Table 3. Prey preference of spiders to moths

	Prey consumed in seven days (%)*			
Spider	Stem borer	Leaf folder	Case worm	Mean
Pardosa	34.60 aB	37.24 aA	29.70 bC	33.85 a
Tetragnatha	29.60 bA	29.07 bA	24.65 cB	27.77 b
Oxyopes	19.51 cC	29.72 bA	35.17 aA	28.13 b
Mean	27.90 C	32.01 A	29.84 A	

In a column, (lower case) and in a row (upper case) means followed by the same letter denotes statistical parity under DMRT (P=0.05)

*Mean of four replications.

B. Prey preference over a mixed population of rice lepidopteran moths

The preference of spiders over a mixed population of moths viz., yellow stem borer, leaf folder and case worm is presented in Table 3. *Pardosa* preferred significantly more leaf folders (37.24%), followed by stem borer (34.60%) and case worm (29.70%). *Tetragnatha* preferred stem borer (29.60%) and leaf folder (29.07%). *Oxyopes* preferred more of caseworm (35.17%) followed by leaf folder (29.72%) and showed a lesser preference to stem borer moths (19.51%). Similar to plant and leafhoppers, *Pardosa* (33.85%) accounted for significant extermination of the prey moths followed by *Oxyopes* (28.13%) and *Tetragnatha* (27.77%). The difference may also be due to the habit of the spiders. *Pardosa* and *Oxyopes* are hunters while *Tetragnatha* is web builder.

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PREDICTING RICE LEAFFOLDER DAMAGE AND YIELD LOSS IN IR 50 RICE BY MATHEMATICAL MODELLING

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ABSTRACT

The predicted damage and yield loss caused by rice leaffolders, *Cnaphalocrocis medinalis* (Guenee) and *Marasmia patnalis* (Bradley) in microplot experiment during *kharif* 1996 showed that the yield loss was higher at the initial infestation by leaffolder larvae at 40 DAS than the infestation at 30 DAS. There was no proportionate increase in yield loss with increasing larval populations. The rate of yield loss due to an increment of one percent damage was more pronounced at 10 percent base level damage i.e., 10 to 11 percent than at higher base level damage of 20, 30 to 90 percent.

KEY WORDS : Rice, leaffolder, damage, yield loss and modelling

INTRODUCTION

In recent past, some of the rice pests, hither to recorded as minor pests have assumed major status under the changed rice ecosystem. The rice leaffolders, *Cnaphalocrosis medinalis* (Guenee) and *Marasmia patnalis* (Bradlely) which were considered as minor and sporadic insect pests of rice in several Asian countries, have become a major threat to rice production in tropical and sub-tropical Asia (Heinrichs *et al.*, 1979). The assessment of yield loss due to leaffolder revealed a negative correlation between damage and yield (Subramanian, 1990). The yield loss was 27 per cent when 23 leaffolder larvae per m^2 caused damaged to 103 leaves per m^2 (Chaudhary and Bindra, 1970).

The present study was conducted in an attempt to predict the leaffolder damage and yield loss in cultivar (c.v.) IR 50 at different larval populations and crop periods under screenhouse microplots.

MATERIALS AND METHODS

The leaffolders were mass cultured on potted rice plants as per the methods suggested by Waldbauer and Marciano (1979), Fujiyoshi *et al.*, (1980) and Godase and Dumbre (1982).

The second instar larvae (3 to 4-day-old) were released on 30, 40, 60 and 80-day-old-plants raised in screenhouse microplots at 15x10 cm spacing. The variants used were one to seven larvae per hill, with a control. Ten hills were maintained for each treatment. The treatments were replicated thrice. After pupation, the pupae were removed from plants and used for mass culturing. Observations were made on the leaffolder to number of and total leaves and arrived at a percentage for each treatment. The damaged plants with the damage suffered during the restricted period (30 to 80-day-old) were allowed to mature and yield per hill was recorded separately at harvest. The yield loss was assessed using the yield of uninfested plants as the basis.

Among the various models tried the Mitscherlich's model was found to be the best based on correlation coefficient and goodness of fit (Morgan *et al.*, 1975).

The Mitscherlich's model is of the form

$$D(l,t) = D_M [1 - \alpha . e^{-\beta^{l(t)}}]$$

Where,

$D(l,t)$ = Leaf damage at various larval loads and crop periods

$l(t)$ = Larval load at t^{th} crop period

D_M = Maximum damage at a given larval loads and crop periods

α and β = Parameters to be estimated.

The rectangular hyberbola model was found to be the best based on R^2 value and the prediction ability of the yield due to damage (Michaelis and Menten, 1913).

The rectangular hyperbola model is of the form

$$Y(l,t) = \alpha + \beta D(l,t)^{-1}$$

Where,

$Y(l,t)$ = Yield obtained after the infestation of various larval loads of different crop periods.

$D(l,t)$ = Leaf damage at different larval loads and crop periods

α and β = Parameters to be estimated

The yield loss due to one percent increase in damage from different base levels of damage was estimated using the formula

$$RYL(l,t) = \alpha - \beta D(l,t)^{-2}$$

Where,

$RYK(l,t)$ = Rate of yield loss at various larval loads and crop periods

$D(l,t)$ = Leaf damage at various larval loads and crop periods

β = Parameter to be estimated

Both the above models were estimated using the non-linear methods of ordinary least squares (OLS).

RESULTS AND DISCUSSION

The loss in terms of grain loss rated against corresponding damage for various larval populations and crop ages were predicted. The crop was infested at the age of 30 days through 80 days at various larval populations on hill basis.

The data revealed that early infestation (30 days) resulted in the highest damage compared to later infestation (Table 1). The damage was found to decrease with increasing crop age. The damage

Table 1. Predicted leaffolder damage and yield loss at different crop growth stages in IR 50

No. of larvae/ hill	30 DAS			40 DAS			60 DAS			80 DAS		
	Damage (%)	Yield obtained (%)	Yield loss (%)	Damage (%)	Yield obtained (%)	Yield loss (%)	Damage (%)	Yield obtained (%)	Yield loss (%)	Damage (%)	Yield obtained (%)	Yield loss (%)
1	19.07	94.21	5.79	15.93	92.89	7.11	0.00	100.00	0.00	0.00	100.00	0.00
2	37.92	71.35	28.65	33.80	62.55	37.45	6.68	97.99	2.01	6.13	98.91	1.09
3	51.47	65.27	34.73	46.37	55.17	44.83	16.16	84.59	15.41	13.75	87.43	12.57
4	61.22	62.52	37.48	55.22	51.95	48.05	22.14	82.08	17.92	18.69	84.88	15.12
5	68.23	61.07	38.93	61.45	50.34	49.66	25.92	81.07	18.93	21.90	83.97	16.03
6	73.28	60.20	39.80	65.84	49.40	50.60	28.30	80.57	19.43	23.99	83.42	16.58
7	76.90	56.92	40.38	68.93	48.72	51.28	29.30	80.23	19.77	25.34	83.06	16.94
Control	0.00	100.00	0.00	0.00	100.00	0.00	0.00	16.00	0.00	0.00	100.00	0.00

$D(l,t) = 86.2\,(1-1.0826\,e^{-0.3295\,l(t)})$ $(r = 0.9762)$ $t = 30$ DAS

$D(l,t) = 76.3\,(1-1.1240\,e^{-0.3512\,l(t)})$ $(r = 0.7927)$ $t = 40$ DAS

$D(l,t) = 32.4\,(1-1.9951\,e^{0.4609\,l(t)})$ $(r = 0.9139)$ $t = 60$ DAS

$D(l,t) = 28.8\,(1-1.8494\,e^{-0.4318\,l(t)})$ $(r = 0.9139)$ $t = 80$ DAS

$Y(l,t) = 3.3300 + 60.6200\,D(l,t)^{-1}$ $(r = 0.7927)$ $t = 30$ DAS

$Y(l,t) = 2.6402 + 68.1926\,D(l,t)^{-1}$ $(r = 0.7927)$ $t = 40$ DAS

$Y(l,t) = 4.4844 + 9.1144\,D(l,t)^{-1}$ $(r = 0.8543)$ $t = 60$ DAS

$Y(l,t) = 42865 + 7.0367\,D(l,t)^{-1}$ $(r = 0.9155)$ $t = 80$ DAS

however, increased with increasing larval densities. For infestation at 30 days the damage was between 19.07 and 76.90 percent for the larval populations of one and seven per hill while for 40th day infestation, it was 15.93 and 68.93 percent. For infestation at 60 and 80 days, the damage was lower compared to the damage suffered by 30 and 40-day-old-crops. In fact, the sum of the damage to 60 and 80-day-old-crops was lower than that of the damage to 30 and 40-day-old-crops.

The yield loss increased with increasing larval density with the corresponding increase in damage level. However, the loss in yield was more in 40-day-old-crop (7.11 to 51.28%) compared to the loss suffered by 30-day-old-crop. The 60-day-old-crop suffered no loss with one larva per hill. The maximum loss in yield corresponding to seven larvae per hill was 19.77 percent. The yield suffered by 80- day-old-crop was still lower (1.09 to 16.94%).

The photosynthetic ability of the rice plant decides the crop yield. Both by feeding and folding of leaves by leaffolder reduced the photosynthetic activity of the plant. Benigno *et al.*, (1988) reported that, leaf folding contributed more to yield loss than leaf feeding and the severity of such feeding behaviour was more during booting to heading stage. Sellammal Murugesan and Chelliah (1983 b) observed that the damage to flag leaf resulted in more yield loss. Pandya *et al.*, (1994) observed that every unit per cent increase, the leaffolder infestation at tillering, early earning and milky seed stage led to 1.98, 2.22 and 1.22 per cent loss in yield during summer and 2.18, 2.50 and 1.27 per cent in yield loss during wet season respectively. In the present study also the yield loss was more in panicle initiaion to heading (40 to 55 DAS) followed by tillering (30 to 45 DAS) and milky seed stage (60 to 95 DAS). The damage, at grain filling stage (67%) had not reflected on a yield loss. However, even a low levels of damage at heading (25%) resulted in a sigficant reduction in yield. The damage at heading stage reduced the percentage of ripened grains and 1000 grain weight (Miyashita, 1985). He had also reported that the yield loss was in proportion to the ratio of the damaged area in the two upper most leaves.

The predicted rate of yield loss for every unit increase in damage from the base levels damage of 10 to 90 percent (segmented at 10% of intervals) (Table 2) also showed a decreasing trend. The rate of fall in yield was the highest (8.77%) for an unit increment of damage from 10 percent level. The rate was reduced to 1/4th when the base level damage was increased from 20.0 percent to 21.0 percent. This was true for all the crop ages compared. The rate fell by half for an unit increase from the base levels of 30 and 40 compared to the rate at the preceeding level at all crop ages. For an

Table 2. Predicted yield reduction (g/hill) due to one percent increase in leaffolder damage.

Base level damage (%)	30 DAS	40 DAS	60 DAS	80 DAS
10	0.6062	0.6819	0.0911	0.0704
	(8.77)	(9.15)	(1.53)	(1.28)
20	0.1516	0.1705	0.0228	0.0176
	(2.19)	(2.29)	(0.38)	(0.32)
30	0.0674	0.0758	0.0101	0.0078
	(0.98)	(1.02)	(0.17)	(0.14)
40	0.0379	0.0426	0.0057	0.0044
	(0.55)	(0.57)	(0.10)	(0.08)
50	0.0242	0.0273	0.0036	0.0028
	(0.35)	(0.37)	(0.06)	(0.05)
60	0.0168	0.0189	0.0025	0.0020
	(0.24)	(0.25)	(0.04)	(0.04)
70	0.0124	0.0139	0.0019	0.0014
	(0.18)	(0.19)	(0.03)	(0.03)
80	0.0095	0.0107	0.0014	0.0011
	(0.14)	(0.14)	(0.02)	(0.02)
90	0.0075	0.0084	0.0011	0.0009
	(0.11)	(0.110	(0.12)	(0.016)

* Figures in parentheses indicate percentage of rate of yield loss.

unit increment from the base level damage of 50 and above, the rate of loss suffered fell to 2/3rd that of the preceeding level. Except for base levels of 10 to 30 percent damage on 30 and 40-day-old-crops, the rate of yield loss recorded was less than one per cent. The rate varied between 0.02 to 0.30 percent for unit increment in 20 and above in 60 and 80-day-old crops. The increment from 10 to 11 percent damage alone recorded a rate of 1.53 and 1.28 respectively in 60 and 80-day-old-crops.

The rate of yield loss was more for lower base levels damage than higher base levels damage. Sellammal Murugesan and Chelliah (1983 a) while relating the yield loss to percentage of leaf damage have showed that a 15 percent increase in damage from the base level of 43.60 percent caused an extra yield reduction of 3.40 percent only. When the damage was further increased to 12 percent from 58.80 per cent, the additional yield suffered was only 4.70 per cent. The rate of yield loss suffered in this study also was minimum against an increase in damage of 15 and 12 per cent. Smaller levels of damage falls on the region of linear relationship, but at higher levels, the change in yield loss for a slight increase from the base level will trend to be small. This might be the reason for the trend, that the rate of yield loss decreased with increasing damage levels observed in the present study.

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