Response of rice plants to rat damage at the reproductive phase

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Rats are the most important among the vertebrate pests of rice. They attack stored grain and rice plants growing in the field. More than 20 species of rats attack rice. The most important rodent pest species belong to the genera *Rattus*, *Mus*, and *Bandicota*. Their distribution depends on geographic location and agroecological situation. Rats can attack rice plants throughout their growth period. However, the attack intensifies during maximum tillering, when the rice canopy becomes dense. The rats cut the rice tillers and panicles, store the panicles inside their burrows, and eat the grains. Damage at the reproductive phase is generally considered to result in a total loss of yield because there is insufficient time for compensation to occur. A few stem-cutting experiments in deepwater rice (Poche et al 1980, Haque et al 1986) failed to provide evidence to support this hypothesis. Recent studies have also indicated that plants probably respond more strongly to artificial than to actual pest damage (Islam and Karim 1999).

We evaluated the impact of actual rat damage to a modern rice variety at the reproductive phase. The field experiment under controlled conditions was conducted at the BRRI experimental farm during the boro (dry) season in 2000 in a randomized complete block design with three replications. The treatments were severe rat damage at booting, heading, flowering, and dough stages. Unit plots were 2 × 2 m, with a 100-cm clear footpath separating the plots and blocks. Modern rice variety BRRI dhan 29 was used. The crop was established by transplanting 5-wk-old seedlings with 20 × 20-cm hill spacing. Standard fertilizer, irrigation water, and weed management procedures were adopted; pesticide was not used.

Bandicota bengalensis and *Rattus rattus* were caught from the farm by using live rat traps. One rat was confined in each plot by using a metal mesh cage measuring 120 × 120 × 120 cm, covering 6 × 6 (= 36) rice hills. Cages without a rat were placed in the control plots. Rats were kept confined in the plot until the desired level of damage was achieved. The field was kept flooded to prevent rat escape by burrowing through the paddy soil. Some kind of refuge (raised land) and food (snails) were provided inside the cage. All the rice tillers within the caged area were counted before rat confinement, and the healthy and damaged tillers were counted at cage removal. At crop maturity, all the mature and immature panicles and tillers without panicles within the caged area were counted. The mature panicles were harvested. Three weeks after harvest, panicles and tillers without panicles of the compensatory crop were counted and the ripe panicles harvested. Panicle length was measured, filled and empty grains were counted, and grain yields were adjusted at 14% moisture content.

On average, rat-damaged (cut or broken) tillers were 42.2% at booting, 65.5% at heading, 32.3% at flowering, and 47.3% at the dough stage (Table 1). Plots attacked by rats had significantly

Table 1. Influence of rat damage at different stages of reproductive growth phase on grain yield and yield components and plants' response observed at harvest, Gazipur, Bangladesh, 2000 boro season.

Characteristic	Booting	Heading	Flowering	Dough	Undamaged control	Mean of damage treatments	*P*<
Tillers damaged (%)	42.18	65.45	32.27	47.26	0	46.79	–
Mature panicles (no. plot^{-1})[a]	161.67 b	113.33 b	232.25 b	203.67 ab	368.67 a	269.90	0.05
Panicle reduction (%)	56.15	69.26	37.00	44.75	0	51.79	–
Compensatory tillers (no. plot^{-1})							
With immature panicles	143.00 a	67.00 b	9.33 c	4.00 c	00 c	55.83	0.01
Without panicles	69.83 b	183.17 a	80.25 b	81.00 b	28.67 b	103.56	0.01
Panicle length (cm)	23.53	24.15	22.12	19.22	24.00	22.26	ns
Grain sterility (%)	29.83	30.89	27.27	27.50	33.94	28.80	ns
Filled grains (no. panicle^{-1})	89.29	98.12	95.92	93.47	92.87	94.20	ns
Panicle weight (g panicle^{-1})	2.02	2.25	2.14	2.09	1.96	2.13	ns
Grain yield (g plot^{-1})	306.43	230.95	506.32	388.29	732.76	358.00	–
Yield loss (%)	58.15	68.48	30.90	47.01	–	51.14	–

[a]Plot was 1.44 m^2 with 36 rice hills. Data in a row followed by a common letter do not differ significantly at the 5% level by Duncan's multiple range test.

fewer mature panicles than undamaged control plots (*P*<0.05). On average, rats damaged 46.8% of the tillers, which resulted in a reduction in panicles by 51.8% and in grain yield by 51.1%. Haque et al (1986) reported that 40% of deepwater rice stem cutting at flowering caused a 59% yield loss. This may have been possible under three situations—basal tillers that bear larger panicles were cut selectively, the cutting operation also damaged some other stems, and stem cutting made plants vulnerable to other pests or diseases. Panicle reduction of 56.2%, 69.3%, 37.0%, and 44.8% at booting, heading, flowering, and dough stages, respectively, resulted in a corresponding grain yield reduction of 58.2%, 68.5%, 30.1%, and 48.0%. However, panicle length, number of filled grains per panicle, and panicle weight were not affected.

Rat damage at the reproductive phase boosted compensatory tiller production (Tables 1, 2). Three weeks after the harvest of the main crop, there were, on average, 260 tillers per 1.44 m^2, of which about 30% contained mature panicles, 22% had immature panicles, and the rest (48%) had no panicles. Plants damaged earlier had more mature compensatory panicles than those damaged later. However, the panicles were smaller, with 60–84% sterile grains and fewer filled grains per panicle. These panicles contributed 15.8%, 13.0%, 5.1%, and 0.2% to total grain yield when damage occurred at booting, heading, flowering, and dough stages, respectively. Thus, the compensatory crop reduced the respective yield loss from 58.2% to 42.4%, 68.5% to 55.5%, 30.9% to 25.8%, and 47.0% to 46.8% when damage was done at booting, heading, flowering, and dough stages.

Table 2. Compensation of rice crop for rat damage observed 3 wk after harvest of the main crop (BRRI dhan 29), 2000 boro season, Gazipur, Bangladesh.

Characteristic	Booting	Heading	Flowering	Dough	Mean of damage treatments
Compensatory tillers (no. $plot^{-1}$)	320.17	302.34	198.09	219.52	260.03
With mature panicles	170.33	114.17	21.67	4.75	77.73
With immature panicles	18.17	99.50	67.67	38.60	55.99
Without panicles	131.67	88.67	108.75	176.17	126.32
Panicle length (cm)	19.24	18.37	18.68	15.69	18.00
Grain sterility (%)	60.05	70.06	67.54	84.28	70.48
Filled grains (no. $panicle^{-1}$)	26.67	19.13	21.82	10.73	19.57
Panicle weight (g $panicle^{-1}$)	0.51	0.33	0.41	0.23	0.37
Compensatory grain yield (g $plot^{-1}$)	116.00	95.03	37.24	1.25	62.38
Contribution to grain yield (%)	15.83	12.97	5.08	0.17	8.51

The results show that rice plants suffered yield losses proportional to the loss of panicles or panicle-bearing tillers as a result of rat damage at the reproductive phase. Other yield components—panicle size, grains per panicle, and panicle weight—were not affected and had no influence on yield loss. Although plants respond strongly to damage and produce many tillers before flowering, plants can only compensate for some of the losses. Plants can contribute 13–16% to total grain yield, provided the compensatory crop is protected and harvested later. The extent of compensation depends on the timing and level of rat damage and agroecological conditions—soil fertility, soil moisture, and incidence of pests after the harvest of the main crop. Farmers can make a second harvest only if the compensatory crop is worthwhile. In cases of minor to moderate levels of rat damage, farmers may not be interested in the compensatory crop. But, in situations of severe damage (40% or more), they may be motivated enough if the compensatory crop can provide a sizable yield. However, the compensatory crop must be protected from pests. An important question is How long can a farmer wait for compensatory yield? Considering the flush of maturity of the first-generation compensatory panicles and the odds a farmer has to face, a cut-off date for the second harvest was set at 3 wk after the main crop harvest. Further delay would be impractical.

References

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