CONTROL THRESHOLD FOR THE RICE LEAF BEETLE, *Oulema oryzae* KUWAYAMA

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Introduction

The rice leaf beetle, *Oulema oryzae* Kuwayama, is one of the major insect pests of rice in northern Japan (Fig. 1). The damage to rice plant is mainly caused by larval stages which are easily killed by insecticide treatment. Since only insecticides are currently available for controlling the beetle, excessive use of insecticides has frequently resulted. The treat-when-necessary application of insecticides, however, requires the development of the control threshold for this insect. In the present paper we were able to determine the control threshold for insecticide treatment as well as the required sample size of rice hills with a reasonable precision.

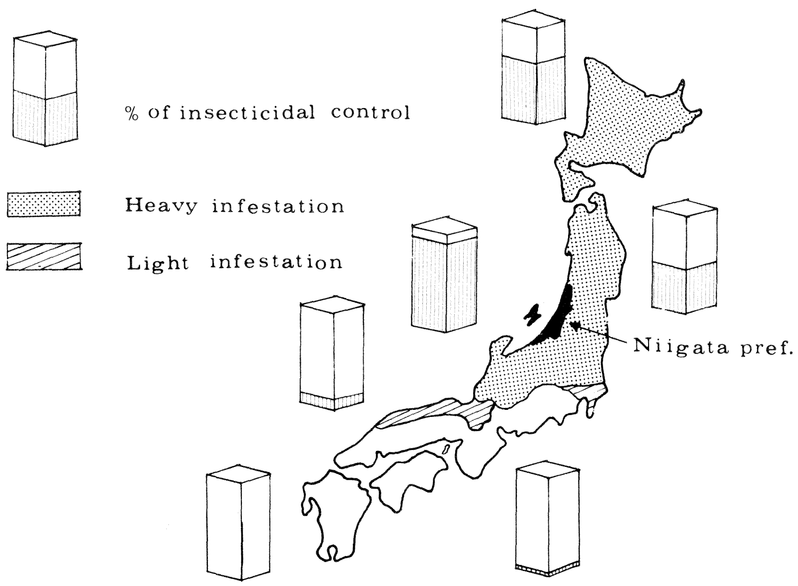

Fig. 1 Geographical distribution and percentage of paddy fields treated with insecticide for control of the rice leaf beetle

Damage of rice plant in relation to the life cycle of the rice leaf beetle

The rice leaf beetle (hereafter RLB) is univoltine and overwinters at the adult stage. Adults that have overwintered immigrate to paddy field during the period of late May to early June for egg-laying. The eggs are oviposited in egg masses on rice leaves. After 5 days of incubation, newly hatched larvae give rise to pupae after 2 weeks during which they moult four times. Larvae feed on the rice leaves at the vegetative growth stage from late May to the end of June (Fig. 2).

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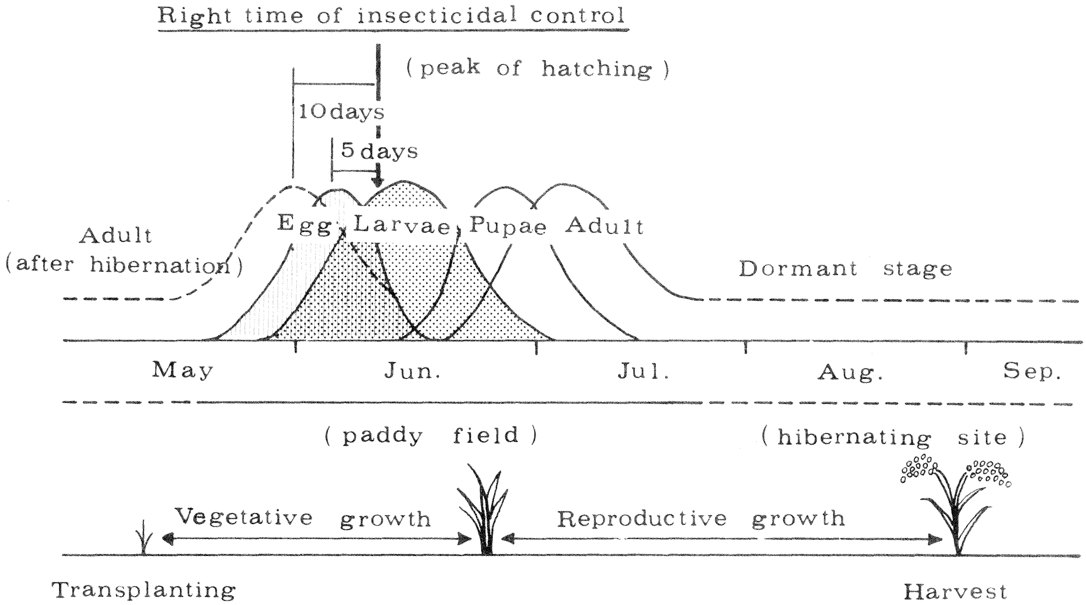

Fig. 2 Life cycle of the rice leaf beetle in relation to the growth stages of rice plant in Niigata prefecture

The growth of infested hills is retarded resulting in the reduction of the number of leaves and stems. Since rice plants reach the reproductive stage at the end of infestation, those rice plants which have been injured severely at the vegetative stage produce a reduced number of panicles, hence the decrease in yield (Hayakawa and Kureha 1951; Okamoto and Abe 1952; Kidokoro and Funabasama 1976; Nakamura *et al.* 1977; Koyama 1978). The rice leaf beetle is distributed in the area where the temperature in spring is low, so that the well-being of young rice plants during this period is very important to secure rice production. This is the reason why the infestation of young rice plants with RLB is economically important in the northern part of Japan.

Determination of control threshold

Iwao and Kiritani (1973) defined the tolerable injury level (TIL) as the maximum injury level that will cause practically no yield loss. The control threshold refers to the population density of RLB, as determined at the right time of insecticide treatment, which is expected to reach the tolerable injury level in due course. The procedure used to determine the control threshold for RLB is shown in Fig.3.

First, the yield loss of brown rice was assessed in relation to the larval density, and the larval density (TIL) at which no yield loss will be expected was estimated. Secondly, through the development of life tables of RLB under various conditions, prediction of population trend would be feasible before it reaches the TIL. Utilizing the survivorship curve of RLB, control thresholds for immigrant adults and eggs which are usually observed 10 and 5 days before the right time of chemical control, respectively, were determined. Finally, sample size as well as sampling method to secure a fixed precision was proposed for making a decision on insecticide application.

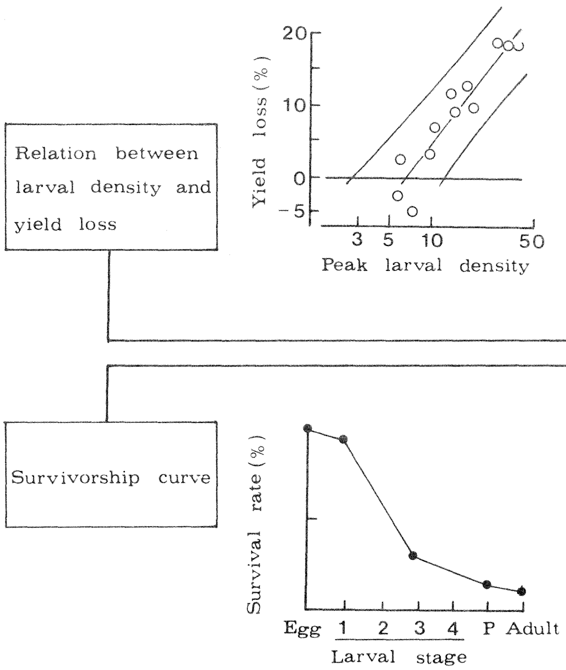

Fig. 3 Schematic representation in estimating the control threshold of the rice leaf beetle

Relation between injury level due to larva and yield loss

Field experiments with different densities of RLB larvae per hill enabled to demonstrate that the resulting yield loss was related to the larval density (Fig. 4). It was found that the highest correlation between both parameters was obtained when the larval density was expressed in terms of the number of 3rd and 4th instar larvae per hill.

The regression equation was calculated as follows:

$$Y = -22.24 + 26.07 \log X \qquad (1)$$

where Y refers to the percentage yield loss and X is the log number of 3rd and 4th instar larvae at the peak density. By substituting zero for Y in Eq. (1), we obtain $\log X = 0.85$ or $X = 7$. Similarly, the upper line of 95 percent confidence interval for Y cuts the X axis of $Y = 0$ at $X = 3.5$. To be on the safe side, we consider 3.5 larvae of 3rd and 4th instars per hill as the tolerable injury level.

Prediction of population trend of RLB

The right time for insecticide broadcasting is 5 days after the peak density of eggs when hatching of eggs reaches its peak. Consequently, if we could predict the trend of change in population density in the rice field during the time interval between egg and 3rd instar, we could set up the control threshold in terms of egg density. Table 1 shows the variations in the survival rate from egg up to the 3rd instar observed in 9 different fields during 1976 -76. The survival rate ranged from 8.3 to 64.9 percent. The mean value calculated by inverse arcsine transformation is 29.1 percent with 16.2 and 44.1 percent of lower and upper 95 percent confidence limits, respectively.

The suspected source of the variation in the survival rate was investigated by laboratory experiments. Each group of 1st, 2nd and 3rd instar larvae was reared under 4 regimes of different

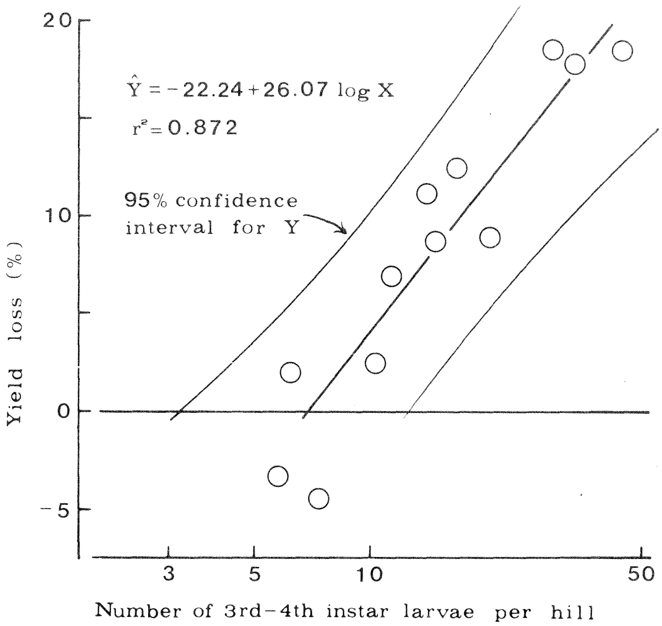

Fig. 4 Relation between percentage yield loss and the log number of 3rd-4th instar larvae per hill (Kojima and Emura 1979)

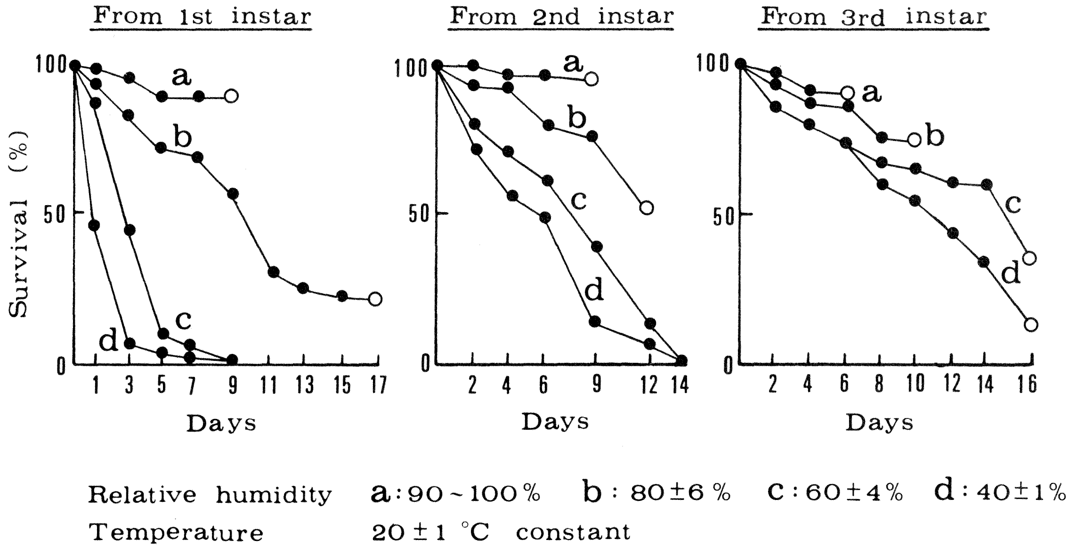

Fig. 5 Relationship between the survival rate and relative humidity in the larvae of the rice leaf beetle (Emura and Kojima 1978)

Table 1 **Survival rate of the rice leaf beetle from egg to 3rd instar larva in Niigata Prefecture (Emura and Kojima, 1978)**

Year	Paddy field	Survival rate
1975	A	46.2%
	B	64.9
	C	9.0
	D	20.8
	E	34.1
	F	44.6
1976	G	30.3
	H	8.3
	I	17.7
95% confidence intervals		16.2 – 29.1 – 44.1*

* inverse arcsine transformation

relative humidity at the constant temperature of 20°C. The younger the developmental stage of larvae and the lower the relative humidity under which they were reared, the lower the survival rate becomes (Fig. 5). This experiment indicated that relative humidity was responsible mostly for the variation in survival rate of larvae. As a matter of fact, it is unlikely that one would be able to forecast the occurrence of low relative humidity in the atmosphere at the time well before its occurrence. For the time being, we decided to use 44.1 percent, the upper limit of 95 percent confidence for the survival rate of RLB from egg up to the 3rd instar, to be on the safe side.

Determination of the control threshold

Parameters used and the control threshold densities estimated for eggs and immigrant adults are presented in Table 2.

Assuming that 3.5 of 3rd-4th instar larvae per hill is the maximum density which caused no actual loss of yield and that the survival rate from egg to 3rd instar is 44.1 percent, the control threshold for eggs was estimated at 8 eggs per hill.

In practice, the earlier the determination of the control threshold the more convenient it is for the growers. As mentioned earlier, the peak density of immigrant adults takes place 10 days before the right time of insecticide treatment. (See Fig. 2). A field cage experiment indicated that the over-wintered adult females lay 120 eggs on an average by the time of peak egg density in the field. The sex ratio was almost 1/1. Then the control threshold for immigrant adults could be obtained by dividing the control threshold density of eggs by both fecundity and sex ratio. (See Table 2). One adult per 10 rice hills was proposed as the control threshold for adults.

Table 2 Estimation of the control threshold density

Parameters	
Maximum number of 3rd to 4th instar larvae which caused no actual yield loss	3.5/hill
Survival rate from egg to 3rd instar larva	44.1 %
Fecundity per female	120
Sex ratio	1 : 1

Control threshold density	
Number of eggs at the peak density	8/hill*
Number of immigrant adults at the peak density	0.1/hill**

* 3.5 : 0.441 = 7.9
** 8 : 120 : 0.5 = 0.13

Sample size required for decision-making

The sample size to secure the proposed precision depends on the spatial distribution pattern of the samples. Also the sample size is limited by the availability of labor.

Eggs of RLB are deposited in egg masses comprising each about 10 eggs. An example of the distribution of egg masses in a paddy field is shown in Fig. 6 which indicates a random distribution. On the other hand, distribution of adults was aggregative, which requires a much larger sample size than for eggs to secure the same degree of precision. Sampling of adults, however, requires less labor as compared with that of eggs. A compromise design for sampling procedure is therefore inevitable. Suggested sampling design is presented in Table 3.

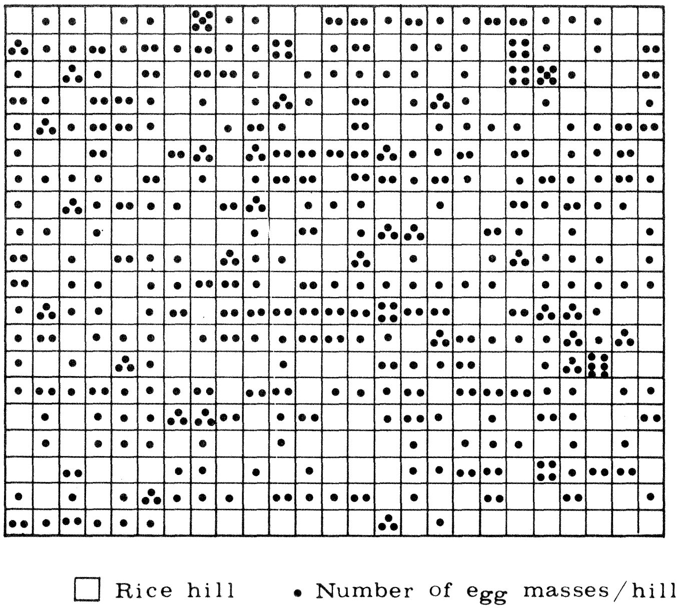

Fig. 6 The distribution of egg-masses of the rice leaf beetle in a paddy field

Table 3 A compromise design for sampling procedure to determine control thresholds for eggs and adults

Determinants	Egg	Adult
Sampling size	36 hills	100 hills
Sampling method	2 hills x 18 points	25 hills x 4 points
Sampling labor (time)	10 min.	10 min.
Precision (error)	20 %	40 %

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Summary

The right time of insecticide application for the rice leaf beetle is at the peak time of hatching of larvae, or 4 to 5 days after the peak density of eggs in the field. Control thresholds were proposed by taking into account the larval density at the tolerable injury level and survivorship curves of larvae. The control threshold for eggs was 8 eggs per hill, while for immigrant adults it was 0.1 at the peak incidence of adults in the paddy field.

Although the degree of precision is somewhat lower for adults than for eggs, 36 hills (2 hills/point × 18 points/field) for eggs and 100 hills (25 hills/point × 4 points/field) for adults, were suggested as practical sample size required for decision-making.

References

1) EMURA, K. and KOJIMA, A. (1978): Threshold density for insecticidal control of the rice leaf beetle, *Oulema oryzae* Kuwayama. I. An analysis of survivorship curves in relation to mortality factor. *Jap. J. Appl. Ent. Zool.* **22**, 260-268 (In Japanese with English summary).

2) ________ and ________ (1980): Threshold density of the rice leaf beetle, *Oulema oryzae* Kuwayama, for insecticidal control. III. Control threshold density and sampling size. *Jap. J. Appl. Ent. Zool.* **24**, 150-156. (In Japanese with English summary).

3) HAYAKAWA, H. and KUREHA, Y. (1951): Relation between the infestation of rice leaf beetle *Oulema oryzae* Kuwayama and the reduction of rice yield, *J. Econ. Ent.* **7**, 76-77 (In Japanese).

4) IWAO, S. and KIRITANI, K. (1973): What is integrated control of insect pest. Integrated control (ed. Fukaya, M. and Kiritani, K.) Kodansha, Tokyo (In Japanese).

5) KIDOKORO, T. and FUNABASAMA, K. (1976): Analysis of damage by the rice leaf beetle, *Oulema oryzae* Kuwayama, *Ann. Rept. Plant Prot. North Japan.* **27**, 84 (In Japanese).

6) KOJIMA, A. and EMURA, K. (1979): Threshold density of the rice leaf beetle, *Oulema oryzae* Kuwayama, for insecticidal control. II. Estimation of the threshold density, *Jap. J. Appl. Ent. Zool.* **23**, 1-10 (In Japanese with English summary).

7) KOYAMA, J. (1978): Analysis of damage by the rice leaf beetle, *Oulema oryzae* Kuwayama, *Jap. J. Appl. Ent. Zool.* **22**, 255-259 (In Japanese with English summary).

8) ________ (1978): Control threshold for the rice leaf beetle, *Oulema oryzae* Kuwayama (Coleoptera: Chrysomelidae) *Appl. Ent. Zool.* **13**, 203-208.

9) NAKAMURA, Y., KITAMI, T., SAKUMA, H., MARU, S. and SHIMIZU, K. (1977): Damage of rice plant caused by the rice leaf beetle, *Prof. Kanto Pl. Prot. Soc.* **24**, 102-103 (In Japanese).

10) OKAMOTO, D. and ABE, Y. (1952): Analysis of damage by the rice leaf beetle. *Chugoku-Shikoku Agricultural Research* **2**, 71-72 (In Japanese).

Discussion

Sadji, P. (Indonesia): Why are you recommending two sampling procedures?

Answer: At the time of deciding whether control measures are necessary, a convenient method should be available as early as possible (in either case there should be enough time for the necessary preparations for the control measures). However, the earlier the forecast, the lower the degree of accuracy. Therefore when the forecast is made at an early stage, thereafter convenient procedures should be available when deciding the application of the control measures.

Ishikura, H. (Japan): 1) In the case of the compensation for the injury caused by the rice leaf beetle, I suppose that the control threshold is a function of the population density of the insects as well as of the weather conditions during the period of growth of the crop. Do you consider this aspect in setting the economic threshold? Is the variation in the threshold due to the weather within the limit of the variance of the control threshold you have established? 2) You have concluded that the distribution of the egg masses in the field is random. Which method did you adopt in drawing this conclusion?

Answer: 1) As we were able to find a positive correlation between the yield and the larval density in 9 different experiments covering a 3-year period, the economic threshold was set in taking into account these changes. As the relation could be observed regardless of the changes in location, it was thought that the economic injury level was also a function of the weather conditions. 2) The results obtained fitted the Iδ index of Morishita or followed the Poisson distribution.