

Spatial Distribution Pattern of Cotton Leafhopper, *Amrasca biguttula* (Ishida) (Homoptera: Cicadellidae)

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ABSTRACT

The spatial distribution pattern of cotton leafhopper, *Amrasca biguttula* (Ishida) was studied under field conditions during 2000 and 2001 at Suwan Farm, Pak Chong, Nakon Ratchasima, Northeastern Thailand. The cotton varieties/lines: Sri Samrong 60 (the recommended variety), Sarid1 and new mutant lines AP1 and AP2 were used in the experiments employing Randomized Complete Block design with 4 replications. The results of both seasons showed that the distribution of *A. biguttula* was clumped for all varieties/lines and degree of aggregation considerably changed during the generations, as indicated by the values of variance to mean ratio (s^2/\bar{x}), negative binomial parameter (k) and the index of aggregation ($I\delta$). The results of distribution analysis were used to estimate a given sample size and precision level of cotton leafhopper. The appropriate sample size of maximum 10 and 30 plants could be required at low and high aggregation levels of *A. biguttula*, respectively.

Key words: cotton leafhopper, *Amrasca biguttula*, distribution

INTRODUCTION

Information on distribution pattern of insect pests was used in data analysis to determine appropriate sampling plan and sample size, and constructed sequential sampling programs. Insect populations were mostly aggregated; some were found to be either random or uniform dispersions (Southwood, 1978; Mabbett, 1980; Taylor 1984; Davis, 1994). It was found that cotton arthropods generally exhibited a clumped pattern of dispersion, which was often characterized by fit to the negative binomial distribution (Wilson *et al.*, 1989). Several methods have been used to describe the distribution of insect counts. Kapatos *et al.* (1997) reported that the Variance mean ratio (s^2/\bar{x}) and the Morisita's

Index ($I\delta$) were found best to describe for classifying spatial distribution pattern during the generations compared with the Taylor relationship. The negative binomial parameter k was described as a degree of clumping and low values of k indicated a higher degree of clumping (Southwood, 1978; Davis, 1994).

The cotton leafhopper, *Amrasca biguttula* (Ishida) (Homoptera: Cicadellidae) is one of the most alarming key pests of cotton in Thailand. The nymphs and adults suck the sap from leaves and cause phytotoxic symptoms known as hopperburn which results in complete desiccation of plants. *A. biguttula* is an early phase pest of cotton. Recently, it occurs throughout the cotton growing season and has become one of the limiting factors in economic

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productivity of the crop. As most cotton growers depend on chemical insecticides for controlling leafhopper, the necessity for more accurate population assessments of this pest become more acute.

Previous studies mentioned that the distribution of *A. biguttula* showed aggregation and could be adequately described by the negative binomial distribution (Mabbett, 1979; Mabbett and Nachapong, 1980; Wilson and Room, 1983; Mabbett *et al.*, 1984; Matthews 1989, 1994). These findings agreed by Evans (1965) who investigated the distribution of leafhopper in Sudan. Mabbett *et al.* (1984) suggested that sequential sampling could be used based on binomial sampling theory. Sample units would be restricted to the infestation sites and treatment decision would be made on the proportion of sample units rather than on actual pest counts. The cost of monitoring can also be reduced by sampling units where the pest is most frequently found (Wilson, *et al.*, 1982).

Many variables, such as soil moisture, fertility, natural enemies, physiological time, weather, and others, can affect the numbers of pests and their distribution patterns (Pedigo *et al.*, 1986; Davis, 1994). Therefore, it is still needed to evaluate the distribution pattern of cotton leafhopper for specific area, different seasons and different cotton varieties to make a correct decision of cotton pest management. The present study was designated to determine the distribution pattern of cotton leafhopper nymphs in the field leading to the development of optimum sampling plan.

MATERIALS AND METHODS

Field experiments were conducted at Suwan Farm, Pak Chong, Nakon Ratchasima Province for two growing seasons, the first crop (1 October 2000 to 15 March 2001) and the second crop (21 July 2001 to 27 Dec 2001). The soil texture was clay and pH was 7-7.5. In both years, cotton varieties: Sri Samrong 60 (SR60), Sarid1 (SD1) and new mutant

lines AP1 and AP2 obtained from gamma-irradiated SD1 were planted as treatments. Agricultural practices adopted in this experiment were treated as required. Each variety/line was grown in 7 rows, each row of 20-meter long. Spacing of row \times plant was 1.0 \times 1.0 meters. Plots and blocks were separated by 2 m each of unplanted areas. The total experimental area was 2,924 m². Randomized Complete Block (RCB) design was employed with 4 replications. At planting time, 38 kg/ha Furadan 3% G and 0.06 kg/ha Imidacloprid 70% WS were applied in the first and second crops, respectively. 50 ml per 20 litres (l) of water Carbosulfan 20% EC and 40 ml/20 l of water Omethoate 50% SL were applied 5,6,7,8 weeks after sowing (WAS), alternately for first crop and 40 ml per 20 l of water Azodrin 60% WSC applied once 4 WAS for second crop, to control severe attack of leafhopper.

Observations were made 5 WAS and continued at weekly intervals till cotton was 3 months old. Visual counts of leafhopper nymphs were only emphasised on 5 leaves/plant (one from the top, two each from the middle and bottom of the canopy) (Evans, 1965; Mabbett, 1980). Stratified random sampling technique was designated on 10 plants to give a total of 160 sample plants. Mean number of leafhopper per leaf was then calculated. Outer rows from every plot were not selected for sampling. Inspections of leafhoppers per plant were fitted to distributions which would be expected if leafhopper nymphs randomly spreaded (poisson distribution) or aggregated (negative binomial distribution).

The distribution pattern of cotton leafhopper was statistically classified by calculating the Variance mean ratio (s^2/\bar{x}) and Morisita's Index ($I\delta$), the mean (\bar{x}), sample variance (s^2) and size of the sampling unit (n) (Morisita, 1962; Southwood, 1978; Davis, 1994). The negative binomial parameter k (a measure of dispersion) was calculated as degree of clumping for each sampling date after classifying the data into frequency distribution. It is inversely related to the degree of aggregation,

whereas the opposite holds for I δ (Southwood, 1978).

The number of samples (n) necessary to estimate the mean with fixed precision was determined as suggested by Southwood (1978). When the confidence limits were used as the predetermined standard, the required half-width was usually set at 10%, then adjusted sample unit (n') was calculated. The calculations were based on the 4 varieties/lines altogether with 7 sampling dates (5 WAS – 11 WAS).

In the first crop, the total rainfall for the planting period (October 2000 to March 2001) was recorded as 397.3 mm and no rain was recorded in December 2000. In the second crop, the total rainfall for planting period (July 2001 to December 2001) was recorded as 489.7 mm and no rain was recorded

in December. In the first crop, the minimum and maximum temperatures were 21.08°C and 30.28°C, respectively while in the second crop, they were 21.73°C and 31°C, respectively.

RESULTS AND DISCUSSIONS

Spatial distribution pattern of cotton leafhopper was investigated in the field to provide the informations necessary for development of appropriate sampling plan and optimum sample size for cotton pest management. Table 1 and 2 present the distribution indices ; Variance mean ratio, Morisita's Index and the negative binomial parameter *k* of each variety/line of the two growing seasons. It was found that both [(s²/ \bar{x}) and (I δ)] showed significantly greater than 1.0 for all cotton

Table 1 Evaluation of spatial distribution pattern of *Amrasca biguttula* (Ishida) nymphs for four cotton varieties/lines at weekly intervals (5 WAS - 11 WAS) during the first crop at Suwan Farm.

Variety /line	Variance mean ratio (S ² / \bar{x})	t-value ^{1/}	Distribution pattern	Morisita's Index (Id)	F ₀ ^{1/}	k-value	Distribution pattern
AP1	8.05	13.58	clumped	1.73	8.05	1.35	clumped
AP2	5.32	10.28	“	1.46	5.32	2.15	“
SD1	8.19	13.57	“	1.73	8.19	1.36	“
SR60	6.79	11.13	“	1.52	6.79	1.90	“

^{1/} significant at p = 0.01

WAS = Weeks After Sowing

Table 2 Evaluation of spatial distribution pattern of *Amrasca biguttula* (Ishida) nymphs for four cotton varieties/lines at weekly intervals (5 WAS- 11 WAS) during the second crop at Suwan Farm.

Variety /line	Variance mean ratio (S ² / \bar{x})	t-value ^{1/}	Distribution pattern	Morisita's Index (Id)	F ₀ ^{1/}	k-value	Distribution pattern
AP1	8.24	22.63	clumped	5.21	8.24	0.24	clumped
AP2	14.74	20.82	“	4.34	14.74	0.29	“
SD1	10.00	20.45	“	4.32	10.00	0.30	“
SR60	16.23	19.05	“	3.75	16.23	0.36	“

^{1/} significant at p=0.01

WAS = Weeks After Sowing

varieties/lines during the investigation period indicating clumped distribution. Further, the results were confirmed by t-value and F_0 value ($P = 0.01$) (Table 1 and 2). The studies clearly showed clumped distribution pattern of leafhopper in the field. It could be assumed that cotton variety/line and growing season did not affect the distribution pattern of leafhopper. It also indicated that cotton arthropods generally exhibited a clumped pattern of dispersion, which was often characterized by fit to the negative binomial distribution (Wilson *et al.*, 1989). The similar findings agreed with Evans (1965) and Mabbett *et al.* (1984) who reported the distribution of leafhopper on cotton in Sudan and Thailand showing aggregation and could be adequately described by the negative binomial distribution.

The general evaluations of spatial distribution of leafhopper for both crops were described in Table 3. In both seasons, s^2/\bar{x} and Id showed significantly greater than 1.0 indicating clumped distribution. The results were also confirmed by t-value and F_0 . Comparing the k values of each variety/line in both seasons, it was obvious that populations were highly aggregated ($k=0.27$) in the second crop with the k value of 1.62 in the first crop (Table 3). Higher temperature possibly caused the result in greater aggregation of insects in the second crop. It was also possible due to the fact that different management practices applied throughout the cropping season such as frequency of insecticide applications in the first

crop were much more than those of the second crop in controlling early infestation of leafhopper apart from soil fertility, application of nitrogen fertilizer and weather (Pedigo *et al.*, 1986; Davis, 1994).

The values of Id for the first crop were found to clearly indicate a considerably low in the amount of aggregation of the insects during early growing stages (5 -7 WAS) of cotton (Figure 1) owing to the applications of insecticide in such periods. It was noticed that the values fluctuated up to 11 WAS except AP1 whose peak (2.00) was at 10 WAS (Figure 1), whereas the reverse was observed for k (Figure 2). The high levels of k value of all varieties/lines were recorded at early growing stages (5 - 6 WAS) and decreased 7-8 WAS except SD1 (7 WAS), then fluctuating continued until 10 WAS. Quite a number of natural enemies was found which might result in low aggregation of the leafhopper. Thereafter, the k value of each one sharply increased again at late growing stage (11 WAS). The results showed 2 distinct peaks of aggregation, one 8 WAS (early December) and the other 10 WAS (late December) (Figure 2) which might be caused by the appearance of the leafhopper's next generation. The populations seemed to be most aggregated when population densities were very low. Therefore, it could be concluded that the degree of aggregation changed considerably during a generation.

The trends of Id value of each variety/line were observed to be inconsistently fluctuated in the second crop (Figure 3). The initial indices were low

Table 3 Overall spatial distribution pattern of *Amrasca biguttula* (Ishida) nymphs for four cotton varieties/lines in the first and the second crops at Suwan Farm.

Crop	Variance mean ratio (S^2/\bar{x})	t-value \perp	Distribution pattern	Morisita's Index (Id)	F_0 \perp	k-value	Distribution pattern
First	7.12	24.48	clumped	1.61	7.12	1.62	clumped
Second	14.13	31.26	"	4.74	14.13	0.27	"

\perp significant at $p=0.01$

WAS = Weeks After Sowing

5 WAS and increased 6 WAS and then decreased and increased again. The highest index (10.38) was recorded in AP1 11 WAS. The indices of $I\delta$ of the four varieties/lines in the second crop were higher than those in the first crop ca. three times. The reversed results were also observed for k values (Figure 4). The initial values were high 5 WAS and decreased 6 WAS and then sharply increased and decreased again. The populations were found to be highly aggregated 6 (early September), 9 (early October) and 11 WAS (late October), except SD1 (Figure 4).

Comparing those patterns, the difference was noticed between the two growing seasons. Southwood (1978) reported that k value could be influenced by predation, size of sampling units, and weather. According to Evans (1965), as the insects developed, nymphs migrated from plant to plant and the aggregation could be reduced. However, that differed from the results of the second crop since there was aggregation peak 11 WAS. It was recorded in Sudan that the distribution changed when the production of new leaves ceased resulting in an obvious decrease in the number of the first -

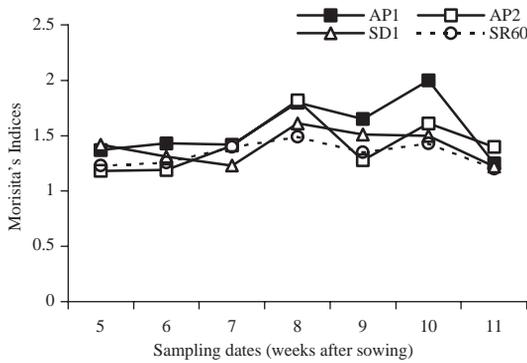


Figure 1 The Morisita's Indices ($I\delta$) of aggregation of *Amrasca biguttula* on four cotton varieties/lines at each sampling date in the first crop.

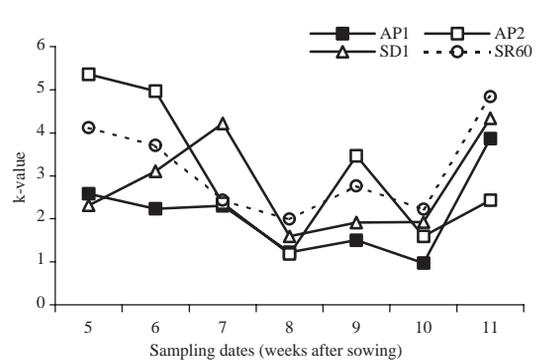


Figure 2 The negative binomial parameters (k) of four cotton varieties/lines at each sampling date in the first crop.

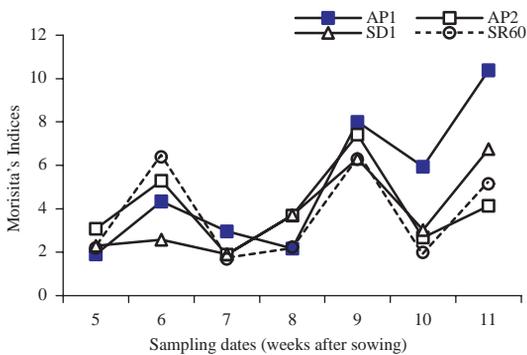


Figure 3 The Morisita's Indices ($I\delta$) of aggregation of *Amrasca biguttula* on four cotton varieties/lines at each sampling date in the the second crop.

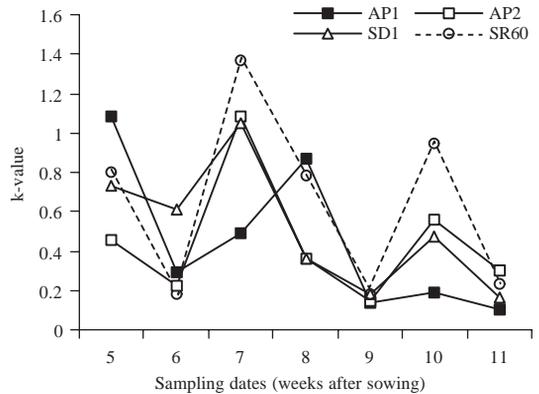


Figure 4 The negative binomial parameters (k) of four cotton varieties/lines at each sampling date in the second crop.

instar nymphs (Evans, 1963).

In accordance with the results, stratified random sampling technique and visual count sampling method could be appropriate for leafhopper scouting procedure. In addition, the sampling time and labor costs would be saved because only clumped distribution pattern was observed throughout the investigation period (5-11 WAS) of both crops. The optimum sample size, a maximum of 10 plants ($p=0.05$) could induce low aggregation (k value higher than 1.0) of leafhopper. However, maximum of 30 plants ($p = 0.05$) should be monitored at high aggregation (k value lower than 1.0) level. The results confirm previous finding in showing that the clumped behavior of an insect affects the number of samples required to estimate the population density with a given level of reliability (Wilson and Room, 1983; Wilson, 1994). The population density can be monitored during the season and treatments can be delayed until the economic threshold is reached.

CONCLUSION

The distribution of cotton leafhopper expressed as clumped throughout the investigation period for both seasons. The changes of spatial pattern were described satisfactorily by the dispersion indices k and $I\delta$. The populations seemed most aggregated when population densities were very low. As the clumping behavior of *A. biguttula* affected the number of samples, therefore, it was reasonable to suggest that the optimum sample size of maximum 10 plants could be required at low aggregation and a considerably larger sample was required maximum 30 plants at high aggregation level of cotton leafhopper. It is possible that sampling frequency could be reduced to save time consuming and labor costs. Recommended sampling technique and appropriate sampling method are stratified random sampling and visual count of cotton leafhopper .

ACKNOWLEDGEMENT

We are thankful to Mr. Somchai Piyapuntawanon, at Suwan Farm, for his assistance in conducting field works. This study was financially supported by SEAMEO SEARCA.

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Received date : 7/01/02

Accepted date : 4/03/02