Economic Thresholds of the Brown Planthopper in Taiwan

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ABSTRACT

General principles and basic considerations in the determination of economic threshold (ET) are briefly discussed. Yield loss assessment of rice caused by the brown planthopper (BPH) is considered first. And the economic thresholds of the brown planthopper in terms of number of 3rd-5th instar nymphs per hill per week are calculated according to Chiang's general model. The validity of ET values is then tested in farmer's fields before transfering to extension. Sampling techniques, especially sequential decision sampling, are emphasized to enable the decision-making in a pest management program. Finally, the determination of ET for BPH and for the planthopper guild on other rice varieties is suggested for future research.

Key words: Economic threshold, brown planthopper, rice, yield loss assessment, control cost, field sampling techniques, sequential decision sampling

Introduction

The aim of a modern pest management program is to maintain or suppress pest population level below an economically and ecologically tolerable level. To achieve this aim, the development of realistic criteria to justify the control action of a pest is very crucial and essential. In this regard, a guiding principle is that a control measure is justified only when the expected incremental return would exceed the incremental costs of control (Headley, 1972). This is expressed in terms of economic threshold (ET) of a pest on a crop. And a pre-requisite to the determination of ET is a quantitative study on pest-crop interactions.

The economic threshold, however, is governed by many factors. Among them are (1) pest factors, such as species or biotypes, behavior, developmental stage, age structure, dispersion, population density, infestation period and population dynamics etc., (2) crop factors, such as variety (i.e. susceptibility to pest attack), stage (i.e. time of attack in relation to crop's tolerance and compensatory capacity), and site of attack, and (3) other factors, such as crop management practices, species competition, natural enemies and weather. In addition, economic variables such as the price of crop produce and cost of control measures ought to be considered. Furthermore, data related to pesticide usage, such as efficiency and efficacy are also important variables (Chiang,1979; Smith, 1967; Strickland & Bardner, 1967).

A simple model for calculating ET value has been formulated by Chiang (1979) as follow:

ET = (Cost of Control) ÷ (yield x % yield reduction x price of crop x efficiency of control x pest survival coefficient) x (critical factor)

This model serves as a guideline for information to be obtained. It is apparent that a change of any variable in the model will subsequently change the ET value. Thus, a practical approach to suit the circumstances of individual farmers in peasant agriculture is to

establish multiple ET values for ready reference (Farrington, 1977). Furthermore, the validity of ET thus determined should be appraised before being adopted for extension.

Population Levels of the Brown Planthopper vs. Rice Yield Loss

Rice yield loss in relation to population levels of BPH has been studied in Taiwan by caging and artificial infestation at various stages of rice plant with a fixed infestation period (Chen & Cheng, 1978; Cheng, 1979) and by chemical treatment (Cheng, 1979). Results showed that responses of rice plants to BPH infestation differed at different stages. The booting stage was the most sensitive stage, followed by the milking, the maximum tillering and the soft dough stage. The yield loss threshold level was 2-3 BPH/hill during reproductive and ripening stage and 4 at maximum tillering stage. Yield loss was proportional to BPH population levels (Fig. 1).

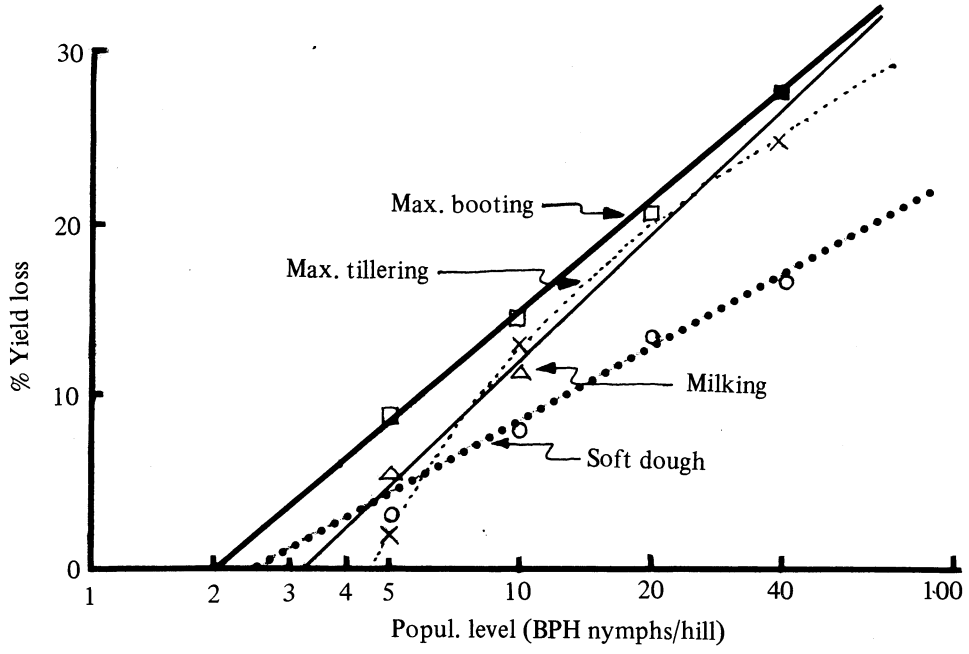

Fig. 1. Population levels of the brown planthopper vs. rice yield loss (Chen, 1981).

With these basic field data and other figures needed for calculation (Chen, 1981), the ET values could be calculated according to Chiang's general model (Chiang, 1979).

Determination of the Economic Thresholds for the Brown Planthopper

The economic thresholds of BPH in terms of number of 3rd-5th instar nymphs per hill per week are shown in Table 1.

It is noted that when the cost of control as well as price of rice change ET values should change accordingly. In general, the higher the control cost is the higher the ET, whereas the higher the rice price the lower the ET.

Appraisal of Validity of Economic Threadholds

The validity of ET values has been tested in farmer's fields at different areas. Chemical

Table 1. Economic Thresholds of the Brown Planthopper in Taiwan (Chen and Li, 1982)

Cost of Control (x 1000 NT$/ha)	Price of Rice (N.T.$/kg)									
	12		14		16		18		20	
	A	B*	A	B	A	B	A	B	A	B
3	3.2	4.4	2.8	4.0	2.7	3.8	2.6	3.6	2.4	3.4
4	4.0	5.2	3.6	4.8	3.2	4.4	3.0	4.2	2.8	4.0
5	4.8	6.8	4.0	5.6	3.6	5.2	3.2	4.8	3.0	4.4
6	6.0	8.0	4.8	7.2	4.4	6.4	4.0	5.2	3.6	5.0
7	8.0	9.2	6.0	8.0	4.8	7.2	4.6	6.4	4.0	6.0

* A and B refer to ET values before heading and after heading stage, respectively.

control guided by these ET's indeed yielded maximum profit. When ET was implemented along with regular crop surveillance by the extension workers in a pilot program of supervised pest control conducted during 1976 to 1979, about one chemical application could be saved in each cropping season. The farmers supervised by field scouts gained a net profit from 13 to 18% over those working alone (Chen, 1981).

Field Sampling Techniques

In order to know if field BPH population reached ET level to justify a control action, simple random sampling by taking 30 to 50 hills and counting the insects *in situ* has been recommended. And the sampling should be conducted from 40 through 80 days after transplanting at weekly intervals.

The application of ET, however, is most efficient when a sequential decision sampling plan is developed. This is illustrated in Fig. 2. Decision of the necessity of control is reached as soon as the cumulative total of BPH falls in either "control advisable" zone or "control unwarranted" zone. And the sampling could stop immediately (Chen, 1981).

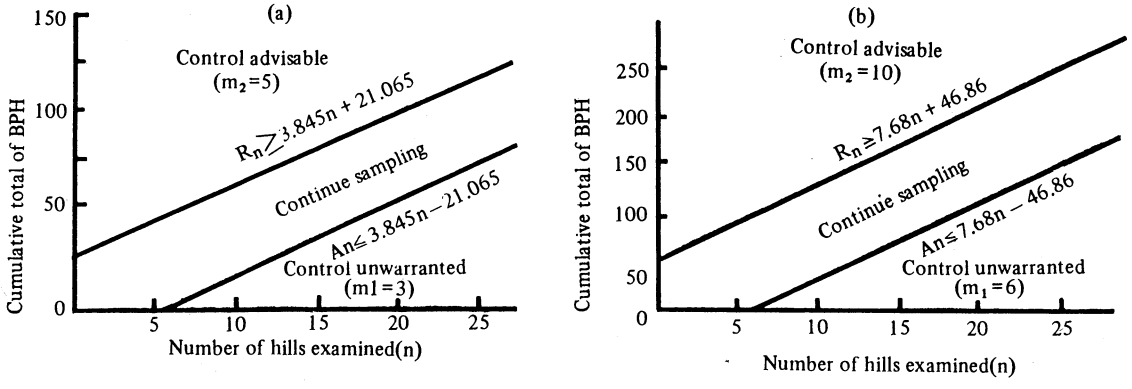

Fig. 2. A sequential decision graph for sampling the brown planthopper in Taiwan. (Chen, 1981). (a) to be used before heading; (b) to be used after heading.

Concluding Remarks

The determination of the economic thresholds for a pest on a crop is a rather complicated problem. It is a study of interactions among the pest, the crop, and control measure in time and space with special consideration to the farmer's profit. Despite many factors having been considered, the ET so far determined for the brown planthopper in Taiwan is still a preliminary one. Yet, it has been proved useful in guiding pest management decisions. And what we need urgently for the near future are: (1) determination of ET for BPH on other rice varieties, especially Tainung No. 67, which is currently the most popular one; (2) determination of ET for the planthopper guild, i.e. the brown, the small brown, and the white back planthopper altogether.

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