PROJECT NO. RP-3

COMPREHENSIVE RESEARCH ON RICE
ANNUAL REPORT

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PROJECT TITLE: Protection of rice from invertebrate pests

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

Objective I: The recognition of physical and biological factors that allow the buildup and movement of pest populations that cause economic injury to rice plants.

1) Experiment to determine the degree of stand reduction by crayfish at Biggs.

2) Experiments with the aster leafhopper to determine: a) maximum infestation period; b) their relationship to weeds in rice fields and the effect of broad leaf herbicides; c) the effect of plant stand on infestation level; d) leaf age structure initially infested; and e) levels that may cause loss in yield. Biggs.

3) Laboratory experiments with the armyworm on the rate of leaf consumption and rate of larval development. Davis.

4) Survey of rice water weevil populations by light trap at Biggs.

5) The interaction of weeds, water weevils, and plant stand on yield (in cooperation with Don Seaman). Biggs.

Objective II: To determine the most effective control of rice invertebrate pests and maintain a quality of the environment compatible with the needs of society.

1) Tadpole shrimp - chemical control. Commercial airplane applications to natural infestations of suspected resistant shrimp were evaluated near Escalon (in cooperation with Mick Canevari and Vern Burton). Parathion at 0.1 lb. AI/acre, carbaryl (Sevin®) at 2.0 lb., and copper sulfate crystals at 10.0 lb. were used.

2) Crayfish - chemical control. Hand applications to collected populations of confined crayfish were evaluated at Biggs.

Fenthion (Baytex®) at 0.1 lb. AI/acre, parathion at 0.1 lb. and methyl parathion at 0.5 lb. AI/acre were used.

3) Rice water weevil - chemical control.

a) Two tests were conducted to determine the systemic effect of selected chemicals on rice water weevil adults. One test was conducted in the field at Biggs on adults confined over rice grown in soil treated with carbofuran at 0.5 and 1.0 lb. AI/acre (preflood). The second test was conducted in the greenhouse at Davis with adults confined on the rice at 16, 29, and 43 days postplant. Chemicals used in the second test were Advantage® granules at 0.5 lb. AI/acre, carbofuran slow release granules at 0.5 and 1.0 lbs. and the standard granular formulation of carbofuran at 0.5 lb. All applications were made preplant, preflood.

b) Three field tests utilizing natural and artificially placed populations of adult weevils were conducted at Biggs to control weevil larvae. Three formulations of slow release granules of carbofuran at 0.5 lb. AI/acre, and Advantage® (a carbamate similar to carbofuran) at 0.5 and 1.0 lbs. were compared to standard formulations of carbofuran at 0.5 and 1.0 lbs.

c) A laboratory test at Davis was conducted with carbofuran (technical grade) on rice water weevil adults to compare current levels of susceptibility with levels measured in 1968 in order to determine if resistance has developed.

d) The insect growth regulators diflubenzuron, an analogue of diflubenzuron, Bay Sir 8514, and UC 62644 were tested at 0.25 lbs. AI/acre by treating rice water weevil adults topically and treating rice plants. These were compared to SN 7219 (a stomach poison) at 0.25 and 0.5 lbs. applied to the rice plants, all in the greenhouse at Davis.

4) Rice water weevil - genetic control. Studies on the tolerance of rice cultivars to the weevil were made at Biggs.

a) Thirteen cultivars from California crosses that showed promise from previous crosses were compared in 4 treated (carbofuran) and untreated replications to 2 standard (tolerant and nontolerant) varieties by measuring plant growth characteristics (including yield).

b) Nine cultivars from Louisiana and Texas that were reported to show resistance to the water weevil were compared to two California experimental lines and M-9 by sampling for larvae on the roots and visually comparing plant growth characteristics.

c) Numerous block plantings of recent crosses by Howard Carnahan and Carl Johnson were visually rated for weevil tolerance by comparing plant growth characteristics.

SUMMARY OF 1981 RESEARCH BY OBJECTIVE:

Objective I:

1) For the third consecutive year crayfish were associated with a reduction in rice seedling establishment. A natural infestation from rice paddies was not available so crayfish were collected from an irrigation ditch and placed in aluminum rings 5 days after M-401 was planted. *Procambarus clarki* and *Orconectes virilis* were the species collected in a size range of 10-15 cm in length. All seed was treated with captan at 2.4 oz. AI/100 lb. to prevent the formation of fungi which has been reported to possibly make the seed more attractive to the crayfish. One month after planting, all crayfish had left the rings but initial populations of 1 per 8 sq. ft. resulted in significant reductions in the rice stand by 62%, 1 per 16 sq. ft. caused a 22% reduction, and 1 per 32 sq. ft. showed a 9% loss. An accumulation of 3 years data is being published and will be used to show the need for registration of a chemical for crayfish control.

2) Data from aster leafhopper studies in 1980 was processed in 1981 and the analysis of studies in 1981 is yet to be completed. Experiments in 1980 used rice variety M-101 that was periodically treated with carbaryl and compared to untreated plants. Adult leafhoppers first appeared on June 19 and were found until August 14 but they were never more than 0.7 adults/plant. Nymphs occurred in maximum numbers on the untreated plants on August 17 and 24 in numbers of 31.8 and 69.1/plant respectively but only up to 0.2/plant on the treated plants. There was a significant reduction in grain of 11.7% for the untreated plants. Of considerable interest was the observation that 84.9% of the nymphs and 99.8% of the adults were found on senescent leaves. In an additional test, all plants were treated to prevent leafhopper colonization. In one set of paired replications the senescent leaves were trimmed off from June 26 to September 4. Yield of the trimmed plants showed a 13.4% reduction, but because of variability this figure was not significant.

3) Field experiments with the armyworm, *Pseudaletia unipuncta*, at Biggs and Richvale were concluded in 1980 but analysis of the data extended into 1981 and laboratory studies at Davis extended into June of 1981. Nine commercial fields, including M-101, M-9, and Calrose 76 were selected with armyworm damage. Yields from plants with 25 to 30% defoliation were compared to plants with 0-10% leaf loss. Plants from 7 of the 9 fields showed a decrease in grain at the higher defoliation level that averaged 24% but only the highest grain losses (34.7, 44.5,

and 50.2%) were significant at the 5% level. The losses resulted from an absence of seed and not blanking. Panicle injury by armyworms was examined in variety M-101. The number of damaged panicles averaged 20.4 $\pm$ 14.8 per m^2. Panicles with an average of 65.7 seeds/damaged panicle showed 6.7% of the seeds to be injured by armyworm feeding. The average amount of total seed loss was 0.35%. Field measurements showed a high positive correlation (r = 0.90) between average percent defoliation and average number of armyworms with an increase in plant stand (r = 0.81). Armyworm development through 6 instars in the laboratory took 24.3 $\pm$ 4.7 days. Rice leaf consumption was determined at each instar. The total consumption was 267.65 cm^2 of leaf tissue/larva. The maximum consumption was during the 5th and 6th instars which amounted to 22.25% and 74.26% of the total. Figure 1 shows the time of 3 levels of potential defoliation of 14 week old plants by 6th instar larvae.

4) Light trap collections are still being counted at this time.

5) Data for the interaction of weeds and water weevils have not been analyzed.

Objective II:

1) Airplane applications of 3 chemicals registered for tadpole shrimp control were followed in commercial rice fields in San Joaquin County where resistance to these chemicals was suspected. Water depth ranged from 2 to 5 in. in the fields. The results were as follows: parathion at 0.1 lb. AI/acre did not show a satisfactory reduction in shrimp; the same population of shrimp (3.5/sq. ft.) was treated with copper sulfate at 10 lb. AI/acre and no live shrimp were found; carbaryl at 2.0 lb. AI/acre showed an adequate reduction in shrimp from 2.0 to 0.5 shrimp/sq. ft. The data indicated that the tadpole shrimp were resistant to parathion but laboratory studies are needed to confirm this.

2) Two species of crayfish (*Procambarus clarki*, and *Orconectes virilis*) were confined in 4 replications of aluminum rings for chemical control tests. Methyl parathion at 0.5 lb. AI/acre resulted in 100% mortality of both species in 48 hrs. Fenthion (Baytex®) at 0.1 lb. AI/acre controlled *P. clarki* but not *O. virilis* and parathion at 0.1 lb. AI/acre was not effective on either species. Both species were collected from the irrigation canal adjacent to rice fields; however, we have only found *P. clarki* within the rice field paddies. The apparent selectivity of fenthion could be considered advantageous for the non-target species if accidental drift or drainage resulted from treating a rice field infested with *P. clarki*.

3) Rice water weevil - chemical control

   a) A systemic effect of carbofuran on adult weevils has previously been demonstrated in the greenhouse and suspected in the field but not tested in the field. Adults caged for 3 days on rice plants grown on soil treated with 0.5 and 1.0 lb. carbofuran before flooding showed no mortality in the field. The test was conducted about 4 weeks after treatment. A test on adults confined for 2 days on plants in the greenhouse that were treated with several chemicals showed the following results: carbofuran granules (standard 5G) at 0.5 lb. AI/acre showed 90% mortality of adults at 16 days after planting and 57% mortality at 29 days; carbofuran (slow release granules) at 0.5 and 1.0 lb. and Advantage® (analogue of carbofuran) at 0.5 lb. resulted in no significant difference in mortality of adults from the untreated at 16 or 29 days. There were no significant differences in all treatments at 43 days. Reasons for the lack of mortality in the field as compared to the greenhouse are unknown but the main difference in the two systems is that water movement in the greenhouse is confined to soil in pots and may allow the chemical to be available to the plant for a longer period.

b) The effect of several carbamate insecticides and different formulations of them on larvae of the water weevil was evaluated in 3 field tests. All experiments were artificially infested with adults at one time interval but the 3rd test also had a prolonged natural infestation of weevils. A summary of the first two tests showed the maximum reduction in larvae, 68-77%, for Advantage® and the standard granular formulation of carbofuran at 1.0 lb. AI/acre. The same chemicals at 0.5 lb. showed only a larval reduction of 31-52%. Two formulations of slow release granules of carbofuran at 0.5 lb. showed no difference in larvae from the untreated which indicated the toxicant was bound up too tight in the resin coating. The third test did not show significant differences in numbers of larvae recovered, which was probably due to the extended period of natural infestation.

c) The occasional failures of carbofuran to adequately control the rice water weevil at 0.5 lb. AI/acre led to the recommendation of 1.0 lb. for preplant, preflood treatments. This would indicate the possibility of resistance developing to carbofuran so a standardized test was conducted this year on the adults to determine their level of susceptibility. Fifty percent of the population was controlled with a rate between 0.010 µg and 0.015 µg/weevil at 72 hours. In 1968 our tests showed the LD_{50} to be 0.0109 µg/weevil which indicates that resistance to carbofuran has not developed. Similar results were recently reported from Louisiana and Arkansas. This supports the contention that degradation of the chemical in the field is the probable reason for occasional control failures.

d) Five chemicals were tested in the greenhouse as potential candidates to be used in a control program for the rice water weevil during flooding at about 3-5 weeks after planting. The following are insect growth regulators that were applied to the insect and applied to the plant at 0.25 lb. AI/acre: diflubenzuron, an analogue of diflubenzuron, Bay Sir 8514, and UC 62644. None affected adult mortality but material applied to the plant resulted in 68, 76, 86, and 54% reduction in larvae from the check in the listed order. Treatment directly to the insect resulted in 64, 75, 41, and 10% reduction in larvae. The fourth experimental chemical SN 7219 (a stomach poison applied to the plant) caused 67% adult mortality at 0.25 lb. AI and 93% mortality at 0.5 lb. Only 49 and 50% reduction in larvae from the check resulted which indicates that adult mortality did not occur until after some oviposition. Several of the growth regulators will be investigated in the field next year.

4) Rice water weevil - genetic control. A continuing study to search for a rice cultivar tolerant or resistant to the rice water weevil was conducted at Biggs in cooperation with the plant breeders Howard Carnahan and Carl Johnson and the Entomologists Mike Smith and John Robinson at Crowley and Clarence Bowling at Texas. Results of three different tests are reported below, all of which were subjected to heavy natural infestations of the rice water weevil.

a) Eleven lines arbitrarily selected from 1980 crosses and 2 lines that showed the most promise in 1979-80 experiments were compared to M-9 (susceptible) and WC-1403 (tolerant parent) by measuring 10 plant growth characteristics at about 75 days and also by taking yield. The average % reduction in plant growth between treated and untreated ranged from 31.5 to 39% for the most tolerant 5 cultivars. M-9 showed a 57.2% reduction in plant growth. The ranking of the top 5 cultivars was as follows: 80-50463, 79-4046, WC-1403, 80-50658, 80-50811, and 80-51118. The maximum yield of the treated plants and minimum % reduction (9.3%) in yield was by 80-50658. It yielded 17% more grain than M-9 when treated and 54.5% more when left untreated. The same line (80-50658) also showed an average 67.8% stand establishment (the highest) whereas M-9 averaged 40.3%. The seed was not treated with a fungicide. All cultivars were later thinned to the same number of plants for comparative purposes.

b) The row plantings in an advanced nursery from Louisiana were replicated 5 times and evaluated on the basis of number of larvae recovered from the roots at 35-45 days after planting and flooding. Plant growth evaluations also were made at this time. The varieties in the order of lowest number of larvae found on the roots were BMT 76323, Bellemont, RU 7603069, and CI 9323. The 4 that had the poorest growth rating were the first 3 of the above. CI 9323 ranked 4th in optimum growth. The test did not show a good correlation with optimum growth and the fewest number of larvae except for CI 9323 which was intermediate.

c) One hundred and 71 lines, primarily from 1980 crosses, were arranged in 3 replications of 2' x 4' block plantings. They were visually ranked for plant growth that appeared to be tolerant to the rice water weevil. About 10 to 20 of these will be examined in 1981 as was outlined in part a above. Several lines that ranked high in this test (c) also ranked high in test a. Numbers 50658 and 51118 looked quite good and 3 other lines from the same crosses ranked in the top 12.

PUBLICATIONS OR REPORTS:

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CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

For the 3rd consecutive year crayfish were associated with a reduction in seedling establishment. Confined crayfish populations of 1 per 8 sq. ft. resulted in a significant reduction in stand by 62%, 1 per 16 sq. ft. caused 22% reduction and 1 per 32 sq. ft. showed a 9% loss. Chemical control experiments that used two species of crayfish showed a 100% reduction of both species with methyl parathion at 0.1 lb. AI/acre; 100% control of the red crayfish (Procambarus clarki) with fenthion at 0.1 lb. AI but no control of the green crayfish (Orconectes virilis). Parathion at 0.1 lb. was not effective on either species.

Commercial treatments of suspected resistant tadpole shrimp were followed near Escalon. Copper sulfate at 10 lbs. AI/acre provided excellent control, carbaryl at 2.0 lb. resulted in adequate control, but parathion at 0.1 lb. was not effective. This would strongly indicate that tadpole shrimp have built up a resistance to this chemical but laboratory studies of populations from several areas are needed to confirm this.

Aster leafhopper populations (1980) of 31.8 and 69.1 per plant during the last half of August were followed by an 11.7 reduction in grain. Eighty-five percent of the nymphs and 99.8% of the adults were observed on senescent leaves.

Seven of 9 rice fields (M-101, M-9, Calrose 76) at Biggs and Richvale (1980) averaged a 24% loss in yield for plants infested with armyworms to the level that 25 to 30% of the foliage was eaten. The range of yield loss was 6 to 50% for these plants. The loss of seeds due to panicle feeding was only 0.35% in a separate test. Laboratory studies showed that 74.26% of the total food consumed by armyworms was in the last instar (6th) over a period of 6.3 ± .6 days. Total time of larval development was 24.3 ± 4.7 days.

Field tests with preplant treatments of carbofuran at 0.5 lb. and 1.0 lb. AI/acre showed no systemic effect on adult water weevil confined on the rice plants for 72 hours. This supports the belief that control of the species in the field occurs only in the larval stage, even at the recently approved higher rate. Topical applications of technical carbofuran to adult weevils in the laboratory showed a level of control equal to that found in 1968. This indicates that the weevil has not developed resistance to carbofuran in the past 13 years.

Several chemicals and formulations were tested in the field for rice water weevil control in comparison to the standard control with carbofuran. Slow release granules of carbofuran looked favorable last year but failed to provide control in 1981 due to to formulation problems. Advantage® (an analogue of carbofuran that is safer to use) provided control equal to or better than carbofuran at 0.5 and 1.0 lb. AI/acre.

Greenhouse experiments with new chemicals for rice water weevil control showed that insect growth regulators diflubenzuron, one of its analogues, and Bay Sir 8514 provided a reduction in larvae ranging from 68 to 86% when applied to the rice plant at 0.25 lb. AI/acre. Neither insecticides applied to the plant nor applied directly to the adult resulted in adult mortality.

Satisfactory progress is being made in cooperation with the plant breeders in developing a rice variety that will show resistance or tolerance to the rice water weevil. One of the more promising lines showed an overall reduction in plant growth characteristics of 34% comparing weevil infested to treated plants but only 9% reduction in yield. The same comparison of M-9 showed a 59% reduction in plant growth and 50% reduction in yield. The tolerant line also had the highest overall yield of grain and the highest rate of seedling survival.

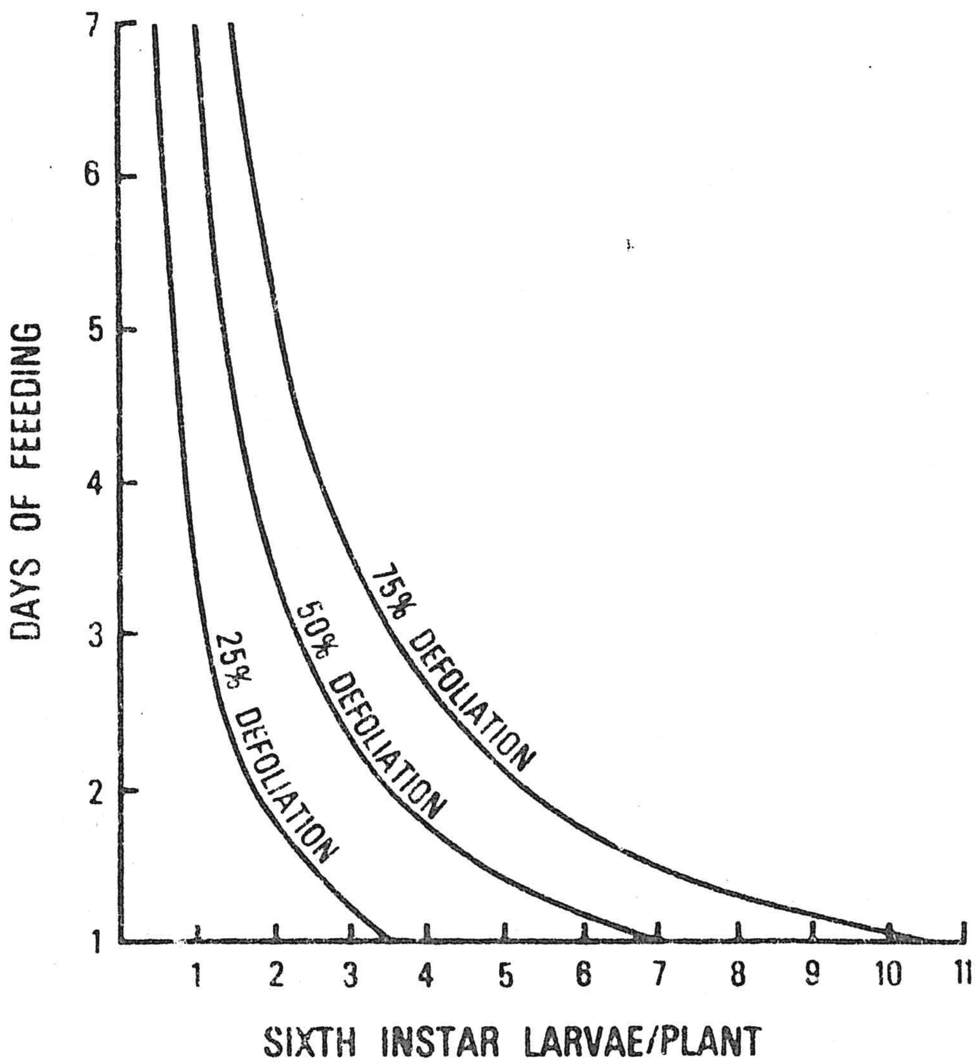

Figure 1. Armyworm leaf consumption