PN-AAK-178

Tropical Pest Management 27(2): 242–246

Rice Yield Reduction by Simulated Rat Damage in Bangladesh

R. M. Poché,[1] M. E. Haque, M. Y. Mian, P. Sultana, and M. A. Karim

Bangladesh Agricultural Research Institute, Vertebrate Pest Division, Joydebpur, Bangladesh.

Abstract. The effects of simulated rat damage (stem cutting) on IR-8 rice yield was examined. Fields were subjected to four damage levels: 0 (control), 10, 25 and 50% of the stems cut. A modified split-plot sampling design was used with ten 1 m^2 plots tested at each damage level in three growth stages: tillering, booting and maturity. Each of the 120 plots (2,400 hills) was harvested and yields compared by Analysis of Variance and Least Significant Difference (LSD) tests. Ten percent of all stems removed during the tillering stage produced growth compensation and a higher yield resulted. Trends in rice yields for different damage levels showed that the later damage occurred, the greater the yield loss. An LSD analysis of yields for the damage levels revealed no significant differences during tillering. At booting, significant differences ($P < 0.05$) in yields were noted with >10% of the stems cut. At maturity, yields for all damaged levels differed significantly ($P < 0.01$). The results of this study demonstrated that rat damage in rice up to the booting stage did not affect yield significantly. From an economic standpoint, rodent control by field baiting before booting stage is not recommended in monsoon rice.

Introduction

Rodent damage to Bangladesh crops varies seasonally and among localities. Factors such as rainfall, soil types, drainage, plant cover, and the availability of food regulate rodent populations. In wheat, Poché *et al.* (1979) studied rat damage accumulation throughout the growing season and estimated 12% was lost before harvest.

Rice is the major crop in Bangladesh and is cultivated over about 10.1 million ha. For this reason field research was initiated to evaluate the impact of rats on rice crops. The effects of various levels of rat damage on rice yield was examined by mechanically cutting stems. The major objective was to determine the effect of stem cutting on yield, when performed at various growth stages and at different damage intensities. Such factors are extremely important in planning for field rodent control.

Guerrero (1970) performed mechanical cuts in rice at different growth stages in the Philippines, and Akhtar and Fulk (1978) conducted similar experiments in Pakistan. We conducted a similar study on the Joydebpur farm of the Bangladesh Agricultural Research Institute to obtain data on local conditions and responses to rice in Bangladesh.

Methods

A split plot design with subsampling was used in the present study. Five blocks (0.25 ha each) of IR-8 Aus rice (monsoon) were selected. The rice was transplanted on 27 May and harvested on 25 September 1979.

[1] Permanent Address: U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Bldg. 16, Federal Center, Denver, Colorado 80225, USA.

Within each of the five blocks, three main plots were randomly assigned, one for each growth stage. The 15 main plots were each divided into four subplots, one per damage intensity. Four intensities of mechanical damage were established at 0 (control), 10, 25 and 50% of all stems cut. Simulated damage was completed during three growth stages: tillering (5 weeks after transplanting (WAT) on 29 June), booting (10 WAT on 3 August) and maturity (16 WAT on 17 September). Within each subplot two 1 m^2 sub-subplots (20 rice hills each) were located at random, marked with bamboo sticks, numbered with metal tags and harvest data combined to represent the sample from the subplot. In total, 120 sub-subplots were delineated. Each stem was cut from 3 to 10 cm above the ground surface at an oblique angle to simulate rat damage.

Within sub-subplots the total number of stems were counted and the appropriate percentage cut with scissors or a knife. Those cut were evenly distributed among the 20 hills within each square.

Hand weeding was done by labourers at 8 WAT. To curtail possible rat damage during the experiment, Vacor (RH-787), an acute rodenticide, was provided at 0.5% treated polished rice bait. The rodenticide was placed in 30X30X20 cm wooden boxes. Two 7X7 cm holes permitted rat entry into the boxes.

We established a rodent population index using 25X25 cm vinyl tiles. One half of each tile was coated with ink. Twenty tiles were placed at 10 m intervals within the blocks and a control plot adjacent to the study. Activity was determined every 2 weeks. Tiles were placed in the fields for two successive nights during each activity assessment. Tiles with rat tracks on the following morning were scored as positive and the average was obtained for the 2-night period. The index was expressed in terms of percentage tiles tracked.

At harvest, individual square metre sub-subplots were cut, tied in bundles, air-dried for 3 days, threshed with a foot-pedal thresher, air-dried again for 4 days, weighed to the nearest 0.1 g, and the moisture content obtained with a Dole Grain Moisture Tester. Statistical analysis of the data included one-way Analysis of Variance (ANOVA), split-plot ANOVA, and the Least Significant Difference (LSD) test (Gomez and Gomez, 1976).

Results

For the three damage levels in each growth stage, 200 hills were harvested. A total of 2,400 hills were cut for yield assessments.

In examining the yield in g/2 m^2 (Table 1), data from the tillering stage show that light damage (10%) produced growth compensation such that a higher yield resulted. The increase of 2.7% over the control plots, however, was not significantly different. Higher damage rates at tillering produced lower yields than the controls, but were not significant statistically.

The trends of different levels of stem cutting at various growth stages (Figure 1) show that the later damage occurred, the greater the rice yield loss. With an increase in maturity, there was less chance for rice to recover from damage.

An LSD analysis for differences between damage levels showed no differences during tillering. At booting, significant differences in yield were noted in samples with more than 10% of the stems cut ($P < 0.05$). All yield differences in the mature crop were highly significant ($P < 0.01$).

A similar analysis for differences between growth stages was completed (Table 1). At the 10% level of damage, no significant yield differences were noted during tillering and booting, at maturity, however, there was a highly significant difference ($P < 0.01$) in the amount of rice produced. Yield differences between the control group and the group with 25% damage during tillering were not significant. Beyond tillering, and for all damage levels at the 50% level, deviations from the controls were highly significant ($P < 0.01$).

In comparing treatment yield reductions with the controls, the intensity of mechanical cuts made during the period of maximum booting almost paralleled the level of damage intensity (Table 1). At the 10% damage level, for example, a yield reduction of 10.4% was observed. The same held true when 25% of the stems were cut and yield declined 25.4%.

Cuts made during maturity reflected slightly different results. As percentage deviations from the control, all plots had a yield loss in excess of the actual amount or percentage of stems cut. For example, at the 10% damage level the yield loss was 21.1%.

The highly significant difference ($P < 0.01$) for the interaction between growth stage and damage level (Table 2) provided some explanation for increasing yield deviations as the crop matured. Later damage to stems, as the crop matured, left less time for compensatory growth to overcome the effects of the damage inflicted.

TABLE 1. SUMMARY OF RICE YIELD DATA FROM 120 1 m^2 PLOTS OF IR-8 AUS RICE SUBJECTED TO MECHANICAL CUTTING OF STEMS

Growth stage[1]	Damage level (%)	Mean yield g/2 m^2	Maunds[2] /acre	LSD test[3]	Percent deviation from control
Tillering	0[4]	928.62	50.52	a	–
(5 WAT)	10	952.32^{ns6}	51.86	a	+ 2.7
	25	898.64^{ns}	48.89	a	– 3.2
	50	852.41*	46.37	a	– 8.2
Mean[5] 901.46^{ns}					
Booting	0[4]	939.88	51.13	a	–
(10 WAT)	10	841.68^{ns}	45.79	a	–10.4
	25	701.21**	38.15	b	–25.4
	50	584.24**	31.78	c	–37.8
Mean[5] 709.04**					
Mature	0[4]	925.32	50.34	a	–
(16 WAT)	10	730.17**	39.72	b	–21.1
	25	641.74**	34.91	c	–30.6
	50	422.05**	22.96	d	–54.4
Mean[5] 597.99**					

[1]WAT = weeks after transplanting. Sample size, 10 plots for each damage level at each growth stage.

[2]One maund = 82 lb = 37.195 kg = 1 sack of rice.

[3]LSD test for differences between damage levels. Any two means having a common letter are not significatly different at the 5% level. LSD's at 5 and 1%, respectively: 5 WAT 101.81, 140.28, CV = 8.4%; 10 WAT 104.68, 144.23, CV = 10.2%; 16 WAT 101.8, 140.27, CV = 11.2%.

[4]Control plot.

[5]Mean for treated plots only.

[6]LSD test for growth stages: ns = not significant, * = significant at 5% level, ** = significant at 1% level. LSD's at 5 and 1% levels, respectively: Control 105.7, 148.2, CV = 8.2%; 10% cut 108.27, 151.79, CV = 9.3%; 15% cut 108.5, 152.13, CV = 10.5%; 50% cut 98.93, 139.96, CV = 12.0%.

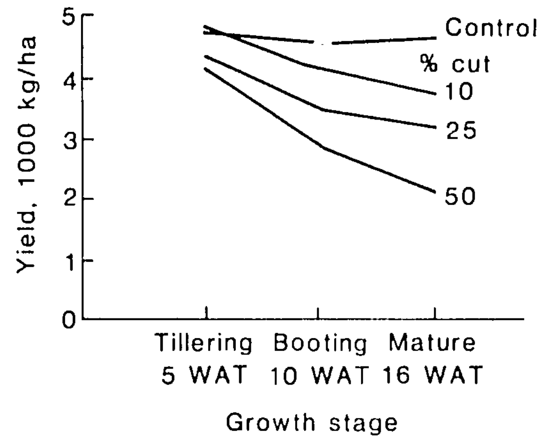

Fig. 1. The effects of simulated rat damage (mechanically cut stems) on yield in Aus rice (summer 1979). As the rice crop matured, rodent damage had a more significant impact on yield. These data are from 120 1-m^2 sub-subplots sampled in fields of IR-8 rice.

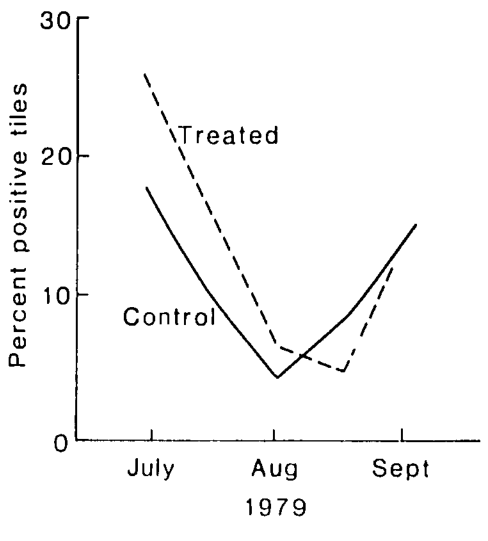

Fig. 2. Rodent population index obtained from tracking tiles. Ink-coated vinyl tiles were placed in fields for 2 nights every 2 weeks. An acute rodenticide was provided on the treated plots.

TABLE 2. SPLIT-PLOT ANALYSIS OF VARIANCE FOR RICE YIELD DATA FROM MECHANICALLY CUT PLOTS DURING THE SUMMER OF 1979

Source of variation	D.F.	Sums of squares	Mean squares	Observed F
Block	4	69,592	17,398	
Growth stage	2	532,175	266,088	47.58**
Error (a)	8	44,732	5,592	
Damage level	3	802,549	267,516	66.12**
Damage X growth stage	6	245,288	40,881	10.10**
Error (b)	36	145,669	4,046	
Total	59	1,840,005		

**Significance at the 1% level.
Coefficient of Variation (a) = 9.5%; CV (b) = 8.1%.

Figure 2 shows the trends in the rodent population index recorded from the treated and control plots. Although activity decreased in both plots in early August, an increase was observed in each during mid-September. An ANOVA of the activity data showed no significant differences between the treated and control fields (Calculated $F_{(1,8)}$ = 0.27; $F_{(1,8)}$ Statistic = 239).

Discussion

The results of this study lent insight into the necessity for rodent control in Bangladesh monsoon transplanted rice. General field observations revealed that yield losses from rat damage in transplanted rice do not increase appreciably until about the booting stage, with maximum losses occurring in the mature crop. A similar pattern of damage was observed in wheat (Poché *et al.,* 1979). Since rat damage in the tillering stage of rice was not reported in excess of 5% of all stems cut, the impact of stem cutting may not have any significant effect on yield as demonstrated in this study. Rat damage during the tillering stage may stimulate growth compensation but, as observed in this study, the yield differences between the treated and controls were not significant. When more than 10% of the rice stems were cut during tillering, however, the effects tend to reduce yield, although not significantly.

The present study has also shown that the actual percentage stems cut in monsoon transplanted rice at maturity underestimates yield loss. More work will be required to develop a model for stem cutting effects on yield. The situation is further complicated in that models will probably vary seasonally with respect to the rice crop and variety.

Taking the results of this study into consideration and knowledge that actual field damage by rats before booting is slight, generally less than 10%, field control before booting in Aus rice may be uneconomical. The high relative humidity during the monsoons also spoiled the bait in bait boxes within 3 or 4 days. The sustained baiting programme developed in the Philippines (Sanchez and Reidinger, 1978), is not directly applicable to Bangladesh. Rodent species, damage patterns, and rodent behaviour differ considerably between the two regions.

Although there was no observed rat damage in the 120 1 m^2 quadrats, it was difficult to determine if the RH-787 had any effect on rodent numbers since there was no significant difference between the population indices of the treated and control plots. Frequent rains, which flooded rat burrows, may have helped to keep activity low. As observed in our wheat study (Poché *et al.,* 1979), rat activity increased in fields as the crops matured and the plots became dry (Fig. 2). Fulk (1977) reported similar influxes of rodents into ricefields in Pakistan. As the rice ripened and water was drained from the plots, rodent numbers increased rapidly.

Acknowledgments

We thank Dr Peter Hobbs of The International Rice Research Institute for reviewing earlier drafts of this manuscript, providing suggestions relative to the statistical analysis, and making available the grain moisture tester. Dr Peter Savarie assisted with the rice harvest. Mr Richard Engeman provided statistical comments. Support for this study was provided by BARI and the U.S. Agency for International Development project 'Agricultural Research, Vertebrate Pest Component', PASA ID/BNG-0003-1-78.

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