

Assessment of crop losses due to insect pests and weeds in rice (*Oryza sativa*)

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ABSTRACT

An experiment was conducted during rainy season (*khari*) 2002 and 2003 to determine crop losses due to multiple pests in rice (*Oryza sativa* L.). The rice crop was found infested with leaf folder [*Chaphalocrosis medinalis* (Guenee)] and weed (*Echinochloa colona* L). Besides stem borer (*Scirpophaga incertulas* Walker) incidence was simulated by artificial tiller removal. Pest incidence levels as well as associated yield losses varied during two years. The leaf folder inflicted a yield loss of 4-5 % during two years while leaf folder and weeds together caused 10-14% loss in yield. Artificial tiller removal @ 25-50% before flowering and after flowering during first year resulted in 11-27.2 % and 16-31 % yield loss, respectively. During 2003, 25-75% tiller removal before flowering caused 9-48.2% yield loss while 25-50% tiller removal after flowering caused 15.2-24.4 % yield loss. The rice crop could compensate for the tiller removal to a certain extent during vegetative growth phase. The yield losses due to multiple pests, such as leaf folder and weeds together were not found to be additive.

Key words: Insects, Multiple pests, Rice, Weeds, Yield loss

Growth in productivity of rice has shown either a decline or stagnation in several intensive-farming districts of Punjab and Haryana due to several biotic and abiotic influences (Sinha *et al.* 1998; Aggarwal *et al.* 2000). Siddiq (2000) reported that bacterial leaf blight, blast, stem borer, leaf folder and plant hoppers constitute today the major yield limiting biotic stresses in rice. Occurrence of several pests simultaneously in field is a rule and not an exception. A crop may behave differently to the presence of a single pest and multiple pests and the crop losses may not always be additive. Therefore it becomes necessary to determine crop losses due to multiple pests to have a clear picture of pests' damage potential.

MATERIALS AND METHODS

Field experiments were conducted with 'Pusa-834' rice (*oryza sativa* L.) in a randomized block design with 3 replications during rainy season (*khari*) 2002 and 2003 at Indian Agricultural Research Institute, New Delhi. Rice nursery was sown on 15 and 16 June during two years, respectively and transplanting was carried out on 20 July during both years. Nitrogen was applied as urea @ 120 kg N/ha in 3 equal splits at transplanting, tillering (18 days after transplanting) and panicle initiation (32 days after transplanting) during first year, whereas it was applied as

urea @ 150 kg N/ha in four equal splits, at transplanting, tillering (17 days after transplanting), panicle initiation (36 days after transplanting) and heading (50 days after transplanting) during second year. Plot size was kept as 3 m x 2 m during both the years, however spacing was 15 cm x 15 cm during the first year and 15 cm x 20 cm during the second year. The plots were separated by an open space of 1 m. Irrigation was applied daily in nursery, while main field was irrigated every alternate day. The treatments in two experiments were as follows.

Treatments in 2002

T₁, crop completely free (no weed, no insect, no disease); T₂, only leaf folder present; T₃, Leaf folder and weeds present; T₄, Only weeds present; T₅, Protection from 40 days after transplanting onwards; T₆, Protection from 60 days after transplanting; T₇, Protection from 80 days after transplanting; T₈, Tiller removal @ 25% before flowering (50 days after transplanting) to mimic stem borer damage; T₉, Tiller removal @ 50% before flowering (50 days after transplanting); T₁₀, Tiller removal @ 25% after flowering (70 days after transplanting) and T₁₁, Tiller removal @ 50% after flowering (70 days after transplanting)

Treatments in 2003

T₁, Crop completely free of pests; T₂, Only leaf folder present; T₃, Leaf folder and weeds present; T₄, Only weeds present; T₅, Protection from 50 days after transplanting onwards; T₆, Protection from 70 days after transplanting

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onwards; T₇, Tiller removal @ 25% before flowering (40 days after transplanting); T₈, Tiller removal @ 50% before flowering (40 days after transplanting); T₉, Tiller removal @ 75% before flowering (40 days after transplanting); T₁₀, Tiller removal @ 25% before flowering (50 days after transplanting); T₁₁, Tiller removal @ 50% before flowering (50 days after transplanting); T₁₂, Tiller removal @ 75% before flowering (50 days after transplanting); T₁₃, Tiller removal @ 25% after flowering (70 days after transplanting) and T₁₄, Tiller removal @ 50% after flowering (70 days after transplanting).

The treatments during second year were modified slightly based on experience of the first year. Data on incidence of pests were recorded at weekly interval in various treatments following random sampling. The leaf folder [*Cnaphalocrosis medinalis* (Guenée)] incidence was recorded on 6 hills in each treatment by selecting 1 hill from each of the 6 centre rows of the plot. Total leaves and infested leaves due to leaf folder were recorded on each hill and per cent leaf folder incidence was determined. The treatments, which were to be protected against the pest were sprayed with profenofos insecticide @ 2 ml/litre of water.

In the detillering treatments, tillers were artificially removed to simulate the effect of stem borer damage on rice growth and yield. Tiller removal was carried out before flowering as well as after flowering depending upon the treatment.

For mimicking crop-weed interactions, the weeds were removed manually as and when required in different treatments. The crop, which was protected from all pests from 40, 60 and 80 days after transplanting onwards, the weeds were removed at the respective stages and after that these were not allowed to grow in the field. Weed biomass was oven dried and weight was recorded.

The crop was harvested at physiological maturity and fresh weight of biomass (grain+straw) was recorded in the field. From this a sub-sample (about one-tenth) was weighed and brought to laboratory and total dry matter (TDM) was recorded after oven drying at 70°C. After thrashing, the fresh and dry weight of grain yield was also recorded for each plot separately.

One thousand grains were counted from the yield of each plot, these were oven dried at 60°C for two days and 1000-grain weight was recorded. Likewise grains of all the hills in 1 m² area were weighed and based on 1000-grain weight, grains/m² was determined.

The data on TDM, yield and 1000-grain weight were analyzed by two-way ANOVA, taking replications as blocks.

RESULTS AND DISCUSSION

Yield and dry matter reduction due to pests

There was incidence of leaf folder, *Cnaphalocrosis medinalis* and weed species, *Echinochloa colona* in the crop.

The yield and dry matter in different treatments in first year (Table 1) varied from 4 919 7 129 and 10 369–15 476 kg/ha, respectively while during second year (Table 2), these were 2 847–5 499 and 7 126–13 132 kg/ha, respectively. The yield and dry matter were less in second year compared to the previous year due to seasonal differences and less number of hills planted (plant-to-plant spacing was 20 cm compared with the 15 cm in previous year).

The leaf folder incidence varied from 2.0 to 6.6% in the first year (T₂) with the peak incidence recorded at 57 days after transplanting while it reached up to 20% during the second year (T₂) with peak incidence at 73 days after transplanting. Despite higher pest incidence in the latter year, the yield and the TDM loss was only 4 and 6.6%, respectively compared with the corresponding loss of 5 and 4% during the former, thereby indicating that it was not only the total incidence which mattered for yield loss but crop stage at which it occurred was also crucial. During first year the highest pest incidence coincided with panicle emergence/flag leaf stage of the crop at which the crop is most prone to pest attack (Satish 2004).

In the weed treatment during first year (T₄), the weed dry biomass measured at crop maturity was 380 kg/ha, causing 8.5% loss in dry matter and 10% loss in grain yield due to reduction in the grain number (Table 1). During second year, the weed biomass was 3–4 times more than the last year that could cause a yield and TDM loss of 14 and 14.5%, respectively due to their increased intensity (T₄). Due to wider plant spacing in the second year, the weeds were able to grow better and cause heavier yield loss.

When leaf folder and weeds together (T₃) infested the crop during the first year, the incidence of the leaf folder was more or less similar to T₂ treatment (leaf folder alone), whereas the weed biomass was slightly less than T₄ treatment (weeds alone). The yield loss in this treatment was nevertheless similar to the treatment having only weeds (T₄). Similar trend was witnessed during second year, where leaf folder and weeds together (T₃) and weeds alone (T₄) caused 14% loss each although there was not much difference in weed biomass in these two treatments. This indicated that effects of the leaf folder and weeds were not additive and there was compensation in the rice crop when multiple pests occurred. The non-additiveness of yield losses due to leaf folder and weeds might be due to their different pest damage mechanisms because leaf folder is a tissue consumer, whereas weeds act as resource stealers (Aggarwal et al. 2004).

There were different populations of leaf folder as well as weeds, when the crop was protected for varying periods. During first year, the crop exposure to joint attack of the leaf folder and weeds up to 40 days after transplanting (T₅) did not cause any appreciable effect on yield as well yield components (Table 1). However when crop was exposed to the pests up to 60 days after transplanting (T₆), there was 7

Table 1 Pest damage, yield and total biomass for 'Pusa 834' rice during *kharif* 2002

Treatment	Crop age Days after transplanting (DAT)							Yield (kg/ha)	Per cent reduction	TDM (kg/ha)	Per cent reduction	1000- grain wt (mg)	Grains/ m ²
	35	40	50	57	65	70	80						
T ₁ , Completely free	-	-	-	-	-	-	-	7 129	-	15 476	-	20.6	34 606
T ₂ , Leaf folder (% folded leaves)	2.04	2.94	5.78	5.9	3.74	3.16		6 772	8	14 860	4	20.01	32 394
T ₃ , Leaf folder and weeds (kg/ha)	2.8	2.46	6.96	6.59	4.97	3.05		6 450	9.5	14 020	9	20.1	31 502
							268						
T ₄ , Weeds (kg/ha)							380	6 400	10	14 150	8.5	20.7	30 063
T ₅ , Protection from 40 DAT	1.59							7 050	1	15 400	0.5	20.5	34 390
Leaf folder and weeds							255						
T ₆ , Protection from 60 DAT	1.79	3.29	6.77	6.54				6 599	7	14 460	6.5	20.3	32 507
Leaf folder and weeds							280						
T ₇ , Protection from 80 DAT	2.45	2.99	4.19	4.82	3.19	2.43		6 550	8	14 350	7	20.5	32 126
Leaf folder and weeds							418						
T ₈ , Tiller removal @ 25% - 50 DAT			25					6 350	11	12 950	16	21.2	29 953
T ₉ , Tiller removal @ 50% - 50 DAT			50					5 190	27.2	10 650	31	21.21	24 469
T ₁₀ , Tiller removal @ 25% - 70 DAT				25				5 988	16	12 536	19	20.5	32 126
T ₁₁ , Tiller removal @ 50% - 70 DAT				50				4 919	31	10 369	33	21.1	25 587
CD (<i>P</i> <0.05)								680		2 600		0.6	

and 6.5% loss in yield and biomass respectively due to reduction in grain number. Further exposure of the crop to pests up to 80 days after transplanting (T₇) did not cause much increase in yield losses. Similarly in second year, when crop was exposed to pests up to 50 days after transplanting (T₅), there was 2 and 3.5% loss in yield and biomass respectively. However, crop exposure to pests up to 70 days after transplanting (T₆) resulted in a yield loss of 13% with a biomass reduction of 20% due to higher incidence of pests as compared to last year. These results indicated that rice crop was most sensitive to pest attack between 50 and 70 days after transplanting and it was less prone to pest attack in early as well as later stage of crop growth. Satish (2004) found the rice crop to be most prone to leaf folder attack during panicle emergence stage of the crop (50-60 days after transplanting). Similarly, the weeds were less problematic in transplanted rice during initial stages and they actually started growing after 40-50 days after transplanting.

When tillers were removed before flowering to mimic stem borer damage at different intensities, there were significant losses in total dry matter as well as yield (T₈-T₁₁). The reduction in grain yield and TDM varied from 11 to 31 and 16 to 33%, respectively during the first year (Table 1) while during second year (T₇-T₁₄), the reduction was 9-

48.2% in the yield and 12-46% in the TDM (Table 2) depending upon the time of removal and intensity. These reductions were mainly due to reduced number of grains. The quantum of loss increased with increasing crop age at the same intensity of tiller removal. This happened because rice plants could compensate for the stem borer damage during early growth stages due to production of new tillers (Dale 1994).

Two years experimentation revealed that rice crop could compensate for attack of leaf folder, stem borer and weeds at early stages of crop growth. The damage due to multiple pests such as leaf folder and weeds together was not additive.

It is evident from the present study that rice crop could compensate for pests' damage before flowering through production of tillers. Also the effects of multiple pests were not found to be additive and thus the crops behaved differently when the pests were present individually and when these were present together. Therefore higher pest population/damage than simple economic thresholds may perhaps be tolerated when multiple pests infest the crops. These facts must get attention before attempting pest management measures in these crops, which would help to avoid unnecessary expenditure and prevent environmental contamination.

Table 2. Pest damage, yield and total biomass for 'Pusa 834' rice during kharif 2003

Table 2 Pest damage, yield and total biomass for Pusa 324 under different treatments													
Treatment	Crop age						Yield (kg/ha)	Per cent reduction	TDM (kg/ha)	Per cent reduction	1000- grain wt (mg)	Grains/ m ²	
	44	52	59	66	73	85							
T ₁ , Completely free	-	-	-	-	-	-	5 499	-	13 132	-	22.78	24 139	
T ₂ , Leaf folder (% folded leaves)	3.51	1.56	2.47	12.9	14.6	-	5 278	4	12 259	6.6	23.45	22 507	
T ₃ , Leaf folder and weeds (kg/ha)	2.25	2.17	5.18	12.46	19.68	-	1 299	4 738	14	11 045	16	23.56	20 110
T ₄ , Weeds (kg/ha)							1 333	4 703	14	11 224	14.5	22.7	20 718
T ₅ , Protection from 50 DAT Leaf folder and weeds	3.47	1.87						5 372	2	12 666	3.5	23.13	23 225
							492						
T ₆ , Protection from 70 DAT Leaf folder and weeds	4.6	3.21	3.3	6.56			1316	4 771	13	10 482	20	22.63	21 083
T ₇ , Tiller removal @ 25% - 40 DAT	25							5 010	9	11 586	12	23.37	21 437
T ₈ , Tiller removal @ 50% - 40 DAT	50							4 477	17	9 792	25	23.22	19 280
T ₉ , Tiller removal @ 75% - 40 DAT	75							3 648	34	7 525	43	23.12	15 778
T ₁₀ , Tiller removal @ 25% - 50 DAT		25						4 944	10	11 356	14	23.51	21 033
T ₁₁ , Tiller removal @ 50% - 50 DAT		50						4 222	23	8 838	33	23.66	17 844
T ₁₂ , Tiller removal @ 75% - 50 DAT		75						2 847	48.2	7 126	46	23.35	12 192
T ₁₃ , Tiller removal @ 25% - 70 DAT			25					4 664	15.2	10 701	19	22.99	20 287
T ₁₄ , Tiller removal @ 50% - 70 DAT			50					4 156	24.4	8 459	36	22.57	18 413
C D (P<0.05)								417		11 94		0.58	

REFERENCES

- Aggarwal P K, Bandhyopadhyay S K, Pathak H, Kalra N, Chander S and Kumar S 2000. Analyses of yield trends of the rice-wheat system in North-Western India. *Outlook on Agriculture* 29: 259-68.
- Aggarwal P K, Kalra N, Chander S and Pathak H. 2004. *Infocrop: A generic Simulation Model for Annual Crops in Tropical Environments*, Indian Agricultural Research Institute, New Delhi, 132 pp.
- Dale D. 1994. Insect pests of the rice plant: their biology and ecology. (In): *Biology and Management of Rice Insects*, pp 363-485. Heinrichs B A (Ed). Wiley Eastern Ltd, New Delhi.
- Satish D G. 2004. 'Quantification of damage mechanism and determination of economic injury level for leaf folder, *Cnaphalocrosis medinalis* in rice'. M Sc thesis, Indian Agricultural Research Institute, New Delhi, 80 pp.
- Siddiq EA. 2000. Climate and rice production in India. (In): *Rice in a Variable Climate*, pp 107-22. Abrol YP and Gadgil S (Eds), APC Publications, New Delhi.
- Sinha S K, Singh G B, RAI M. 1998. *Decline in Crop Productivity in Haryana and Punjab: Myth or Reality*, Indian Council of Agricultural Research, New Delhi, 89 pp.