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Efficiency of Sticky Boards for Population Estimation of the Brown Planthopper, *Nilaparvata lugens* (STÅL) (Hemiptera : Delphasidae) on Rice Hills

Toru NAGATA and Takeo MASUDA

Kyushu National Agricultural Experiment Station, M. A. F.
Chikugo, Fukuoka Pref. 833, Japan

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A simple sampling method using a sticky board of 18×25 cm for estimating the population of brown planthopper nymphs on rice hills was developed and the efficiency of this method was studied.

When a rice hill was struck by hand three times successively, about 90% of the total catch was caught by the initial two beatings. Approximately 40% of the total nymphs which fell around the rice hill were caught by a sticky board in the standard position. A significant correlation was obtained between the catch on the sticky board and the total number of fallen nymphs. Highly significant correlation coefficients were also obtained between the partial counts in the medial 1/2～1/4 area of a sticky board and the whole board counts, suggesting that the partial count can be substituted for the whole board count.

INTRODUCTION

Population surveys of the brown planthopper in rice paddies have been made by various sampling techniques, such as beating, sweep-net and portable suction sampler. However, none of these methods is adapted for quick and accurate sampling of a large population of hopper nymphs including newly hatched nymphs in the latter part of the season when the population often attains a level of 1,000 nymphs per hill or more.

The beating method has been most extensively used. Nymphs fallen on the water surface are counted in this technique, but it is time-consuming and usable only when the plants are young or a few hoppers infest a hill, and it is almost impossible to estimate the number of minute first instar nymphs.

It was reported in an earlier paper that a sticky board was suitable for sampling hopper nymphs, especially when nymphs were young and their numbers were large (NAGATA and FUKUDA, 1968). This technique was recommended for obtaining the relative density of nymphs in pesticide tests.

In the present work, a quantitative study was conducted to confirm the efficiency of sticky boards.

MATERIALS AND METHODS

This study was conducted in the rice fields of our experiment station in September 1976. Rice hills with a small or large populations of mostly newly emerged nymphs were selected at the heading stage of the rice plant. The surrounding hills of the sam-

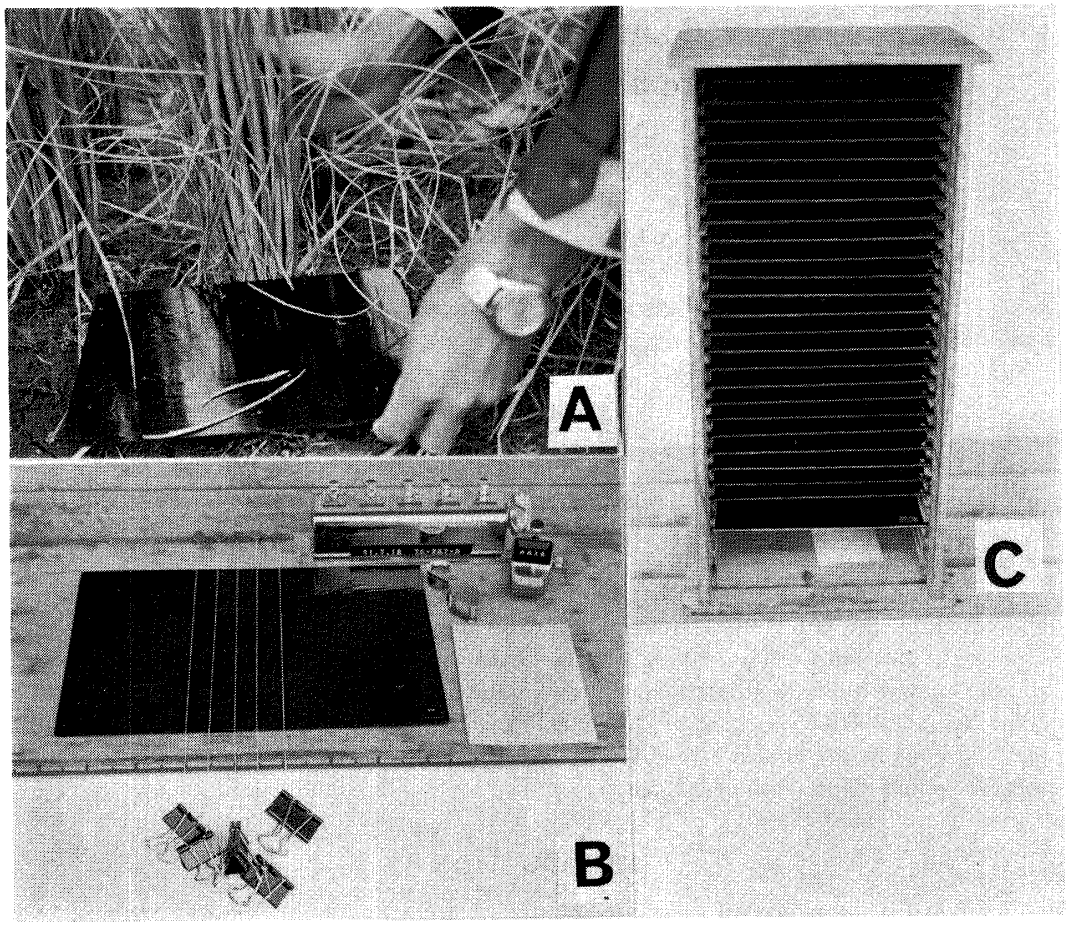

Fig. 1. A. Beating rice hill to sample the nymphs of the brown planthopper. B. Marking off a sheet of sticky board into small sub-squares with strings weighted to make counting easier. C. A wooden container with shelves inside used to maintain and carry sticky boards.

pling hill were removed while taking care not to disturb the nymphs on the sampling hill. Occurrence of the brown planthopper in this year was of a degree such that a slight "hopper burn" was observed at the end of October.

A board of black coloured plywood, 18×25 cm, was coated with an adhesive, Fujitangle® (Fuji yakuhin Co. Ltd). The board was held horizontally to one side of the rice hill at ca. 2 cm above the paddy water, and the hill was beaten by hand to dislodge the nymphs (Fig. 1, A). The boards carrying the samples were taken back to the laboratory where the hoppers were sorted and counted using a 25-power magnifying glass. The boards were cleaned of the adhesive after counting to be used again.

RESULTS

The number of beatings Table 1 shows the percentages of nymphs obtained byeach beating when one hill was beaten three times successively. An average 76.4% of the total catch was obtained by the first beating, and 91.1% of the total catch was obtained by the first two beatings. It was observed that a negligible number of nymphs was left on the hill.

Table 1. Relation between Number of Beatings and the Number of Nymphs Captured on each Beating[a]

Number of beatings	Percentage of nymphs caught on each beating					Coefficient of variance (%)
	1[b]	2	3	4	Avg. of 4 hills	
1st beating	69.0 (196)[c]	83.2 (243)	75.9 (302)	77.3 (447)	76.4±5.8[d]	7.6
2nd beating	16.9 (48)	10.6 (31)	16.1 (64)	15.2 (88)	14.7±2.8	19.2
3rd beating	14.1 (40)	6.2 (18)	8.0 (32)	7.5 (43)	9.0±3.5	39.3
Total	100.0 (284)	100.0 (292)	100.0 (398)	100.0 (578)		

[a] Beating : 3 times.
[b] Replications.
[c] Figures in parentheses indicate the number of nymphs.
[d] Mean percentage±standard deviation.

These results indicate that two successive beatings are sufficient for collecting most of the nymphs from a rice hill.

Direction of dispersal by beating impact

At beating impact, nymphs on a hill disperse in various directions and some of them escape capture by the sticky board. The proportion of nymphs which escaped in the opposite direction of beating was compared with those captured by the sticky board held in the standard position (Fig. 2).

The average number of nymphs caught by board A was 69% of the total nymphs collected with two boards; the remaining 31% was caught by board B which was placed in the opposite direction of beating. These percentages remained fairly constant (Table 2).

Table 3 represents the distribution of nymphs which fell on five sticky boards arranged around a rice hill as shown in Fig. 3 so that all the nymphs on a rice hill can be recovered, and the portion of fallen nymphs on each board was determined. The hill was beaten twice. The board in the standard position (C) placed just beside the rice hill in the direction of impact caught an average of 41% of the total catch with the least coefficient of variance (C.V. 16.2%), followed by board D which collected 24.3% of the total catch. The catch by board C correlated significantly with the total number

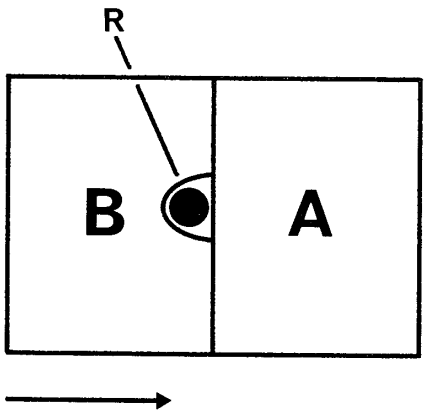

Fig. 2. Layout of two sticky boards to determine the direction of dispersal of nymphs at beating. R, rice hill. Arrow indicates the direction of impact.

Table 2. DIRECTION OF FALL OF THE NYMPHS FROM THE BEATEN HILLS[a]

Position of boards		Percentage of nymphs						Coefficient of variance (%)
		1[b]	2	3	4	5	Avg. of 5 hills	
(Board A)	In the direction of beating	66.5[c] (169)	68.9 (282)	67.9 (561)	67.8 (687)	72.8 (776)	68.8±2.4[d]	3.5
(Board B)	Opposite to the direction of beating	33.5 (85)	31.1 (127)	32.1 (265)	32.2 (327)	27.2 (290)	31.2±2.4	7.9
	Total	100.0 (254)	100.0 (409)	100.0 (826)	100.0 (1014)	100.0 (1066)		—

[a] Beating : 2 times.
[b] Replications.
[c] Figures in parentheses indicate the number of nymphs.
[d] Mean percentage±standard deviation.

Table 3. DISTRIBUTION OF THE FALLEN NYMPHS ON STICKY BOARDS PLACED AROUND A SAMPLING HILL[a]

Position of boards	Percentage of nymphs caught on each board									Coefficient of variance (%)
	1[b]	2	3	4	5	6	7	8	Avg. of 8 hills	
A	4.7	5.2	14.2	12.0	14.8	7.4	12.6	13.7	10.6±4.2[c]	39.2
B	17.8	12.7	25.8	18.8	22.0	17.5	16.6	21.5	19.1±4.0	20.9
C	49.4	34.8	42.6	36.9	31.2	49.5	38.5	40.8	40.5±6.6	16.2
D	20.0	42.7	9.7	27.0	28.1	21.5	26.0	19.5	24.3±9.5	38.9
E	8.1	4.6	7.7	5.3	3.9	4.1	6.3	4.5	5.2±1.3	25.2
Total	100.0[d] (360)	100.0 (379)	100.0 (713)	100.0 (962)	100.0 (1066)	100.0 (1238)	100.0 (1648)	100.0 (2311)		

[a] Beating : 2 times.
[b] Replications.
[c] Mean percentage±standard deviation.
[d] Figures in parentheses indicate total number of nymphs caught with 5 sticky boards.

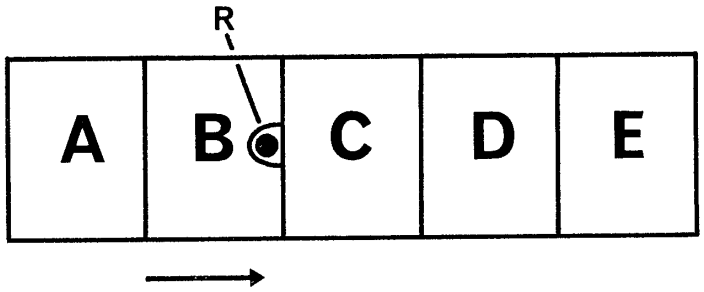

Fig. 3. Layout of five boards around a rice hill to determine dispersal of fallen nymphs. R, rice hill. Arrow indicates the direction of beating.

of nymphs captured by five sticky boards at the 1% level of error (r-0.975**). If the rice plants were young or small in size, much greater efficiency would be obtained due to reduced dispersion of the fallen nymphs.

Partial counts

As the hopper population increases, the number of nymphs captured from a rice

hill by a sticky board often reaches 1,000.

In this case, the board was marked off into small sub-squares of 3×18 cm along the short length of the board with fine strings with a weight on each end as shown in Fig. 1, B, and Fig. 4. The number of nymphs in the middle two or four sub-squares was counted to save time. However, the nymphs caught on the board were not distributed uniformly over the board. They were distributed densely in the middle part of the board, decreasing toward the edge. The pattern of distribution of 12 samples with different populations are shown in Table 4.

When the counts on the central four squares were used, they represented ca. 70%

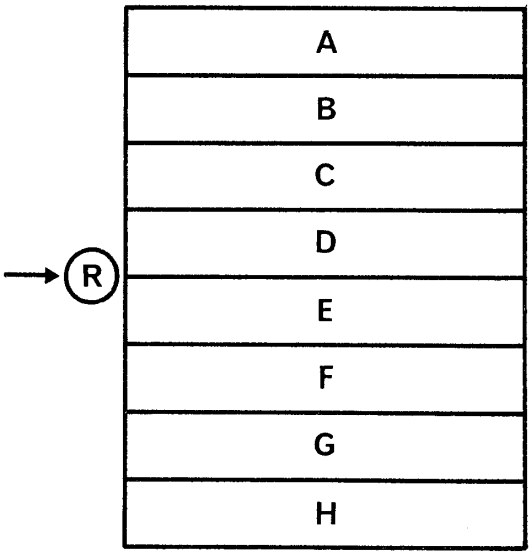

Fig. 4. Division of a board into eight sub-squares to count the number of nymphs. R, rice hill. Arrow indicates the direction of beating.

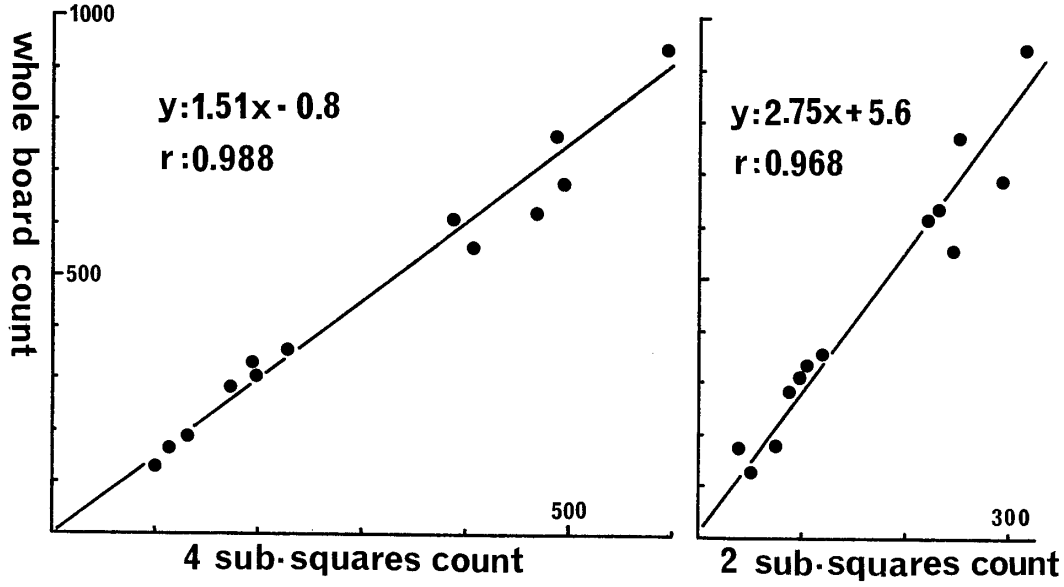

Fig. 5. Regression equations between the partial counts and the whole board counts.

Table 4. DISTRIBUTION OF Nymphs on SUB-SQUARES OF A STICKY BOARD SHOWN BY PERCENTAGES OF NYMPHS CAUGHT ON EACH SUB-SQUARE[a]

Sub-square	High density hills								Coefficient of variance (%)
	1[b]	2	3	4	5	6		Avg. of 6 hills	
A	4.3	10.9	6.3	4.8	2.4	7.7		6.1±3.0[c]	49.1
B	8.0	17.3	11.8	9.0	6.2	8.7		10.2±3.9	38.7
C	14.4	20.2	24.9	16.0	7.9	11.3		15.8±6.1	38.7
D	20.9	20.4	20.0	21.0	15.2	15.4	67.5 / 37.3	18.8±2.8	14.6
E	22.1	15.0	16.9	22.0	16.9	17.8		18.5±2.9	15.9
F	14.4	7.3	11.4	12.7	22.4	17.9		14.4±5.3	36.7
G	10.9	5.4	4.9	8.0	15.9	14.1		9.9±4.6	46.1
H	5.0	3.5	3.8	6.5	13.1	7.1		6.5±3.6	54.6
Total	100.0[d] (561)	100.0 (613)	100.0 (634)	100.0 (687)	100.0 (776)	100.0 (944)			

Sub-square	Low density hills								Coefficient of variance (%)
	1[b]	2	3	4	5	6		Avg. of 6 hills	
A	3.6	3.4	11.0	3.3	4.2	7.6		5.5±3.1[c]	56.9
B	20.1	9.6	12.1	3.9	13.8	13.8		12.2±5.4	43.8
C	29.6	10.1	18.4	7.9	17.1	13.1		16.1±7.8	48.3
D	12.4	27.0	15.6	10.9	15.0	19.4	65.3 / 33.4	16.7±5.8	34.8
E	13.0	18.5	15.6	21.7	16.8	14.6		16.7±3.1	18.4
F	14.2	17.4	11.7	24.7	10.2	16.3		15.8±5.2	32.7
G	7.1	9.0	8.9	17.4	12.0	10.7		10.3±3.6	34.9
H	0	5.0	6.7	10.2	10.9	4.5		6.2±4.0	65.3
Total	100.0[d] (169)	100.0 (178)	100.0 (282)	100.0 (304)	100.0 (333)	100.0 (355)			

[a] Beating : 2 times.
[b] Replications.
[c] Mean percentage±standard deviation.
[d] Figures in parentheses indicate total number of nymphs caught on a board.

of the total number of nymphs on a board, and those in the central two squares comprised 30～40%. These percentages remained considerably constant regardless of the population density on rice hills as shown in Table 4.

A high correlation was obtained between the counts of the central two or four squares and those on the whole board (Fig. 5). The correlation coefficients obtained were 0.97 and 0.99 for the two and four square counts, respectively.

DISCUSSION

Population sampling using sticky materials was originally developed for studies of aphids because it was most relevant to recording the number of flying aphids when used as sticky traps.

A stationary type of sticky trap based on this principle was applied to studies of inter-field migration of the rice leafhoppers and rice planthoppers (KITAKATA and SUENAGA, 1958). However, it was not suitable for sampling hoppers resting on a plant.

In the present experiments concerning the efficiency of sticky boards, this method

proved to be reliable as a relative sampling technique. But there remain some other factors to be considered when it is used as a tool for estimation of the actual population on rice hills.

If the object is to estimate the efficiency of the catch by sticky boards directly, the most appropriate procedure is comparison of the correlations between the catch on the boards and the total number of nymphs present on a hill.

For complete determination of the actual number of nymphs on a hill, various methods such as the nylon gauze cage proposed by KISIMOTO (1965) are available. However, both sampling methods cannot be applied on a sampling hill simultaneously. We adopted an alternate method to give an approximate estimate of the total population on a hill and the percentage catch by a board among the total number of nymphs fallen around a hill was determined.

The absolute population of nymphs on a sampling hill can be estimated from the catch on a board by the following equation.

$$N=\frac{N_0}{\left(\frac{R_1}{100}\right)\times\left(\frac{R_2}{100}\right)}$$

where:

N_0 the number of nymphs caught on a board by a specified number of beating.

R_1 percentage of nymphs caught on a board in the standard position by the same number of beatings among the total nymphs captured when beatings were repeated until no more nymphs fell.

R_2 percentages of nymphs caught on a board in the standard position among the total fallen nymphs.

The respective values obtained in our data were, R_1: 91.1, R_2: 40.5, (beating: 2 times). Hence, the efficiency of the catch ($R_1 \cdot R_2$) was calculated as ca. 37%.

To obtain a better estimate of the total population, the coefficients, R_1 and R_2, should be determined at various stages of nymphs or rice plants.

Another advantage of this method is that much less labour is needed than with conventional techniques. A longer time had to be spent in the fields to count the number of scarcely recognizable nymphs by the usual beating method or visual observation, but the present method takes less than 10 minutes even for non-specialists to sample 100 hills. Furthermore, sticky boards are inexpensive, easy to prepare and handle, and specimens remain in good condition for at least a week because the nymphs cannot escape from the adhesive.

In ordinary insecticide screening tests, the authors beat 10 hills successively along rows of rice plants with a sheet of sticky board giving two beatings to each hill. The accumulated number of nymphs captured on the board was counted. More than two boards for one plot have to be used to minimize sampling errors because a patchy distribution of the brown planthopper in the fields is common. Care should be taken not to choose the hills already sampled.

As the catching efficiency decreases considerably when the surface of the boards is wet as a result of dew or rain, it is recommended to avoid sampling in the morning or in rainy days.

This method is also readily applicable to other species of rice planthoppers, the white-backed planthopper or the green rice leafhopper with a slight modification of the beating position.

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