treatments were made at Davis.

2) Rice water weevil - genetic control.

a) Studies on the tolerance of rice to the weevil were made at Biggs with a standardized test that compared 20 cultivars.

b) A second test at Biggs for tolerance to the weevil compared growth characteristics and larval development on two promising cultivars 83-2200 and 85-2385 to M-9.

c.) A greenhouse test at Davis compared the effect of larval feeding by three population levels of the rice water weevil on the cultivars 85-2385 and M-9.

SUMMARY OF 1985 RESEARCH BY OBJECTIVE:

Objective 1:

1) Light trap collections for the rice water weevil are made annually to determine peak flight periods and better interpret periods of infestations in research plots. The maximum flight of overwintering weevils in 1985 and 1986 was during the 2nd and 3rd weeks of April. The numbers were 3X greater in 1985 than 1986. This occurred before the fields were flooded at Biggs but flights continued off and on until May 24 in 1985 and May 27 in 1986.

The light trap also catches armyworm adults and these are recorded to obtain background information for the trap's potential as a method that may substitute for field examinations for larvae. The peak flight that has the greatest potential for ovipositing on rice occurs about mid to late June. Larval injury following that oviposition period is in July-August. A summary shows that in 1984 (6/20-24) there were 63 moths collected, in 1985 (6/21-25) 156 moths, and 1986 (6/12-18) 453 moths. General complaints of armyworm injury to rice and spray activity during these 3 years were greatest in 1985 so the numbers collected in the light trap do not necessarily indicate potential for injury to rice.

2) The cost of light traps and a ready source of power preclude them from being used as indicators of water weevil flight activity in each field that this information may be needed. Since knowledge of weevil flight activity may be more critical to the timing of postflood chemical treatments, sticky traps and plastic pane traps were used at three different fields and compared to the catches of a nearby light trap. The peak flight periods in May were about mid-May for all three types of traps. The last flights recorded for the light and sticky traps were 5/27-5/30. The pane traps

showed flight activity ending one to two weeks earlier. This may reflect a decreased efficiency of the pane traps as they caught fewer weevils than the sticky traps. The trapping information should continue in 1987 to see if the same trends continue.

Objective II:

1) Rice water weevil - chemical control.

a) In recent years duck mortality has been associated with some rice fields at the time of flooding. Chemical analyses have shown carbofuran (the chemical used to control the rice water weevil) to be the cause of mortality in most of the cases. A light incorporation of the surface applied granules has been recommended to alleviate the problem in areas near waterfowl refuges. The value of this procedure has not been documented and the following experiment is an attempt to address this problem. The experiment was conducted on the east end of field L-102 at the Biggs Experiment Station. Experimental units were 6x10 feet, separated by 4 feet, and replicated 3 times in randomized complete blocks. Two sets were treated on 5/5 with 5% carbofuran granules at 1.0 lb. a.i./acre to the soil surface. A third set was left untreated. One set of the treated was lightly incorporated with a garden rake. Chicken-wire cages enclosing 4x8 feet were placed on each unit which left a 2 foot treated border beyond the margins of the cages. Four drake and two hen, one year old mallards were placed in each pen just before flooding. Floodwater reached the cages in approximately one hour. The pen reared mallards were prohibited from drinking or eating for 24 hrs. before placement. No mortality was observed during the course of the experiment (3 days) but one bird was sacrificed from each cage 6 hours into the test, 1 drake and 1 hen from each cage at 30 hrs. (May 6), and the remainder sacrificed the 3rd day (51 hrs. on May 7). Viscera and heads were removed and frozen for later residue analysis and measurement of cholinesterase. No symptoms of poisoning or mortality were observed during the 3 day exposure period. There was no significant difference in the cholinesterase activity in the brain tissue of the ducks in the treated pen areas and the control at 6, 30, or 51 hrs. after the ducks were placed in the cages. Residue analyses of the viscera were made of ducks from both treatments and the untreated at the 6 hour exposure. One duck (a drake) showed 0.21 ppm carbofuran in one replication of the treatment with surface applied granules but no detectable residue was found in the remainder of the ducks removed at this time period. The cholinesterase level of the duck with a detectable carbofuran residue was not significantly different from the mean level of cholinesterase of the control ducks. Some duck mortality and/or reduction in cholinesterase level was expected in the experiment. The absence of either and the single incidence of a low level of residue in the viscera indicated the ducks were not coming into contact with significant amounts of carbofuran. The optimum management scenario would be that the man-made or duck-made incorporation prevented the ducks from reaching the granules, but there are other possibilities. Spring is the mating season for mallards and the caged birds (combined sexes) may have been more concerned with mates than with feeding activity during the three day period of confinement. Field (wild population) birds are said to be under more stress than pen-reared birds for various reasons and thus thinner. Their feeding activity in rice fields may be at a greater intensity than the pen-fed birds and thus may have a greater exposure to the chemical. Such problems and interpretations are to be expected for caged studies but the most discouraging management scenario would be for heavy mortality throughout the cages on treated soil. It is questionable at this time if additional cage studies with ducks and carbofuran would resolve the wild birds vs. pen-reared birds question or if the duck soil disturbance incorporation could be avoided.

The study area was seeded on May 14. Metal rings enclosing 8 sq. ft. were placed in the units following removal of the cages and 25 rice water weevils were added to each ring on June 2. Rice plants were evaluated (10 cores/ring) for weevil larvae on June 24. A mean number of 18 larvae were found in 10 cores from the untreated plants, 0.6 larvae/10 cores of plants from the surface applied granule treatment and 0.3 larvae/10 cores of plants from the plots with incorporated granules. The numbers of larvae from the control were significantly higher from the treated but the numbers of larvae found in the treated plots were not significantly different from each other. The carbofuran granules were obviously toxic to the rice water weevil larvae as indicated above. The infestation level was rather low when compared to other adjacent experiments. This may be due to soil compaction caused by the ducks. It was obvious when using a core sampler to extract rice plants for larval evaluation that the soil within the cages was compacted when compared to that outside of the cages. The presence of the ducks and their disturbance of the soil probably resulted in some soil incorporation of the granules in both treatments so there may not have been a distinct difference between unincorporated and incorporated carbofuran plots.

b) Several of the following experiments deal with the two chemicals Alsystin and diflubenzuron. Both are benzoylphenyl urea compounds that act primarily on the adult weevils resulting in eggs that are oviposited but do not hatch.

The first field test was conducted in a paddy 50'x900' at Biggs. Each treatment plot measured 15'x15' and was separated by 20' from the next nearest plot. The paddy was flooded on 5/5 and treatments were made at 5,7, and 11 days after the rice emerged from the water. Rates of 0.125, 0.25, and 0.375 lb ai/acre were replicated 4 times at the three time intervals. Ten cores with 1 plant/core were removed from each plot to wash and recover weevil larvae from the roots and to measure plant growth. The numbers of larvae (a natural population) ranged from 3.3 to 5.3 per plant but there were no significant differences between the treated and the untreated plots. There were also no significant differences in plant growth between the treated and the untreated. This was the first time two different benzoylphenyl urea compounds, at different rates and time of applications, with a control were used in the same paddy. Previous tests have used separate paddies and water management for each replication. It appears that there may have been chemical contamination between the plots by water in spite of a 20' separation, or contamination by movement of water weevils from plot to plot. The latter is suspected.

c) The second field test with Alsystin and diflubenzuron was conducted in 12 plots (each 20'x146' with separate water management) at Biggs. Each treatment and the control were replicated 3 times in a randomized complete block design. The paddies were machine seeded with 150 lbs/acre of rice variety M-201 on 5/12. Paddies were flooded on 5/13. Weevil flights were recorded in these paddies from 5/14 to 5/30. Applications of Alsystin at 0.25 and 0.375 lb ai/acre, and diflubenzuron at 0.25 lb were made on 6/6, approximately 5 days after rice emergence from the water. Water was held for 4 days after application before a continuous flow was started again. Ten cores with one plant/core were removed from each paddy on 7/1 and 7/16 to record the immatures found on the roots. Plants were measured for differences in growth characteristics. The paddies were drained on 9/15, and harvested by combine on 10/6.

On 7/1 (25 days post treatment) the mean number of larvae/plant in the treatments ranged from 2.3 to 5.3 and in the untreated 8.3 larvae. The differences in the treatment numbers were not significantly different from each other at the 5% level but were significant from the control at the lower range. Most plant growth characteristics showed a general trend for reduced growth in the control at this time but the differences were not significant at the 5% level. On 7/16 (40 days post treatment) the mean number of larvae ranged from 1.7 to 2.4 larvae/plant in the treated and 5.6 larvae in the untreated. Treatment numbers were not significantly different from each other at the 1% level but all were significantly different from the untreated. All plant growth characteristics were greater than the check but only significantly so (1%) for root length.

To insure that there would be an adequate infestation, aluminum rings enclosing 8 sq. ft. were placed in the paddies containing the two rates of Alsystin and also the control. The two rates of Alsystin had 1.2 and 1.6 larvae /plant and the control 5.0 larvae/plant. This compared rather closely to the counts found for the natural infestation 11 days later.

Rice yields of the four treatments and control were as follows: Alsystin at 0.25 lb ai/acre had a 6% increase over the control; diflubenzuron at the same rate showed a 11% increase and Alsystin at 0.375 lb ai showed a 21% increase over the control. The high rate was significantly different from the control at the 5% level but the lower rates were not because of variability.

A subsidiary experiment was conducted in the greenhouse at Davis which utilized the field application of the 0.25 lb/acre rate of Alsystin by transporting plants and water from the field test to the greenhouse so that controlled infestations of the weevil could be utilized. Treated and untreated plants were brought to Davis at 1,3, and 5 days post-treatment and water from treated and untreated paddies at 1, 2 and 3 days after application. Two treated plants per replication were transplanted to pots and 8 field collected weevils were confined on each pot for 24 hrs. to feed and oviposit. This was repeated at 1, 3, and 5 days post application. The roots were examined for larvae about 3 wks. after the weevils were removed. The one day post-treatment exposure showed 78% fewer larvae than the control; the three day post-treatment exposure revealed 48% fewer larvae than the control; and the 5 day post-treatment exposure had 21% fewer larvae. Some residual effect from treated leaves may have lasted beyond 5 days but the effectiveness was rapidly decreasing under these conditions. An effect of the chemical in the water on the egg stage has been demonstrated in greenhouse tests the previous year but a conclusive effect of field treated water was not observed in this test.

The effect of Alsystin on non-target organisms over the past two years is still in the process of evaluation.

d) Two experimental chemicals from Japan CMI 8501 (cycloprothrin) and CMI 8601 (ethofenprox) the former a synthetic pyrethroid and the latter a chemical with similar activity to the synthetic pyrethroids were field tested at Biggs and in the greenhouse at Davis for control of the rice water weevil. As with other pyrethroids, they have a very low mammalian and bird toxicity but differ in having a comparatively low fish toxicity.

The chemicals were reported to be effective on the rice water weevil in Japan but information on what stages of the life cycle were affected was not known. Greenhouse tests at Davis were designed to examine their effect on the adults, eggs, and late 1st to 4th instar larvae. Recommended rates for testing were 0.30 lb ai/acre for CMI 8501 and 0.15 lb ai for CMI 8601. Both chemicals were formulated as granules and all applications were made postplant to the water. Neither chemical showed a significant effect upon the egg stage. CMI 8501 was not effective upon larvae but CMI 8601 showed a 42% reduction in larvae that was significant. The adult stage showed the greatest susceptibility to both chemicals. No adults survived a 24 hrs. exposure to the chemicals. No oviposition was in evidence during this period for CMI 8601 and a 99% reduction in oviposition was found for CMI 8501.

A field evaluation of these two chemicals at the same rates was made at Biggs in aluminum rings. Thirty weevils per ring (approximately 1 weevil/2 plants) were placed in 3 replications on 5/24 and the granules applied on 5/26. The two newest leaves were examined for adult leaf feeding scars on 5/28 and 5/31. There was no significant difference in scarring on leaves within treated and untreated rings on the first count because of the weevils being present 2 days before treatment, but there was a 62-66% reduction in new scars compared to the control by the 5th day after treatment. This confirms a strong reduction in adult activity. A core sampling of the rice roots on 6/19 showed 64% fewer larvae in the CMI 8501 treatment than the control and 75% fewer larvae for CMI 8601. Both were significant at the 1% level. The fact that the adult stage is the primary stage controlled with these chemicals indicates that the time of application will be very critical for adequate plant protection.

e) A greenhouse test at Davis with SC-0567 (organophosphate) and PP993 (pyrethroid) was made with granules as a preplant, preflood treatment for water weevil control. The test showed that the compounds were most active on the adult stage. The PP993 does present more hazard to fish and SC-0567 to wildlife in general than other experimental compounds tested.

2) Rice water weevil - genetic control

Weevil control through the development of a tolerant or resistant variety has been an objective of this project from its onset. Progress has been slow but steady. A source of tolerance was found but it had many undesirable agronomic properties for this area. Thus an extensive breeding effort was necessary to improve the cultivar and maintain the tolerance.

The evaluation of this tolerance is limited to one period each year because the weevil has but one generation a year in California. Resistance in the form of antibiosis or xenosis has not been found in our studies so research has concentrated on the development of a tolerant variety.

a) The standard test (see previous annual reports) of comparing 4 replications of the treated (carbofuran) cultivar and the same untreated one under a natural weevil infestation was conducted at Biggs. Eighteen of the most promising lines from the Biggs plant breeder's tests of 1985 were used in the standard test for the first time. They were compared to the most promising line used in last year's standard test (85-2385) and the standard susceptible M-9. There was a very high natural infestation of weevils this year which caused a considerable stress on the plants. The carbofuran provided adequate control to make comparisons with the untreated but there was some weevil injury in the treated plots. From 5 to 7 of the 18 new lines tested in 1986 showed greater tolerance than 85-2385 depending on the plant growth characteristics used for comparison. The 5 lines showing the least reduction in yield between treated and untreated were 86-2404, 86-2325, 86-2348, 86-2377, and 86-2362. The first (86-2404) showed a 4.3% reduction in grain due to the weevil and the following four lines showed a reduction in grain that ranged from 8.9% to 12.1%. The susceptible M-9 had a 31.5% reduction in grain in the untreated. The yield reduction of 85-2385 in 1985 was 17.4% and in 1986 it was 19.6% which shows the weevil infestation was equally as strong this year.

b) A test similar to the standard test for tolerance was conducted in the same paddy as the variety test. The tolerant lines 85-2385 and 83-2200 and the susceptible M-9 were used. Plant samples and larval counts were made in the treated and the untreated at 40, 65, and 100 days from planting. One additional treated and untreated replication was included for yield. The purpose of the test was to see if some major differences in growth could be noted that would provide information on the mechanism of tolerance. The water weevil population was very high in this part of the field and the carbofuran was not providing a high level of control so the combination appeared to be masking or overwhelming the level of tolerance that was expected. The numbers of larvae per plant were highest at the 40 day sample. No significant differences in numbers of larvae occurred between treated and untreated but the most tolerant line (85-2385) had the greatest number of larvae on the roots and the M-9 the least number. The numbers of larvae were directly proportional to the root mass on the variety at that time. In other words, the root mass of the M-9 plants was pruned so badly that it could not support more larvae. This same general trend was observed at the 65 day sample but there were fewer larvae and root growth had begun to recover for all rice lines. The larval counts were quite low at 100 days and not significantly different between the different lines. Only slight differences were noted in yield between the different lines. Less weevil pressure and a more effective control will be necessary to better interpret the mechanism of tolerance.

c) A greenhouse test was conducted at Davis to attempt to provide information on the mechanism of tolerance. Five replications of 85-2385 and M-9 were planted in pots and infested with 1st instar weevil larvae at the rates of 40, 20, and 0 per plant at 23-24 days following planting. Contents of the pots were washed to recover larvae 45 days after infestation and plant growth characteristics were measured. The number of larvae recovered was 4.8 and 20.2/plant for the M-9 at the 20 and 40 larvae/plant exposure, and 6.4 and 19.4 for 85-2385. The difference in larvae recovered from the two rice lines was not significant but numbers of larvae from the two rates of infestation was significantly different at the 1% level. There was a mean mortality rate of larvae at 20/plant infestation of 72% and at the 40/plant infestation a 50% mortality. The reason for greater larval mortality at the lower infestation rate is not known but one might speculate that there is a chemical or biological factor of the plant interfering with larval development that can be overcome by higher larval numbers. Significant effects (1% level) were found in plant growth that showed a decrease in plant growth with an increase in larval numbers but the differences were not significant between the two rice lines. The lack of significant difference in growth between tolerant and susceptible lines may be attributed to rapid plant growth that occurred under the favorable greenhouse conditions. Previous experiments in the field have shown the maximum weevil effects to be on the youngest plants. Plants of a comparable age and pedigree in the field were much smaller than those in this experiment. The greenhouse experiment needs repeating with plants of several age groups and a higher range of weevil larvae.

PUBLICATIONS OR REPORTS:

Grigarick, A.A. 1985. Comprehensive research on rice, RP-3, 11pp.

Grigarick, A.A. 1986. Interaction of pests with rice water management practices. Section on objectives 3-6, invertebrate pests. IPM Cooperative Project 8pp.

Grigarick, A.A., H.L. Carnahan, and C.W. Johnson. 1986. Studies on rice water weevil resistance. Rice Field Day, p. 3-6.

Grigarick A., M. Oraze, and K. Smith. 1986. Comparative growth characteristics of and rice water weevil development on a susceptible and two tolerant cultivars of rice. Proc. Twenty-first Rice Tech. Working Group, Houston TX, p.92-93.

Scardaci S.C., Hill J.E., Crosby D.G., Grigarick A.A., Webster R.K., and S. Palchick. 1985. Preliminary report on evaluation of rice water management practices on molinate dissipation, rice pests and production. Agron. Prog. Rep. 51 pp.

Williams J., A. Grigarick, S. Scardaci, C. Wick, J. Hill, and R. Webster. 1986. Field evaluation of the effects of coated rice seed on pest damage and crop growth. Proc. Twenty-first Rice Tech. Working Group, Houston, TX. p. 57.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Light trap collections of rice water weevils in 1985 and 1986 showed the maximum flights to occur during the 2nd and 3rd weeks of April which indicated an early season for both years. However, flights continued until May 24 in 1985 and May 27 in 1986. Late flooding to avoid infestations of the weevil could have been initiated the 4th week of May in the Biggs area. Research with sticky traps and pane traps for determining weevil flight in individual fields showed the sticky traps to be the most effective.

Light trap catches of armyworm adults in late June (the period in which the infestations in rice normally begin) in 1986 were 7X greater than in 1984 and 3X greater than in 1985. Reports of economic damage by and treatment for armyworms were light in 1986 compared to the previous two years. The numbers of adults collected in light traps do not necessarily reflect the potential for injury in the field based on collections from the past three years.

Duck mortality has been associated with some rice fields that have been treated with carbofuran and flooded at the beginning of the growing season. An experiment was conducted with caged ducks on soil treated with carbofuran granules at 1.0 lb ai/acre. In one set of three replications the carbofuran granules were left on the soil surface, they were lightly incorporated in one set and one set was left untreated. The birds were without food or water for 24 hrs and then caged on all plots one hr before flooding. No symptoms of stress or mortality were noted in the caged birds over the three day period of the test. Birds were removed from the cages each day and sacrificed for analysis of cholinesterase enzyme of the brain but none showed a significant reduction from the untreated birds. An analysis of the contents of the crop and gizzard revealed only one bird out of nine on the first day with a detectable residue (0.21 ppm). The same bird did not show a significant reduction in cholinesterase level. An artificial infestation of water weevils was started in the same area of the pens after pens and birds were removed. Core samples of the rice roots later showed significant control in the treated areas compared to the control. There were no differences in control between surfaced applied granules and the incorporated. Duck activity in the pens (6 birds in 60 sq. ft.) resulted in some soil compaction and possible incorporation of granules in both treatments. The absence of mortality, no significant reduction of cholinesterase, and the slight amount of residue found in the viscera of only one duck indicates the ducks were not contacting significant amounts of carbofuran under the conditions of the cage study.

Two field experiments were conducted with the chemicals Alsystin and diflubenzuron. These chemicals act primarily on the adult weevils, by their feeding on and contact with treated foliage, that results in a situation where the eggs are oviposited in the plant but they do not hatch. One experiment was conducted in a single paddy (50'X900') with multiple rates and times of applications. There were no significant differences in the number of larvae recovered or effect upon plant growth. It appeared that there may have been chemical contamination between plots (even with

20'separations) or contamination by movement of water weevils from plot to plot.

The second experiment was carried out in 12 paddies (each 20'X146') that had separate water management and some valuable data was obtained. Alsystin at 0.25 and 0.35 lb ai/acre and diflubenzuron at 0.25 lb were sprayed on the paddies five days after mean emergence of the rice through the water. Rice plants sampled for larvae at 25 and 40 days after application showed significant reductions in larvae from the untreated for both chemicals at both rates but no significant differences between chemicals and rates. Plant growth at these periods showed a general trend to be greater for the treated than the untreated. Rice yields were as follows: Alsystin at 0.25 lb ai\acre had a 6% increase over the control; diflubenzuron at the same rate showed a 11% increase and Alsystin at 0.375 lb showed a 21% increase over the control. The highest percent increase was significantly different from the control at the 5% level but the lower increases were not because of variability.

A subsidiary experiment was conducted in the greenhouse which utilized the field application of Alsystin at 0.25 lb ai\acre. Plants from the field were tested at 1, 3, and 5 days after application with controlled weevil infestations. Adults were placed on plants collected on these days and larvae were recovered later. The treated showed 78% fewer larvae than the untreated at 1 day after treatment, 48% fewer larvae at 3 days and 21% fewer larvae at 5 days. This experiment shows that adults flying into the field after treatment would be progressively less affected due to the natural breakdown of the chemical. For another part of the greenhouse study, untreated and treated (0.25 lb Alsystin) plants were brought to the greenhouse the day of treatment in the field and adult weevils were confined on them for 24 hrs. They were removed and placed on new untreated plants each day for 5 consecutive days. No 1st instar larvae hatched from eggs oviposited during the 5 day period. This shows that the initial exposure of the adults at the day of application provides complete control for at least 5 days. Water from paddies that had been treated failed to show conclusive effects upon oviposited eggs in this study.

The experimental chemicals cycloprothrin and ethofenprox from Japan were tested for rice water weevil control in field and greenhouse studies. The former is a synthetic pyrethroid and the latter has an activity similar to the pyrethroids. The pyrethroids were not seriously considered for rice water weevil control in the past because of their high toxicity to fish but the two materials being tested have a relatively low toxicity to fish, birds, and mammals. Field and greenhouse tests showed cycloprothrin (0.3 lb ai/acre) and ethofenprox (0.15 lb) to be highly effective on adult weevils, to have little or no effect on the egg stage and only ethofenprox to show significant activity on larvae. The fact that the adult stage is the primary stage controlled indicates the time of application will be very critical but their safety to wildlife warrants further investigation as candidates for future registration.

The standard test for evaluating rice water weevil tolerance this year compared 18 of the most promising lines from the plant breeders selections in 1985 to the most tolerant line, 85-2385, of last years standard test along with the susceptible M-9. From 5 to 7 of the new lines tested showed greater tolerance than the 85-2385 depending on the plant growth characteristics used for comparison. The 5 lines that showed least reduction in yield between treated and untreated plots were 86-2404 with 4.3% reduction, 86-2325 with 8.9%, 96-2348 10.5%, 86-2377 12.1%, and 83-2362 12.1%. The 85-2325 showed 19.6% reduction in yield which was about 2% higher than last year. M-9 had 31.5% reduction in grain. Grain quality is also improving with the new lines.

Tests to provide information on the mechanism of tolerance were conducted in the field with 83-2200, 85-2385, and M-9. and in the greenhouse with the latter two. The field test utilized a natural infestation of weevils but the larval pressure was so great that it masked the levels of tolerance we had observed in previous years and overwhelmed the treated paired plots. Greenhouse results were not conclusive because of abnormally rapid rice growth due to the moderated conditions of the greenhouse. A technique was developed to apply specific numbers of 1st instar larvae to the roots which should reduce variability in future evaluations.