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Yield reduction in wheat by simulated rat damage

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Abstract. A study of simulated rat damage was done to determine the loss of wheat yield when 0 (control), 10, 30 and 50% of the wheat stems were cut at tillering, booting, dough and mature crop stages. The yields at harvest from each of 128 1-m² plots were compared by analysis of variance and least significant difference tests. Yield at the tillering stages was not significantly different from the controls but yields at all other stages differed significantly. Yield losses in tillering and booting stages were not significant for the different damage levels except for 50% stem cutting at the booting stage. The yields from dough and mature crop stages at all damage levels were significantly lower than yields from controls. No significant differences in yield at all growth stages were observed between control plots and those receiving 10% damage, but 30 and 50% damage gave significant losses.

Introduction

Rats are considered one of the world's most serious pests, damaging not only field crops, but also destroying and contaminating stored foods and other valuable commodities. They are reservoirs of several important human diseases. The lesser bandicoot rat, *Bandicota bengalensis* Gray, is the most destructive and the commonest rat species found throughout Bangladesh. This species occurs in fields and invades houses in villages, towns and cities.

Wheat, *Triticum vulgare*, has become one of the major food crops in Bangladesh. Wheat production rapidly increased from approximately 190,000 ha planted in the 1977–78 crop season to 521,725 ha in 1982–83 (Bangladesh Bureau of Statistics, 1984) and total production was 1,075,255 tonnes in the latter crop season. Wheat is probably subjected to more damage from rats than any other pest. Tiller cutting by rats and hoarding of cut panicles in burrows leads to significantly lowered yields of wheat in Bangladesh. The primary rodent pest of wheat in Bangladesh is *B. bengalensis*.

Poche' *et al.* (1982) assessed pre-harvest rat damage in wheat in Bangladesh and found that about 12% of the tillers were cut, amounting to an estimated loss of 77,000 tons of wheat. Rejasekharan and Dharmaraju (1975) mentioned an average of 41·1% of wheat tillers damaged in Andra Pradesh in India. Srivastava (1966) reported that wheat tillers damaged by rats ranged up to 13·5% in south India. In Pakistan, Beg and Khan (1977) found 5 to 7% of wheat tillers were cut by rats and Layallpur District and damage in some fields was as high as 44%.

Poche' *et al.* (1981) observed that when 10% of the stems were cut in the tillering growth stage of upland rice the plots produced higher yields than the control, presumably from plant growth compensation. Similar stem cutting in the mature stages however, lowered yields significantly. Guererro (1970) found no significant difference in yield of rice between 20% mechanical damaged plots and control plots when rice stems were cut 4 to 10 weeks after transplanting, but 60% mechanical damage gave significantly less yields at all growth stages.

The objective of this study was to determine the response of wheat yield when stem cutting was performed at various growth stages (tillering, booting, dough and mature) and at different damage intensities (0, 10, 30 and 50% cut tillers).

Methods

A completely randomized design (CRD) was used for this study. The experimental area was a 30 × 30 m farmers field. From 900 available quadrats (1 m² size) within the wheat field, 128 were randomly selected and were assigned different combinations of damage level and growth stage. Inia wheat variety was used. The seeds were broadcast on 13 December 1979, irrigated and fertilized twice and harvested on 25 March 1980.

Mechanical cuts were made during four growth stages: tillering, 32 days after seeding (d.a.s.), booting (57 d.a.s.), dough (74 d.a.s.) and maturity (103 d.a.s.). At each growth stage, four intensities of mechanical damage were done by cutting: 0 (control), 10, 30 and 50% of the tillers. Each selected quadrat was marked with bamboo sticks and a numbered metal tag.

Within each quadrat the total number of stems were counted (mean 360; range 211–502) and the appropriate percentage of stems were randomly cut obliquely with scissors at 2 to 5 cm above ground level. The number of tillers cut for the desired intensity of damage was computed as follows:

$$\frac{\text{Total no. of tillers} \times \%\ \text{damage}}{100} = \text{No. of tillers to be cut}$$

Wheat plants from individual quadrats were harvested, tied into bundles and stored separately. The wheat was threshed manually, cleaned thoroughly by hand winnowing, sun-dried for 2 days and stored in separate labelled bags. The grain from individual quadrats was weighed to the nearest 0·1 g and moisture content was determined with a Dole Grain Moisture Tester. Moisture content of samples weighing less than 140 g was determined with a

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Satake Moisture Meter. Moisture content was adjusted to 10% using the formula:

$$a = \frac{100 - m}{100 - 10} \times W$$

where a is the weight of the sample adjusted to 10% moisture content;

m is the moisture content of the sample; and

W is the weight of the sample.

Two-way analysis of variance (ANOVA) and the least significant difference (LSD) test (Gomez and Gomez, 1979) was used to determine the significance between treatments and growth stages.

Results

Yields are summarized in Table 1. Yields from the tillering stage at all damage levels were not significantly different from the control. At the booting stage the 10 and 30% damage gave no significant difference, whereas the 50% damage levels were significantly different ($P = 0.05$) from the controls. In the dough stage, yield reductions due to 10 and 30% damage were significant ($P = 0.05$), and highly significant at the 50% damage level ($P = 0.01$). Yield reduction at the mature stage was significantly different ($P = 0.01$) for all damage levels.

Table 1. Summary of wheat yield data (kg/ha) from 128 1-m² quadrats subjected to simulated rat damage by mechanical stem cutting

Growth stage	Damage level (%)	Mean yield (kg/ha)	LSD test for growth stages†	LSD test for damage levels‡	% yield reduction from control
Tillering	0*	2927			
	10	2889	N.S.	N.S.	1.3
	30	2812	N.S.	N.S.	3.9
	50	2544	N.S.	N.S.	13.1
Booting	0*	2868			
	10	2537	N.S.	N.S.	11.5
	30	2435	N.S.	*	15.1
	50	2140	*	**	25.4
Dough	0*	2806			
	10	2504	*	N.S.	10.8
	30	2302	*	**	18.0
	50	1526	**	**	45.6
Mature	0*	2602			
	10	2364	**	N.S.	9.2
	30	1946	**	**	25.2
	50	1406	**	**	46.0

* Control plots.

† L.S.D. test for differences among damage levels: N.S., not significant; *, significant at 5% level; **, significant at 1% level. LSDs at 5 and 1% level respectively: tillering: 490.8, 673.0; cv = 17.4%; booting: 386.3, 521.2; cv = 14.7%; dough: 441.2, 595.2; cv = 18.1%; mature: 420.4, 567.1; cv = 21.6.

‡ LSD test for growth stages: N.S., not significant; *, significant at 5% level; **, significant at 1% level. LSDs at 5 and 1% level respectively: control: 478.1, 645.0; cv = 16.7%; 10% cut: 433.2, 584.4; cv = 17.0%; 30% cut: 476.6, 508.1; cv = 16.1%; 50% cut: 470.6, 634.9; cv = 18.4%.

Analysis of the yield data by ANOVA indicated that the treatments, growth stages and damage levels were significant at the 1% level but the replications and interaction between growth stage and damage level were not significant (Table 2). The effect of simulated rat damage at several growth stages on wheat yield is shown graphically in Figure 1.

Table 2. Two-way analysis of variance for wheat yield data from simulated damage quadrats

Source of variation	Degrees of freedom	Sum of squares	Mean observed square	Mean observed F
Replication	7	4157413.8	593916.3	2.36 N.S.
treatment	15	25579122.0	1705274.8	6.78**
Stage	3	8929822.5	2976607.5	11.83**
Damage	3	13976516.5	4658838.8	18.51**
Damage × growth stage	9	2672783.0	296975.9	1.18 N.S.
Error	105	26420673.9	251625.5	

N.S. = not significant; ** = significant at the 1% level.
Coefficient of variation = 20.1%.

There was no significant difference (LSD test) in yield between the control and 10% stem cutting at any growth stage but yield differences were highly significant at the 30 and 50% damage levels (Table 1). Yield reductions at 30% damage did not differ significantly in the tillering stage, but did in the booting ($P = 0.05$), dough and mature stages ($P = 0.01$). At 50% damage, yields were significantly reduced ($P = 0.01$) for all growth stages except tillering.

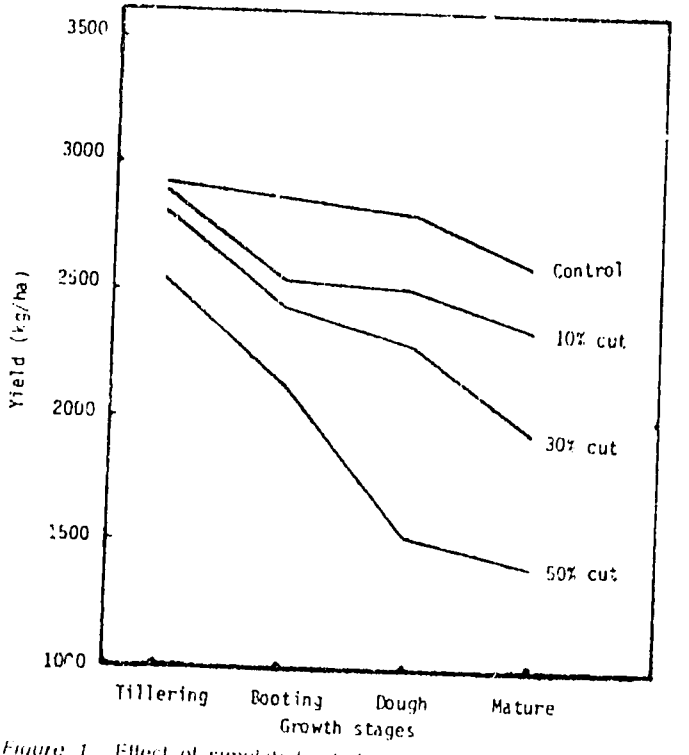

Figure 1. Effect of simulated rat damage on yield in wheat at different growth stages.

Discussion

Cereal grain plants possess a large potential for compensatory recovery from rat damage that occurs during

the early growth stages. Beyond the vegetative [illegible] stage, however, this potential disappears rapidly. At the tillering stage, the secondary tillers are as productive as the original intact tillers, and growth compensation offsets the early damage. In the booting stage some plant compensation was observed but yield was reduced because the grain had had less time to mature fully. At the dough stage there was no measurable plant compensation and panicles did not form before harvest. There was no opportunity for retillering when damage was caused at the mature stage so yield losses were very high.

Actual yields were higher than expected when 50% of the stems were cut. This may be attributed to several compensatory mechanisms, including increased tillering at earlier growth stages, more photosynthetic activity due to increased space and light, and greater nutrient and water intake from the soil. This would have allowed the remaining plants to produce heavier panicles.

When 10% of the stems were cut in the mature stage, yield reduction of 9·2% was observed. Similarly, when 30 and 50% of the mature stems were cut, yield declined by only 25·2 and 46·0%. In each case, the yield loss should equal the damage level but probably due to sampling error, each is less than expected. Yield reduction when 50% of the stems were cut at dough and mature stages were directly proportional to the intensity of damage. We have no explanation as to why the yield of the control plots decreased stepwise with the growth stages.

With the advancement of crop growth stage the ability for compensatory growth by the plants gradually decreased and damage done in the later stages of growth resulted in lower yields. Rat damage was found to gradually increase with the age of the crop with maximum damage occurring during the mature stage (Poche' *et al.* 1982).

In the tillering stage, simulated rat damage of 10% reduced the yield but not significantly due to plant growth compensation. These findings indicate that rat damage on wheat before the booting stage does not affect yield sig- [illegible] control rodents bef [illegible] this [illegible] uneconomical.

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References

BANGLADESH BUREAU OF STATISTICS. 1979. *Statistical Yea [illegible] Book of Bangladesh*. Dhaka: Statistics Division, Ministry o [illegible] Planning, Government of the Peoples Republic of Bangla [illegible] desh. pp. 327.

BEG, M. A. and KHAN, A. A., 1977. Rat damage to wheat crop. Abstract from *Proceedings of the 18th Annual Conference o [illegible] Scientific Society of Pakistan*.

GOMEZ, K. A. and GOMEZ, A. A., 1976. *Statistical procedures for agricultural research*. Los Banos, Philippines: International Rice Research Institute. pp. 294.

GULFRO, R. D., III, 1976. *The yield reduction of rice caused by mechanical and actual rat damage*. M.S. thesis, University of the Philippines. pp. 47.

POCHE', R. M., HAQUE, M. E., MIAN, M. Y., SULTANA, P. and KARIM, M. A., 1981. Rice yield reduction by simulated damage in Bangladesh. *Tropical Pest Management* 27(2), 242–246.

POCHE', R. M., MIAN, M. Y., HAQUE, M. E. and SULTANA, P., 1982. Rodent damage and burrowing characteristics in Bangladesh wheat fields. *Journal of Wildlife Management* 46(1), 139–147.

REJASEKHARAN, M. R. and DHARMARAJU, E., 1975. Studies on field rodent in Andhra Pradesh. pp. 54–55. In *All India Rodent Seminar, 23–26 September, 1975, Ahmedabad, India*.

SRIVASTAVA, V. S., 1966. Rats and their control. *Labdev. Journal of Science and Technology* 4(4), 207–240.