PROJECT NO. RM-7

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 1994-December 31, 1994

PROJECT TITLE: Management-Oriented Simulation of Rice-Weed Dynamics (RM-7)

PROJECT LEADERS: Theodore C. Foin, Division of Environmental Studies
James E. Hill, Agronomy and Range Science

PRINCIPAL INVESTIGATORS: Kevin Gibson, Division of Environmental Studies
Barney Caton, Division of Environmental Studies

LEVEL OF 1994 FUNDING: $25344

RESEARCH OBJECTIVES:

1. The first objective of Project RM-7 was to continue the study of competition for light between rice and weeds, particularly redstem (*Ammannia* spp.) under controlled greenhouse conditions, with special emphasis upon identifying common properties in weeds responsible for yield reduction.

2. The second objective was to begin a new series of experiments to identify the interactions of fertilizer on weed-rice interactions. In keeping with previous practice in studying light competition, we conducted growth analysis experiments at four nitrogen levels for rice and three weed species (watergrass, *Echinochloa oryzoides*, smallflower umbrella sedge, *Cyperus difformis*, and redstem).

3. The third objective was to conduct competition experiments using nitrogen fertility level as a key factor. These experiments were conducted with variable rice densities.

4. The fourth task was to begin a series of field experiments to confirm the results seen in the greenhouse experiments of 1993, specifically the potential control of redstem using delayed emergence of the species in rice canopies.

5. The final task was to continue development of the model of weed-rice competition.

SUMMARY OF 1994 RESEARCH BY OBJECTIVE

Objective 1. Competition for light between rice and redstem.

In 1993 we documented how redstem growth patterns permit it to compete successfully with rice, and how delaying the growth or destroying seedlings for a period of time after seeding the crop could be used to control redstem damage in the field.

The competition experiments with simultaneous seeding at different ratios were repeated in 1994, and the results were the same as in 1993. The principal result was that relative reduction in rice grain yield (Figure 1), measured in percent, was substantially the same in both years, although three points from 1994 are somewhat low, for unknown reasons. At 50-100 plants m^{-2}, redstem significantly reduced rice tiller density, panicle density, total above-ground biomass, and grain yield. Total biomass was reduced by 21.5% and 27% in low and high weed density treatments, respectively. Grain yields were reduced to 69% and 60% in the same treatments. In 1993 we showed that redstem has an adaptive growth response of internodal elongation (Figure 2), suppression of lateral branches, and allocation of biomass to the shoot at the expense of roots to competition with rice. These responses enable it to penetrate the rice canopy (Figure 3). After penetrating the top of the canopy, it branches extensively; shading accounts for the significant rice yield losses seen.

Following the discovery in 1993 that delaying redstem growth allows rice to compete successfully, we conducted an experiment to measure the delay required. Last year, we found that it was < 28 days, but could not determine how much less. A greenhouse experiment was conducted in which rice planting date was held constant, and redstem seeds were sown at 0, 8, 13, 18, and 23 days after planting (DAP). The experiment was harvested at about 75 DAP. At harvest, individual redstem plants had equalled or exceeded mean rice canopy height only in the 0 and 8 DAP treatments (Figure 4). Redstem that germinated at 13 DAP or later was unable to penetrate the canopy. In addition, weed density, drymass, and seed production decreased significantly with treatment.

This experiment suggests that herbicide control of redstem be targeted for the period two weeks to one month after rice planting. After this time, given a uniform rice stand with no gaps, the rice canopy should effectively suppress most or all of the later-germinating redstem plants.

Objective 2. Growth analysis of three common weeds under variable nitrogen input.

Rice, smallflower umbrella sedge, watergrass, and redstem were grown as single plants under four nitrogen treatments ranging from 0 to 180 kg/ha. All four species showed linear or near-linear increases in biomass with nitrogen increases when grown alone (Figure 5). Leaf area increased linearly for both redstem and rice. Regression analysis showed that nitrogen explains most of the variability in rice response variables ($R^2 > 0.70$) but considerably less of the variability in weed response variables. Factors other than nitrogen level are needed to explain weed growth adequately, even in the absence of competition.

Figure 5 shows that manipulation of fertility alone cannot suppress watergrass, which responds with higher growth rates at all nitrogen levels, but rice is better at utilizing nitrogen than smallflower umbrella sedge and redstem at most nitrogen levels (the exception is redstem with no nitrogen added).

Objective 3. The effect of nitrogen on weed growth and rice - redstem competition

Target plants of redstem were planted either between two or four rice plants, and grown for 78 days. Biomass, leaf area and panicle weight of the rice plants all increased with nitrogen at both rice densities. Biomass increase was greater in the 4:1 ratio treatment than in 2:1 (Figure 6). The only redstem variable that responded linearly to nitrogen was plant height, and only at the higher rice density. Biomass and leaf area were higher for redstem at intermediate nitrogen levels than at higher or lower levels (Figure 7).

The highest panicle weight for rice and the lowest redstem plant weight occurred at the highest nitrogen level. The lowest redstem weight was found at the combination of high rice density and high nitrogen treatment. This suggests that redstem can be suppressed by combining higher seeding rates with good fertility management. While this result requires further confirmation, it is consistent with the results of growing plants alone at different nitrogen application rates and with the suppression of redstem seen in the delay experiment.

Objective 4. Field validation experiments of rice-redstem interaction.

A field experiment was carried out on Tres Picos Ranch in Butte County, with the cooperation of grower Brent Owen. Rings were established in a check in which redstem was the only important weed. The initial grower treatment, application of Londax (bensulfuron) at 11 DAP, was used as the control. Additional Londax treatments were made at 32 and 57 DAP, and samples were also taken from a section of the field treated by the grower with MCPA at 55 DAP.

The results in terms of redstem control are shown in Figure 8 and for rice production in Figure 9. "Control" and "Londax at 32 DAP" treatments both had an average weed density of about 32 weeds m^{-2}. Londax at 32 DAP was apparently ineffective because of the method of application (dissolved directly into the water), and unfortunately does not provide a satisfactory field test of the previously-discussed greenhouse timing experiment. Weed density declined by half with Londax treatment at 57 DAP, and rice grain yield increased by 8%. The MCPA treatment provided complete control of the redstem, but rice yields were reduced almost 11% below that for control plots. This was almost certainly due to rice injury caused by the late timing of the MCPA application; extensive damage to tillers was noted at harvest. A possible trade-off for the damage due to MCPA was the extensive lodging caused by the redstem in the control area, which did not occur in the MCPA-treated area.

Objective 5. Continuing work on rice-weed interaction models.

The bulk of the modeling activities were transferred to support granted by the UC Integrated Pest Management Program in 1994. The empirical research discussed above has been critical in reformulating the original model into two successors: CANWER, a multiple-layer canopy development model, which has been completed and is being tested extensively; and RICECOMP, the direct reformulation of the original CARICE model, that is still in the design and programming stage. Extensions of the model development, to incorporate nitrogen effects into RICECOMP, will be developed by Kevin Gibson and will remain in this program.

Summary of 1994 Research Results

Two principal results deserve reiteration here.

- The evidence that competition for light is the most important determinant in rice - redstem competition is growing. Our results suggest that canopy closure is important, and that cultural control should be directed at closing the rice canopy as quickly as possible. The importance of light for redstem is also consistent with previous work on monochoria and annual arrowhead. Together, these results suggest that growers give higher priority to cultural control of weeds by managing to accelerate canopy closure, especially if the problem of resistance to Londax continues to worsen.
- Initial work on nitrogen fertility suggests that for some weeds, manipulating seeding density and fertility level together can improve weed control. When rice is more efficient than its competitors in sequestering nitrogen, higher planting densities and higher nitrogen availability serves to close the rice canopy more quickly and thereby achieve better competitive advantage to the rice.

PUBLICATIONS AND REPORTS

Breen, John, Barney P. Caton, Theodore C. Foin, and James E. Hill. 1994. A general function for the reduction of rice tillers by weeds. Rice Field Day Abstracts for 1994, pp. 41-42.

Foin, Theodore C., and James E. Hill. 1993. Management-oriented simulation of rice-weed dynamics. 25th Annual Report to the California Rice Growers. Rice Research Board, Yuba City.

Foin, Theodore C., and James E. Hill. 1993. Management-oriented simulation of rice-weed dynamics. Annual Report, Comprehensive Rice Research for 1993. Pp. 72-76. Published jointly by the University of California and the United States Department of Agriculture.

Figure 1. Rice yield loss to *Ammannia* spp. (redstem) competition

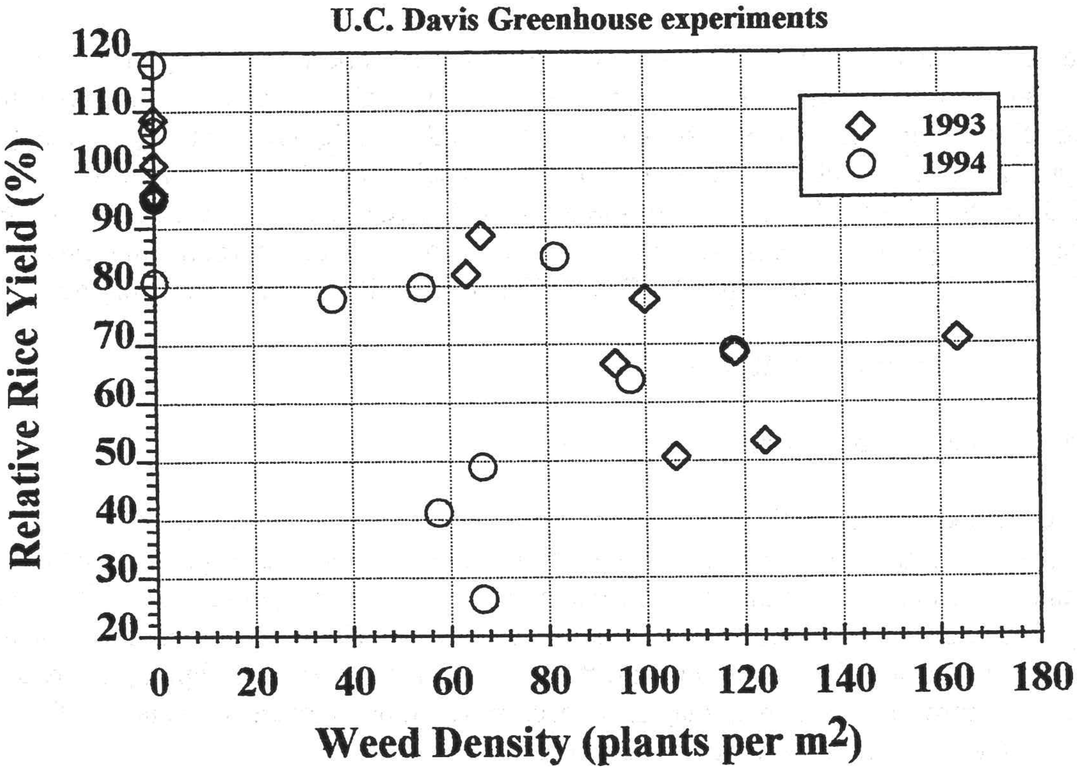


Figure 2. *Ammannia* spp. growth response to competition with rice: stem elongation.

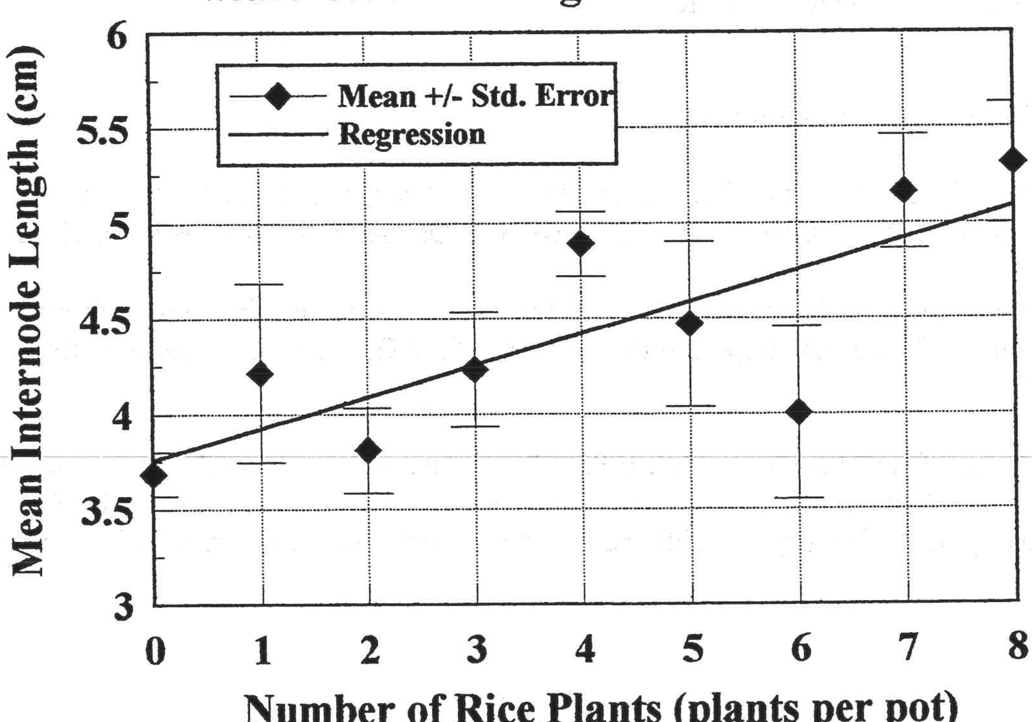
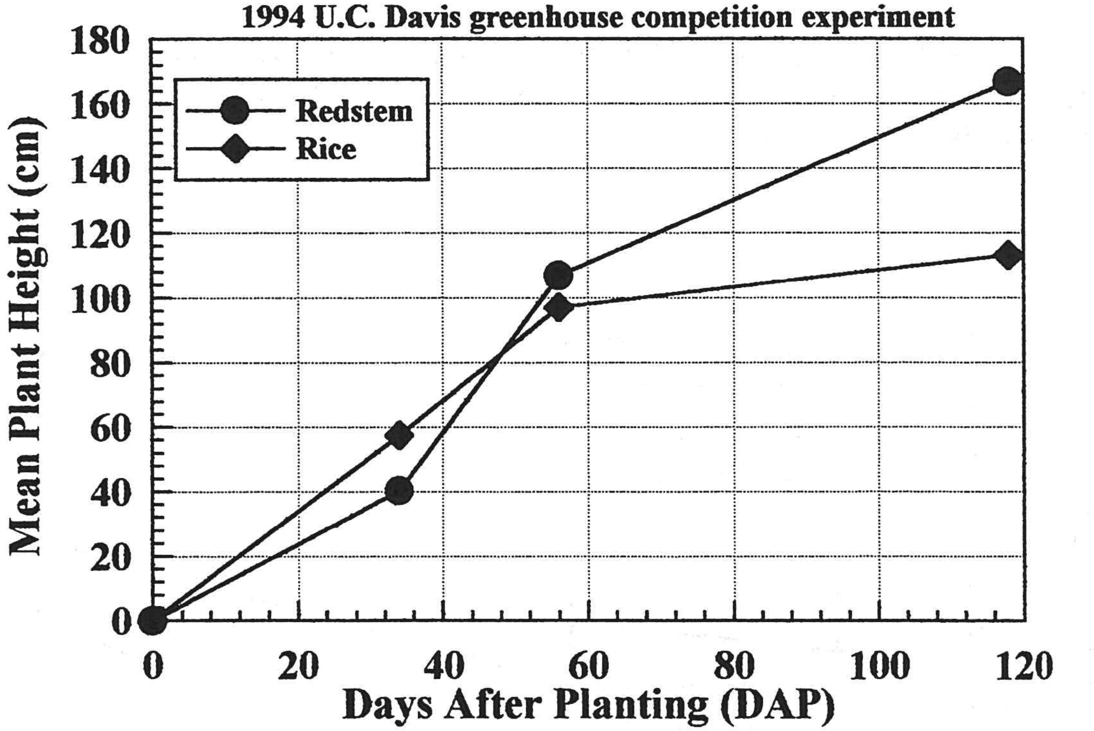
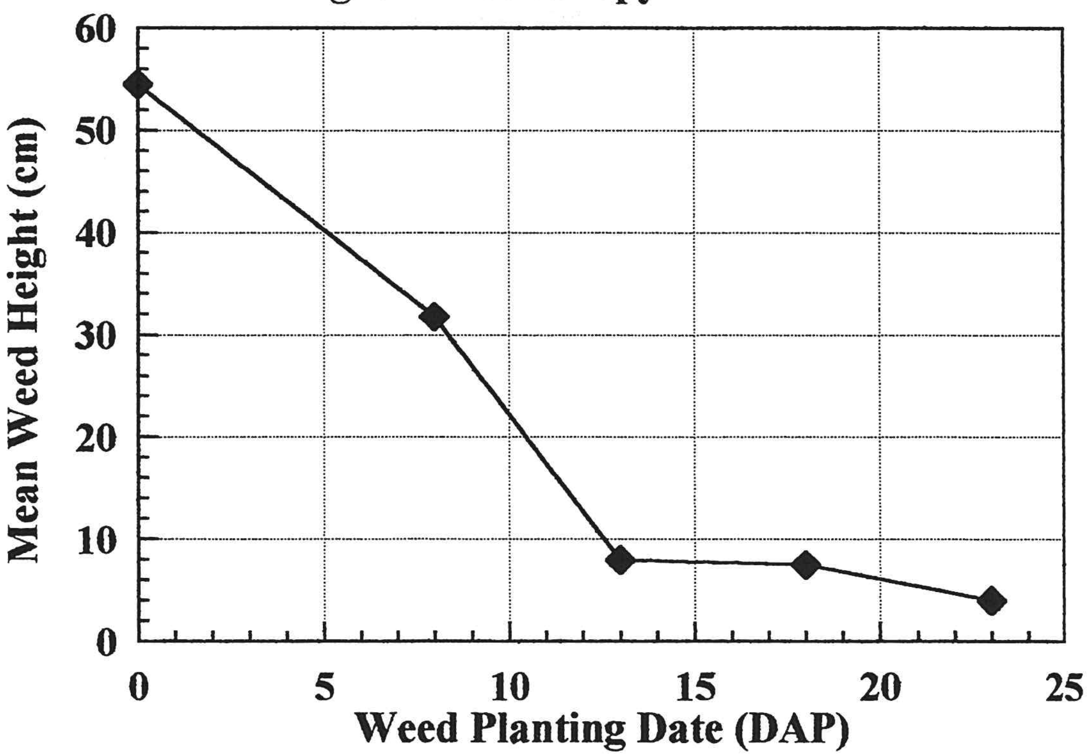


Figure 3. Rice and *Ammannia* spp. growth* over season



*Rice data are means of monoculture plots. Redstem values are for competitive stands.

Figure 4. Effect of delayed germination on *Ammannia* spp. height in rice canopy



Experiment harvested about 75 days after rice planting.

Figure 5. Growth responses of rice and three weed species to nitrogen. Means are for 3 plants; error bars represent ± 1 s.e. Plants were grown singly in pots for 78 days.

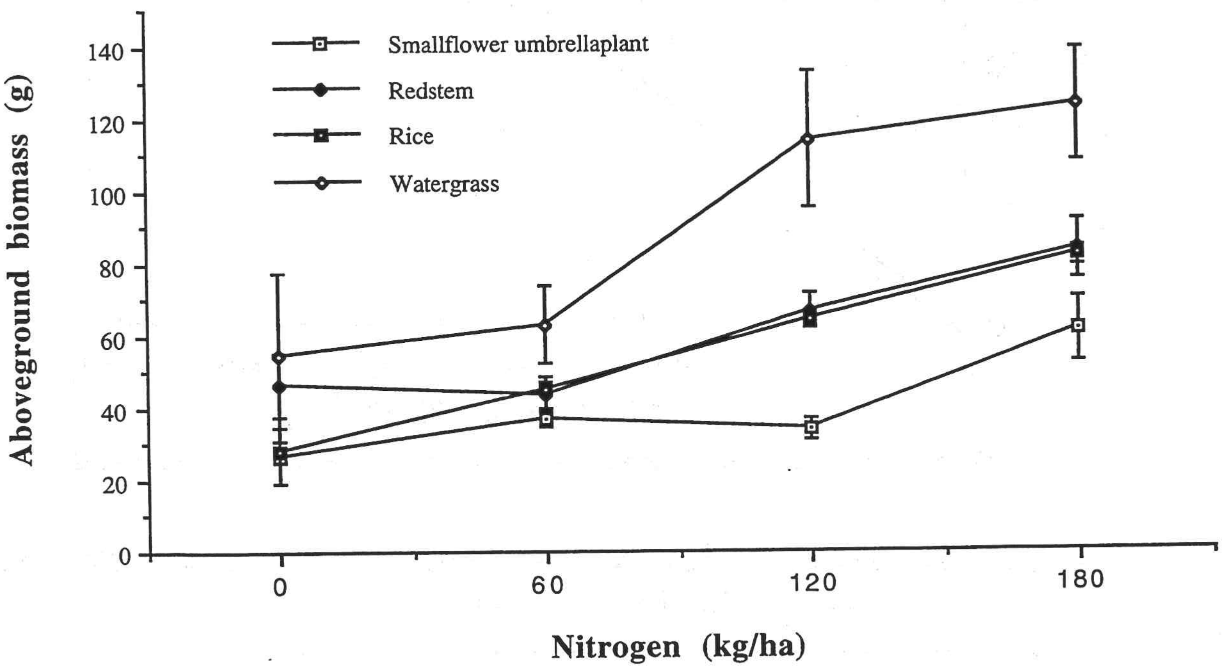


Figure 6. Rice biomass per pot. A single redstem plant was grown with either 2 or 4 rice plants in pots for 78 days at 4 nitrogen levels. Means are from 3 pots; error bars are ±1 s.e.

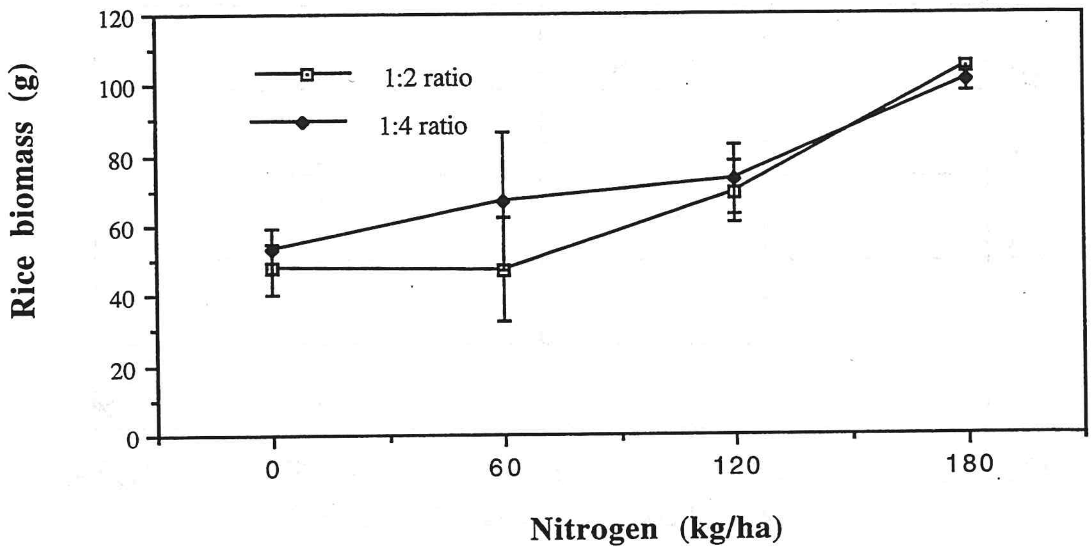


Figure 7. Redstem biomass when grown in competition with 2 or 4 rice plants at 4 nitrogen levels. Plants were grown in pots for 78 days. Means are for 3 redstem plants; error bars represent ± 1 s.e.

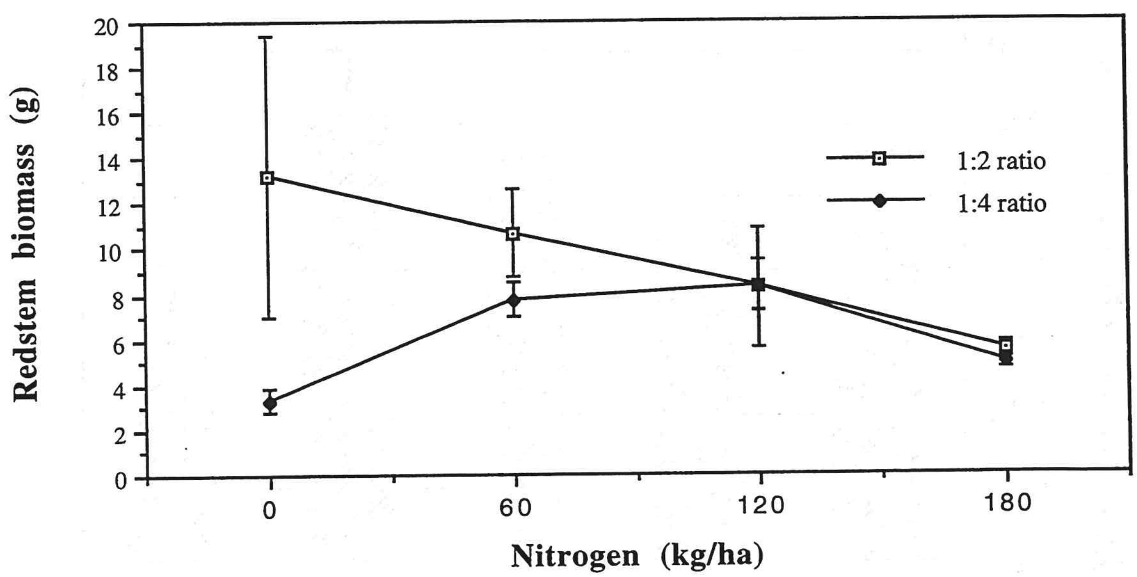


Figure 8. Control of *Ammannia* spp. by Herbicide Treatment*

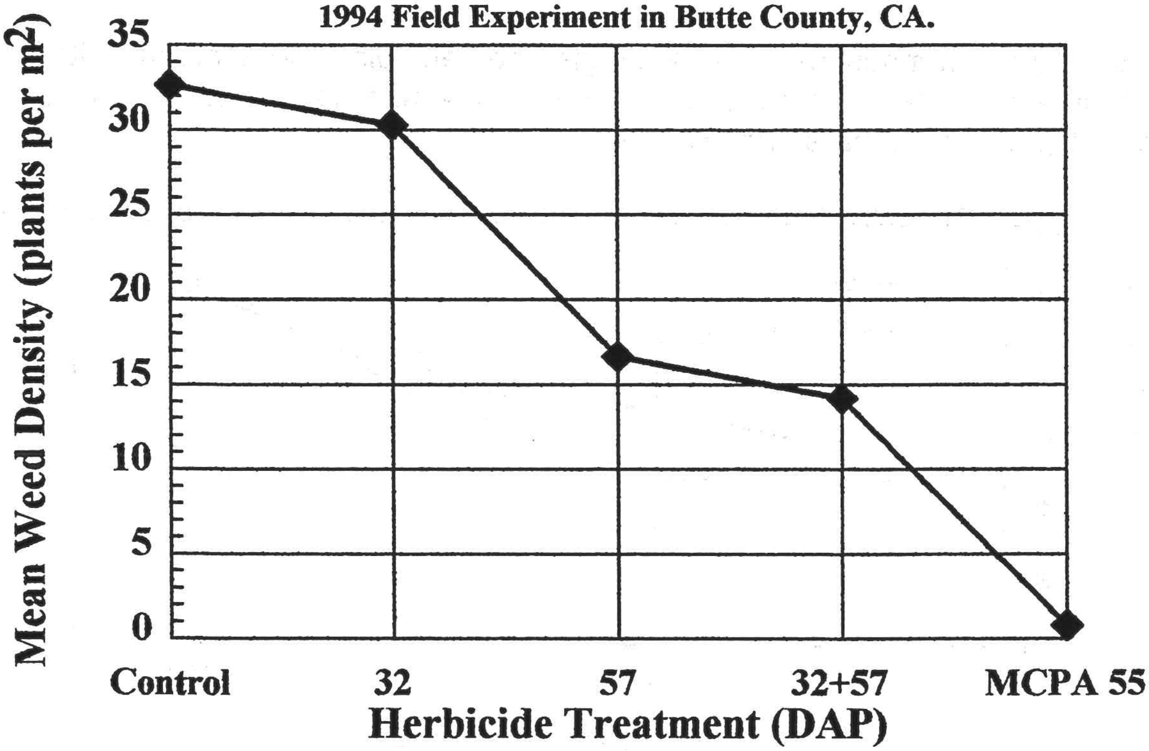
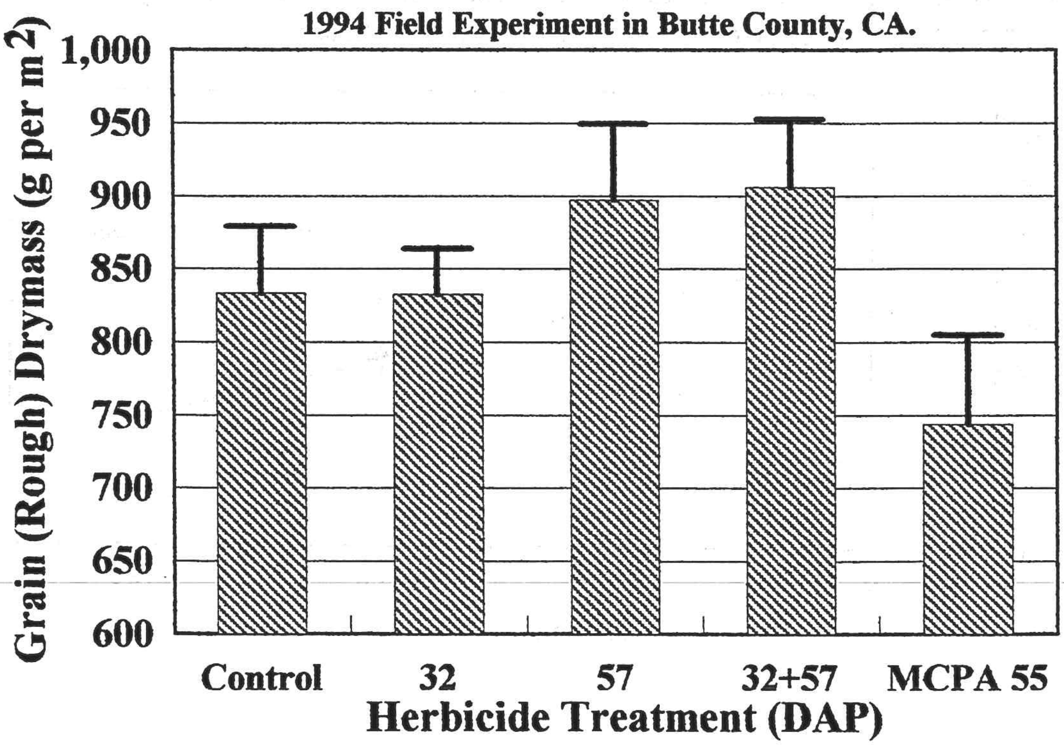


Figure 9. Effect of Herbicide Treatment* on Rice Grain Yield



*** Data from final harvest at about 130 DAP. All received Londax at 11 DAP. All treatments with Londax (1.25 oz. ai), except grower-applied MCPA.**