

Effect of Leaf and Panicle Feeding by Armyworm (Lepidoptera: Noctuidae) Larvae on Rice Grain Yield¹

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ABSTRACT

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Artificial defoliation of several varieties of rice plants to simulate late-season damage by *Pseudaletia unipuncta* (Haworth) reduced yields at 100 and 50% defoliation but not significantly at 25% defoliation. Defoliation averaging 25 to 30% by armyworm larvae resulted in yield reductions of -2.8 to 50.2%. An average of 4.8% of the panicles was damaged by armyworm larvae, but the average seed loss was 0.35%.

The armyworm, *Pseudaletia unipuncta* (Haworth), is a cosmopolitan pest of grasses. It occurs sporadically in epidemic numbers on rice in California (Lange and Grigarick 1970) and in other countries (Tsutsui 1959, Alam 1967). In many rice-growing areas other armyworm infestations are early in the season, during seedling or tillering stages. Artificial defoliation of rice to simulate feeding by chewing insects during these rice growth stages has indicated defoliation can reduce yields significantly (Navas 1974, Bowling 1978), but often plants will recover and compensate for the damage, resulting in higher yields than that of undefoliated plants (Taylor 1972). In California, armyworm infestations occur relatively late in the growing season, ca. 3 to 4 weeks before heading. Little is known about how this late-season defoliation affects yield.

For 2 consecutive years, rice plants were artificially defoliated at times corresponding with observed armyworm damage in commercial California rice fields. During an outbreak of the armyworm in Butte County, Calif., the effect of larval defoliation on rice yield and panicle injury by this natural infestation was examined, and the results are reported here.

Experimental Procedure

Artificial defoliation studies were conducted at the Rice Research Facility, University of California, Davis, in 1978 and at the Cooperative Rice Research Station, Biggs, Butte County, Calif., in 1979. Four varieties were planted in a randomized complete block design, with four blocks composed of four plots each. Each of the four plots in a block was seeded with a different variety at 140.3 kg of seed per ha. In 1978, the varieties tested were 'S6,' 'SSS6,' 'Calrose,' and 'Calrose 76.' The varieties used in 1979 were 'S6,' 'M5,' 'M9,' and 'L-201.' All varieties were planted at the same time, and standard management practices were followed.

Leaf tissue was removed to simulate armyworm damage at about the time of visible armyworm defoliation in commercial rice fields. In 1978, there were three treatments of 83-day-old plants: 100, 50, and 0% defoliation. The four treatments used in 1979 were 100, 50, 25, and 0% defoliation of 81-day-old plants. In each

plot, 10 groups of three (1978) or four (1979) closely spaced plants of equal size were chosen. From one plant of every group, 100% of each leaf was removed with scissors, from another plant 50% of each leaf was removed, and from a third plant nothing was removed. In 1979 the same procedure was used, plus 25% of each leaf was removed from a fourth plant.

When mature, the heads were harvested by hand and taken to the laboratory where the panicles were stripped of seed. Yield and percent blanking (percentage of unfilled kernels) was determined for each treatment.

For the larval defoliation studies in 1980, nine commercial rice fields in Butte County, planted with varieties 'M9,' 'M101,' or 'Calrose 76,' were selected in which armyworm damage was easily visible at ca. 3 to 4 weeks before heading. Plants of about equal size were selected at random, and the amount of defoliation was estimated for each plant. Defoliation was estimated by assigning each leaf on a plant to a category of 0, 25, 50, 75, or 100% leaf tissue removed. The categories of all leaves of a plant were added, and the total was divided by the number of leaves for an estimate of overall defoliation.

In each field, 10 plants with less than 10% defoliation and 10 plants with between 20 and 40% defoliation (averaging 25 to 30% per field) were marked by placing a labeled stake next to each plant. Leaf defoliation assignments were recorded for each plant. When the panicles matured, they were removed and stored in paper bags to dry. When the panicles were dry, the seeds were stripped from the stems. Filled and blanked seeds were counted.

Panicle injury was investigated at the Cooperative Rice Research Station, Biggs, Calif., in one field a variety of 'M101' where armyworm damage was observed at the time of heading. Most panicle damage involves indirect damage to the seeds; feeding on the developing seeds is uncommon. When an armyworm feeds on a spikelet or branch of a panicle, all tissue beyond the point of injury dries and turns white, and the seeds will not mature. Because each branch of a panicle bears several spikelets, many seeds may be destroyed indirectly when a panicle branch is damaged. Ten samples were taken with a hoop enclosing 0.74 m², dropped at random. The number of panicles within the hoop was recorded, and all panicles with feeding damage were

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removed. The total number of seeds on each panicle and the number of unfilled seeds on each panicle were recorded.

Results

Artificial Defoliation

There was a significant reduction in average grain yield at both 50 and 100% defoliation for all varieties during both years (Table 1). At 25% defoliation, average grain yield was 2 to 12% less than at 0% defoliation, but the reduction was not significant. Blanking increased with nearly all increases in defoliation. The increases were significantly different from the uncut only at 50% defoliation for 'Calrose' in 1978, at 50% defoliation for all varieties in 1979, and at 100% defoliation for all varieties both years, except 'S6' in 1978.

Larval Defoliation

Only three fields showed a significant difference in grain yield between the two levels of defoliation (Table 2). There was no significant difference in percent blanking between the two groups. Fewer seeds were produced on defoliated plants than on undefoliated plants. In those fields with significant yield reduction there was also a significant reduction in the number of seeds per plant.

Panicle Injury by Larvae

The number of damaged panicles ranged between 4.0 and 55.1 out of 402.7 ± 60.0 panicles per m^2 , with an average of 20.4 ± 14.8 damaged panicles per m^2 . Of 65.7 ± 12.3 seeds on a damaged panicle, 4.4 ± 1.3 (6.7%) were affected either directly or indirectly by armyworm feeding. The average amount of seed loss was 0.35%, with 0.81% being the greatest reduction in seed.

Discussion

Large amounts of defoliation will reduce the yield of rice plants. Armyworm outbreaks, such as occurred in Butte County in 1980, seem to cause much less than 50% defoliation, except in localized areas. Even during

sampling in fields that appeared to be the most heavily damaged in the area, rarely did an individual plant exceed 50% defoliation. At the levels of defoliation produced by a pest outbreak there may or may not be a reduction in yield. Different environmental conditions or management practices could have caused the variation in yield in the larval defoliation experiment.

The amount of yield reduction at 25 to 30% larval defoliation was much higher than the amount of yield reduction at 25% artificial defoliation. The response of rice plants to artificial defoliation may not be the same as to insect feeding damage. The artificial defoliation technique used was not an exact simulation of insect damage. Armyworms remove irregular portions of the leaf blade, generally leaving the midvein intact. The larvae do not remove the same proportion of each leaf, nor do they feed on all leaves of a plant. On artificially defoliated plants, the same amount on all leaves and the entire leaf, blade, and midvein was cut off. With insect feeding, the amount of defoliation increases gradually over a period of time, whereas manual clipping removes leaf tissue all at once. Different leaves or parts of leaves may contribute differentially to plant growth and grain production, so instantaneous artificial defoliation may not have the same effect as irregular, prolonged larval defoliation. With other plants, the response to insect damage has been shown to differ from the response to artificial defoliation. The rate of growth of wheat seedlings was lower when defoliated by grasshoppers than when defoliated to an equal level by manual clipping (Capinera and Roltsch 1980). However, Dyer and Bokhari (1976) found that the regrowth potentials of grasshopper grazed blue grama grass plants were much higher than for clipped plants. If the response in yield and regrowth of rice to artificial and larval defoliation differs, yield reduction might also be different.

The 4.8% damaged panicles encountered in this study did not warrant treatment. At current costs of recommended chemical control measures and rice values, panicle damage would have to approach 20% for the cost of treatment to be less than potential losses, assuming the same proportion of seed injury. A low rate of panicle

Table 1.—Grain yield and blanking of varieties in artificial defoliation test on rice^a

Variety	Avg yield (g)/10 plants at the following defoliation levels:				% Reduction in yield at:			Avg % blanking/10 plants at:			
	100%	50%	25%	0%	100%	50%	25%	100%	50%	25%	0%
Davis, Calif., 1978											
'Calrose 76'	80.9a	131.3b	—	234.3c	65	44	—	22.5a	17.3ab	—	8.8b
'Calrose'	64.5a	110.1b	—	240.8c	73	54	—	22.8a	21.8a	—	12.3b
'SSS6'	65.5a	140.8a	—	277.7b	76	49	—	47.0a	29.0ab	—	11.3b
'S6'	93.1a	175.8b	—	316.0c	71	44	—	21.8a	22.3a	—	12.3a
Biggs, Calif., 1979											
'S6'	35.3a	92.7b	112.4c	120.3c	71	23	7	57.5a	15.0b	3.5c	3.2c
'M5'	27.4a	64.3b	103.3c	105.2c	74	39	2	67.0a	24.5b	9.5c	4.5c
'M9'	39.0a	94.7b	131.5c	144.7c	73	35	9	70.5a	43.5b	21.0c	9.0c
'L-201'	47.6a	86.6b	116.1c	131.5c	64	34	12	51.2a	24.0b	8.0bc	6.5c

^aNumbers not having a letter in common (across) are significantly different at the 5% level, by Duncan's multiple range test.

Table 2.—Grain yield, blanking, and number of seeds of plants in defoliation test with armyworm larvae on rice, butte County Calif., 1980^a

Variety	Avg yield (g)/plant at the following defoliation levels:		% Yield reduction	Avg % blanking at:		Avg no. of seeds/plant at:	
	25-30%	0-10%		25-30%	0-10%	25-30%	0-10%
'M101'	58.1a	56.5a	-2.8	16.6a	14.0a	267.4a	250.1a
'M9'	40.9a	41.0a	0.2	13.3a	17.1a	172.5a	183.9a
'M9'	37.5a	40.0a	6.3	8.8a	10.6a	163.7a	165.1a
'M9'	48.4a	57.6a	16.0	30.6a	28.8a	274.3a	310.6a
'M9'	34.6a	42.0a	17.6	14.4a	25.7a	167.0a	218.9a
'M9'	39.1a	50.0a	21.8	11.1a	8.6a	190.8a	200.6a
'Calrose 76'	49.5a	75.8a	34.7	6.5a	4.1a	207.9a	289.9b
'M9'	25.3a	45.6b	44.5	35.3a	26.4a	139.7a	224.6b
'M9'	24.7a	49.6b	50.2	8.3a	4.6a	112.3a	194.0b

^aNumbers not having a letter in common (across) are significantly different at the 5% level, by Student's *t* test.

injury occurs in the field because armyworm larval development is generally completed when heading occurs. If high larval populations and heading coincided, there could be much greater damage to panicles.

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