JARQ 26, 130-138 (1992)

Causes of the Seasonal Changes in Population Density of Soybean Pod Borers in Java, Indonesia

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Abstract
Six monitoring fields were selected in the northern part of West Java, Indonesia to identify the factors which influenced the seasonal fluctuations of population densities of soybean pod borers, Etiella zinckenella (Treitschke) and E. hobsoni (Butler). Data of patrol surveys in Central Java were used for comparative analyses on the data obtained from field census in West Java. In the northern part of West Java, the Etiella population density was high in the dry season, while in Central Java, in the wet season. The Etiella population density tended to become high in both areas, in case where large fields were planted with soybean and/or mung bean. The difference in the Etiella population densities between the two seasons could possibly be caused by the variations in the quantity of the host plant mass in the area in each season. The size of area which could be covered by one monitoring field to predict the Etiella occurrence was estimated at approximately 14,000 ha.

Discipline: Insect pest
Additional key words: Etiella hobsoni (Butler), Etiella zinckenella (Treitschke), infested area, mung bean

Introduction

In Indonesia, the following five species of pod borers are found: *Etiella zinckenella, E. hobsoni, E. chrysoporella, E. griseadrososcia* and *E. behrii*. Among them, only *E. zinckenella* and *E. hobsoni* are found to infest soybean in Indonesia[8] and listed as major pests of soybean in its producing centers[1,2,6,7,11-13]. *E. zinckenella* is widely distributed throughout the tropical and temperate zones, while *E. hobsoni* inhabits specific areas extending from Southeast Asia to Australia[6].

Regarding the seasonal changes in the population density of *E. zinckenella* and *E. hobsoni* in Indonesia, it is reported that there is a great difference between the dry and wet seasons[3,5]. The present study attempts to identify the major factors which cause the seasonal fluctuations of population densities of *E. zinckenella* and *E. hobsoni* taking place in Central and West Java, Indonesia.

Methods

1) Study area

The field surveys were carried out in six fixed

The present paper is prepared on the basis of the results of the cooperative study implemented by the Directorate of Food Crop Protection, Ministry of Agriculture, Indonesia, and the Japan International Cooperation Agency, Japan, under the Indonesia-Japan Joint Program on Food Crop Protection (ATA-162), during the period 1980 to 1992.
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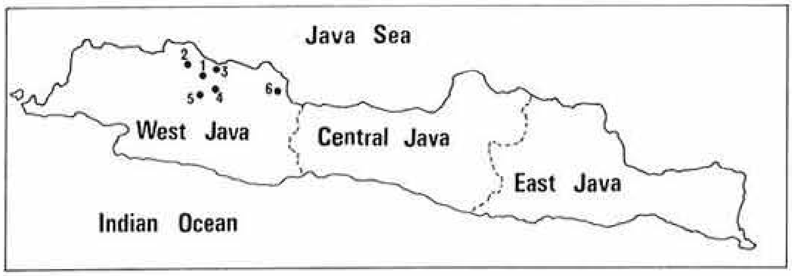

Fig. 1. Locations of the experimental fields
1: Jatisari, Karawang 2: Lemahabang, Karawang
3: Ciasem, Subang 4: Kalijati, Subang
5: Campaka, Purwakarta 6: Plumbon, Cirebon

Table 1. Altitude of each experimental field, area of the subdistrict where each experimental field is located, and the dates of beginning and end of sowing

Name of subdistrict (Kecamatan)	Altitude (m)	Area (ha)	Sowing	
			Beginning	End
Jatisari (JTS)	30	13,404	5 Jul 1988	8 May 1991
Lemahabang (LMB)	15	4,671	5 Jul 1988	8 May 1991
Ciasem (SHS)	7	10,237*	5 Jul 1988	8 May 1991
Kalijati (KLJ)	105	20,894	5 Jul 1988	6 Jan 1991
Campaka (CPK)	74	16,856	5 Jul 1988	6 Mar 1991
Plumbon (PLM)	18	3,585	5 Jul 1988	6 Mar 1991

* The area where patrol surveys were conducted.

plots in the province of West Java during the period July 1988 to July 1991 (Fig. 1). Table 1 shows the altitude of the experimental fields, area of each subdistrict (Kecamatan) where the fixed plot was located, and dates of the beginning and the end of sowing in each experimental field. Lokon, a variety of soybean, was sown every two months in the fixed plots, each of which had an area of approximately 250–370 m^2 with 3,000–4,500 hills. The soybean plants were harvested usually in 80–90 days after sowing (hereafter, DAS). The dry season usually starts in April, ending in September, in West and Central Java.

For the purpose of comparing the results of field census between West and Central Java, pest observers' data in the Central Java Province, covering the period April 1984 to March 1988, were analyzed. There are 157 observatory units in Central Java, for which 285 officials of the central government are assigned as pest observers.

2) Census method

Routine surveys on population density were initiated in 14 DAS and continued once a week until harvest in the experimental fields in West Java. The surveys adopted a removal method for census of *Etiella* larvae, with which each hill was covered with tetron gauze and removed to the laboratory, where species names of larvae and their number in each pod were recorded for each hill. Each hill was adopted as a sampling unit. The hills for surveys were sampled systematically in each census. The experimental field was divided into six subplots, in each of which five hills were randomly sampled from July 1988 to March 1989. From May 1989, seven hills were sampled in each subplot.

Patrol surveys were also carried out once every two weeks to record the areas under soybean and mung bean cultivation in each subdistrict, where the experimental field was located. Mung bean cultivated extensively in each subdistrict was infested by *E. zinckenella* and *E. hobsoni* in the northern part of West Java. Density of the pod borer larvae, however, was much lower in mung bean than that in soybean.

In Central Java, patrol surveys were undertaken in each observatory unit by its pest observer once every two weeks. The surveys recorded the area under soybean cultivation as well as under soybean infested by pests.

Results

1) Patterns of changes in larval density of Etiella zinckenella and E. hobsoni

Fig. 2 shows an example of changes in larval density of *Etiella zinckenella* and *E. hobsoni*, both of which include all developmental stages, i.e. the first to the fifth instars. Larvae of those two species usually appeared in approximately 45–50 DAS, and the peaks of their densities were observed in approximately 60–70 DAS. The patterns of changes in larval density in soybeans were similar to each other

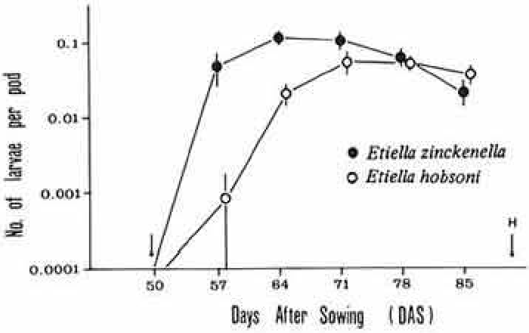

Fig. 2. Changes in number of larvae of *Etiella zinckenella* and *E. hobsoni* per pod in Ciasem in the dry season, 1991
The number of larvae included all developmental stages (the first to the fifth instar).
The sowing date was on 13 May 1991.
H: Harvesting. Arrows represent zero.

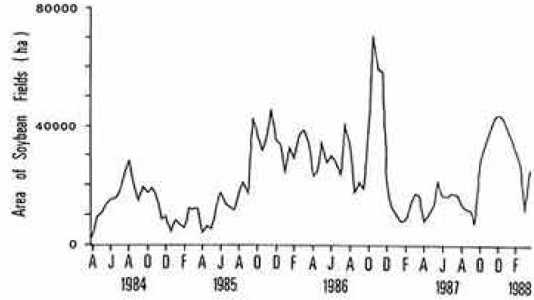

Fig. 4. Changes in area under soybean cultivation every two weeks in Central Java Province

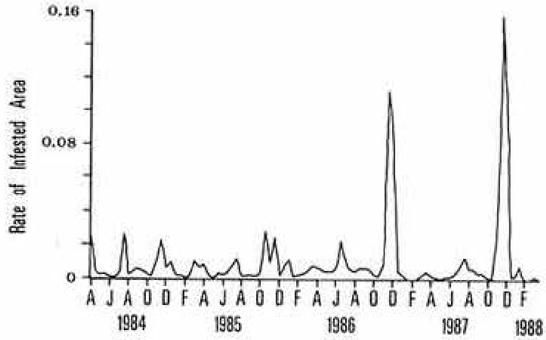

Fig. 5. Changes in rate (RI) of the area of soybean fields infested by *Etiella* larvae to the total area under soybean cultivation every two weeks in Central Java Province

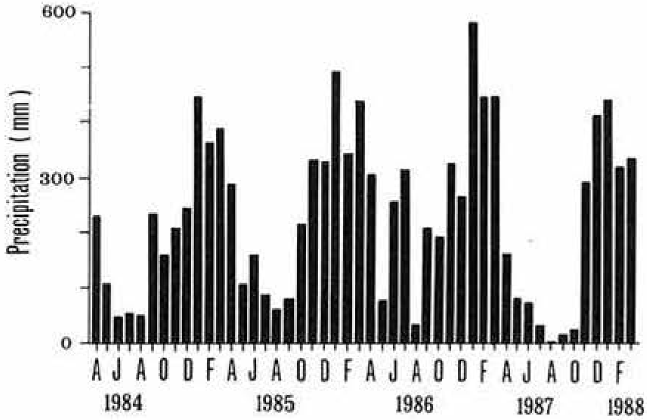

Fig. 3. Monthly precipitation in Central Java Province

in the two species.

2) Factors causing fluctuations of Etiella population density in Central Java

Figs. 3 and 4 show monthly precipitation and area under soybean cultivation, respectively, data of which were both taken every two weeks. Fig. 5 presents changes in the rates (RI) of the area of soybean fields infested by *Etiella* larvae to the total area under soybean cultivation.

The rates of infested area tended to be larger in the wet season (Oct.-Mar.) than in the dry season every year except in 1984 (Fig. 5). When the areas of soybean fields were expanded, the rates of infested area were high (Figs. 4 and 5). Fig. 6 shows that there is a significantly positive correlation between

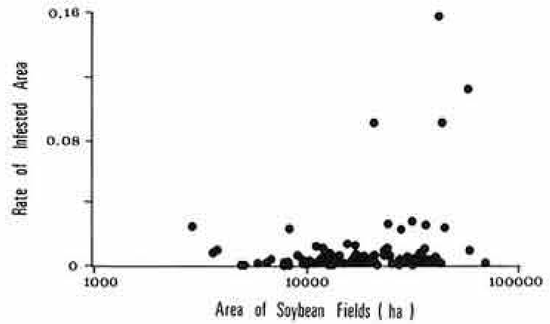

Fig. 6. Relationship between the rate of infested area (RI) and the total area under soybean cultivation $Y = 0.020 \log X - 0.074$ ($r^2 = 0.058$, $p < 0.05$)

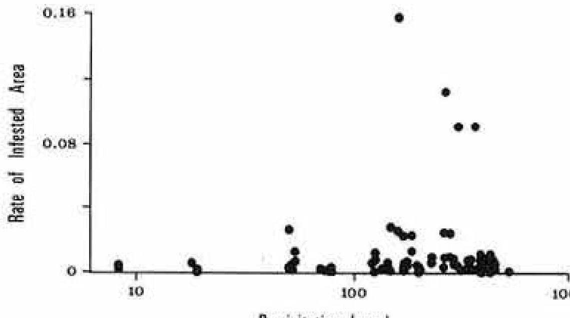

Fig. 7. Relationship between the rate of infested area (RI) and precipitation (RM)

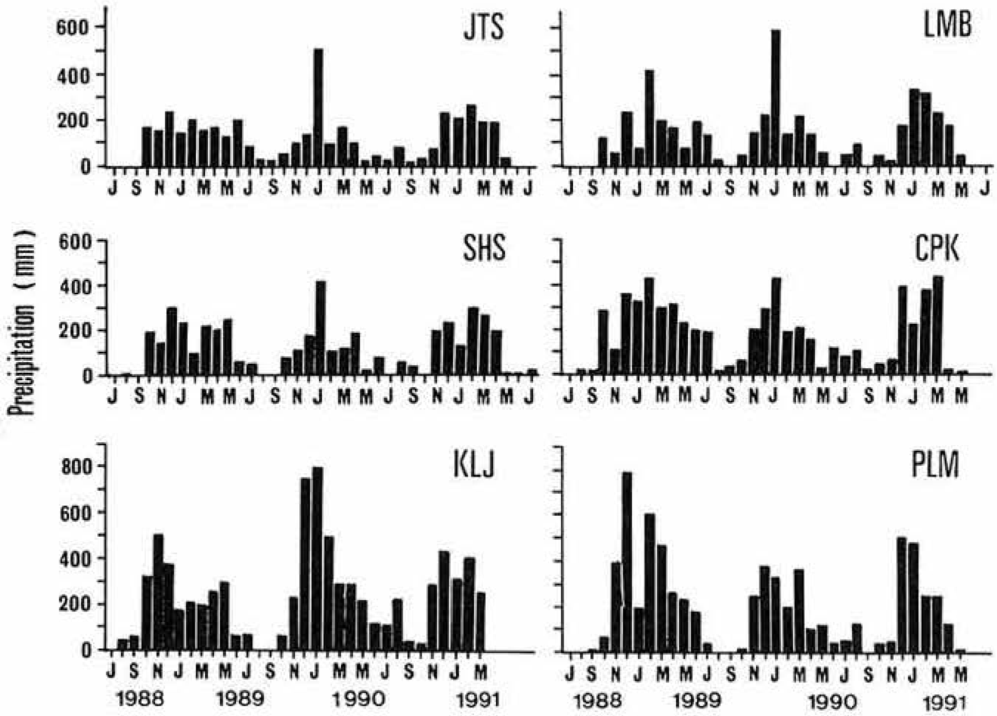

Fig. 8. Monthly precipitation in each experimental field located in northern part of West Java Abbreviations of the location names: Refer to Table 1.

the rates of infested area and the total areas of soybean fields. This means that the *Etiella* population density tends to be high when the cultivation area of the host plant is expanded.

Fig. 7 shows relationships between the rate of infested area (RI) and the rainfall (RM): RM is the average of monthly precipitation during the two successive months (*i*–*1*th to *i*th month), and RI is obtained in the *i*th month. There is no significant correlation between the two variables (Fig. 7).

3) Factors causing fluctuations of Etiella population density in West Java

The larval data (the first to fifth instars) on *Etiella zinckenella* and *E. hobsoni* were combined to analyze the factors which influence the population density fluctuations. Fig. 8 presents monthly rainfall in each experimental field. Fig. 9 shows changes in the average area under soybean and mung bean cultivation (AASM) during the three-month period, starting each month, within the respective subdistricts where the experimental fields were located. Fig. 10 presents changes in daily larval density (DLD) in each peak period of larval density in the experimental fields, where soybean was sown every two months. The value of DLD was calculated with the following equation:

$$DLD = \Sigma t_i \ (n_i + n_{i+1}) / (2\Sigma t_i),$$

where, n_i: number of larvae per pod caught on sampling day i (i = 1, 2), which consists of three consecutive points of capture including the peak of the larval density to maximize the value of total larva-days during the period, t_i: period (day) between the sampling days i and i + 1.

In all the six places, the larval populations had far greater density in the field where soybeans were sown in May, July and September, as compared with

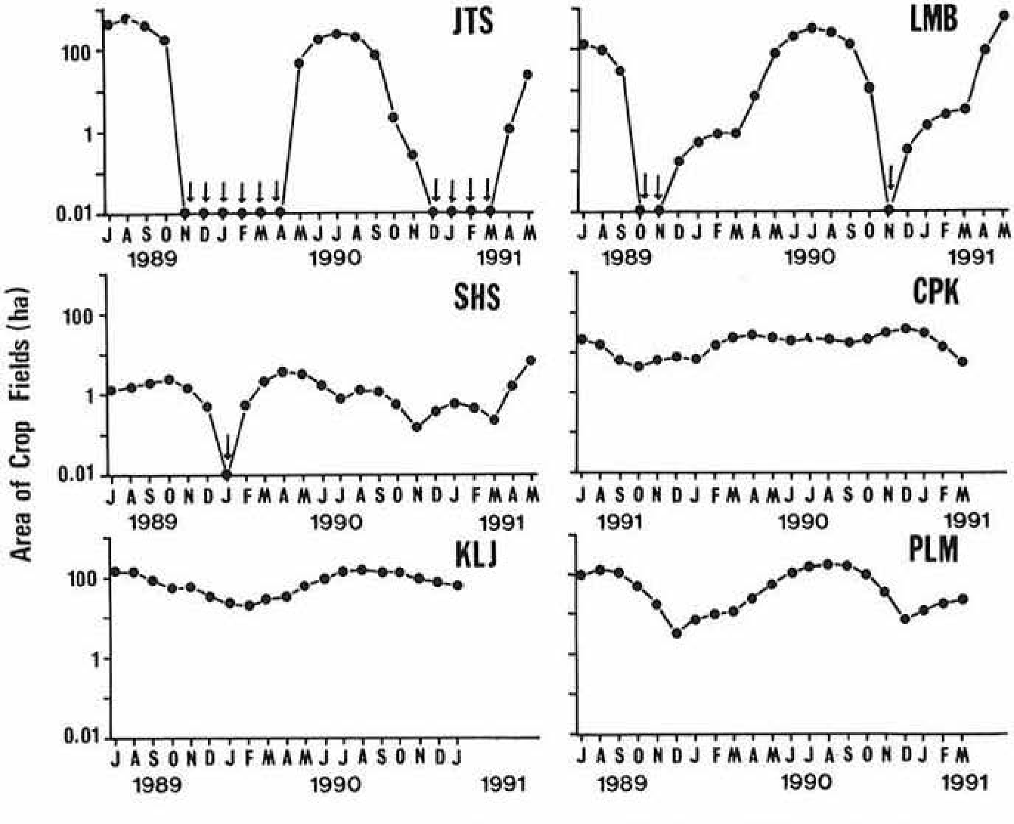

Fig. 9. Changes in areas under soybean and mung bean cultivation (AASM) in each subdistrict
Arrows represent zero.
Abbreviations of the location names: Refer to Table 1.

those in other months of sowing (Fig. 10). In other words, the population density of *Etiella* larvae was generally high in the dry season. Fig. 11 shows relationships between DLD and AASM in each sowing month. Significant positive correlations between these two variables were observed in the four locations. Fig. 12 shows relationships between the area of the subdistrict where the experimental field is located and the coefficient of determination (r^2) of the linear regression presented in Fig. 11. It seems that the r^2 tended to be low when the area of subdistrict concerned was large (Fig. 12). It suggests that it is difficult to monitor an incidence of the *Etiella* population by one monitoring field, if the area of the relevant subdistrict is too large, as in the case of Campaka and Kalijati.

Relationships between DLD and the mean of daily rainfall during the period of 30 to 90 DAS are presented in Fig. 13. Some seemingly negative correlations between these two variables were observed in the four locations. However, those negative correlations could be only superficial, because the *Etiella* population density was generally larger in the wet season than that in the dry season in Central Java (Figs. 3, 5 and 7).

Discussion

Soybean of the variety Lokon was sown in the experimental field every two months. The soybean plants reached the flowering stage in approximately 32 DAS, and the harvesting stage in 80-90 DAS. Under such a cropping pattern, even if *Etiella* larvae moved from the harvested field to the newly sown experimental field, they could not find any pods to get into, because the soybean plants were in or before the flowering stage. Naito and Harnoto[5] reported that the life cycles from egg to adult emergence of *E. zinckenella* and *E. hobsoni* were respectively completed on an average in 30.2 and 31.6 days on soybean plants, and that the pupa period of the two species was both 11.2 days. This life cycle

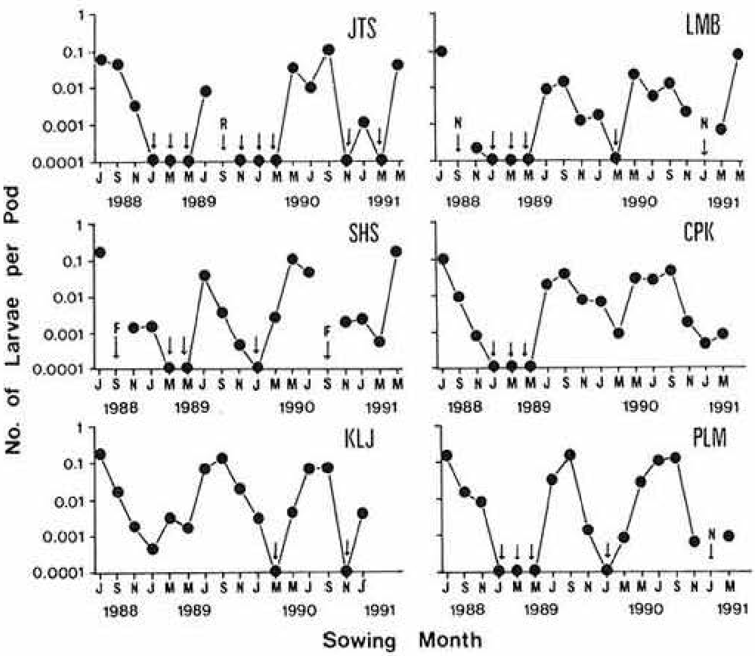

Fig. 10. Seasonal changes in daily larval density during its peak period in each experimental field
The month in the figure indicates the time when soybean was sown.
N: Not planted. R: Rats infested soybeans heavily. F: Flood.
Arrows represent zero.
Abbreviations of the location names: Refer to Table 1.

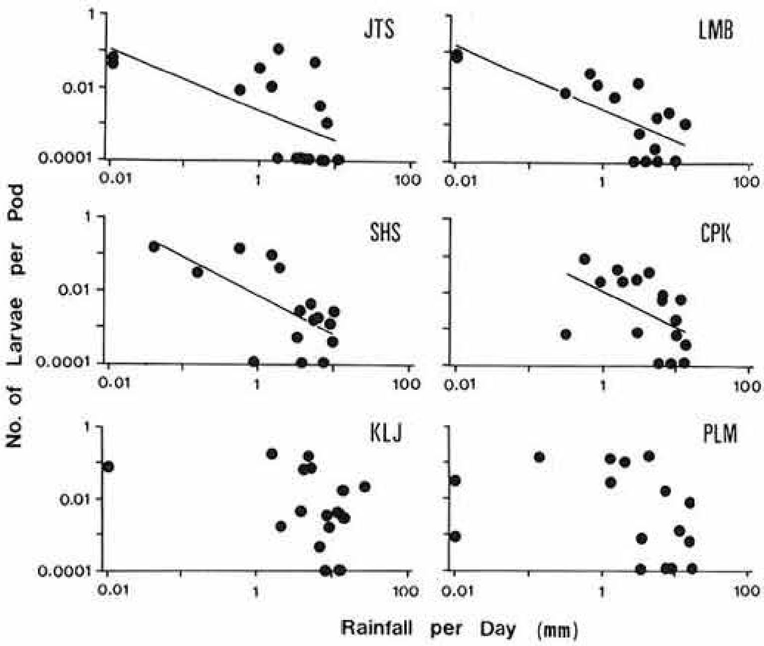

Fig. 11. Relationships between the daily larval density (DLD) and the area of soybean and mung bean fields (AASM) in each subdistrict
JTS: log Y = 0.534 log X − 2.780 (r^2 = 0.764, $p<0.01$).
LMB: log Y = 0.320 log X − 2.652 (r^2 = 0.452, $p<0.05$).
SHS: log Y = 0.982 log X − 2.176 (r^2 = 0.537, $p<0.05$).
CPK: (r^2 = 0.015, $p>0.05$). KLJ: (r^2 = 0.333, $p>0.05$).
PLM: log Y = 2.354 log X − 6.020 (r^2 = 0.900, $p<0.01$).
Abbreviations of the location names: Refer to Table 1.

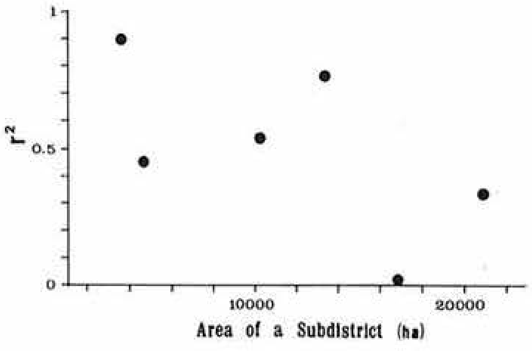

Fig. 12. Relationship between the area of the subdistrict where each experimental field is located and the coefficient of determination (r^2) of linear regression presented in Fig. 11

suggests that if the *Etiella* larvae reach the pupa stage at the harvesting time of soybean, the adults may find new pods for oviposition in the new experimental fields, because the early stage of the pod formation begins in approximately 40 DAS. Therefore, the *Etiella* population in the experimental field, where soybean seeds were sown every two months, might have been generally brought up by the individuals that pupated in the old experimental fields at the harvesting time as well as by the immigrant adults from the neighboring farmers' soybean fields.

In cases where soybean and mung bean were cultivated extensively, the *Etiella* population density tended to increase (Figs. 6 and 11). The dependence of *Etiella* population density on the size of cultivation area of host plants could be justified as follows: (1) Since the sowing time of soybean is not necessarily the same all over the farmers' fields even in the dry season, two successive soybean plantings may possibly promote the increase in *Etiella* population; and (2) The density of adults which immigrated into the fields of host plants might increase, if the host plants are cultivated extensively. Kalshoven[3]

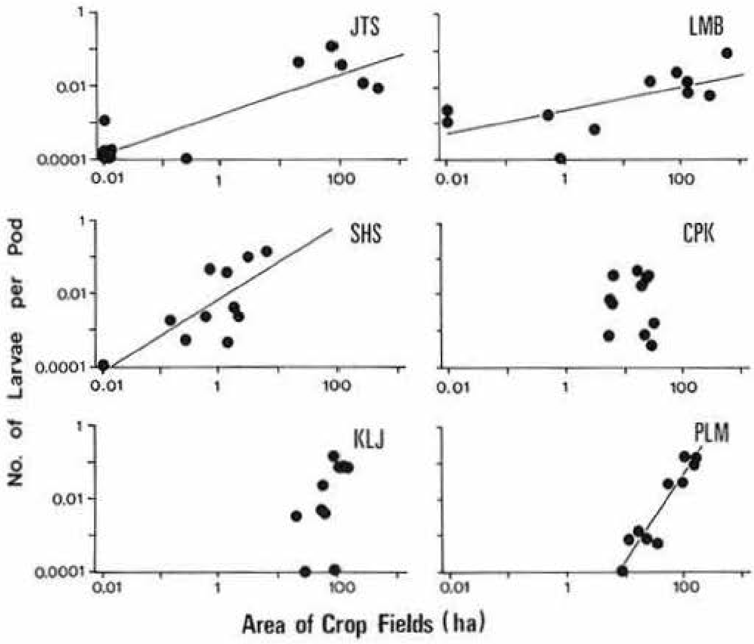

Fig. 13. Relationships between the daily larval density during its peak period and the mean of daily rainfall in the period of 30 to 90 days after sowing
JTS: log Y = −0.825 log X − 2.623 (r^2 = 0.362, $p < 0.05$).
LMB: log Y = −0.849 log X − 2.548 (r^2 = 0.594, $p < 0.05$).
SHS: log Y = −1.053 log X − 2.130 (r^2 = 0.408, $p < 0.01$).
CPK: log Y = −0.980 log X − 1.961 (r^2 = 0.244, $p < 0.05$).
KLJ: (r^2 = 0.142, $p > 0.05$). PLM: (r^2 = 0.122, $p > 0.05$).
Abbreviations of the location names: Refer to Table 1.

earlier suggested the possible incidence of the former case in *Etiella*.

The *Etiella* population density was high in the dry season in the northern part of West Java, and in the wet season in Central Java. Naito and Harnoto[5] and Kalshoven[3] reported that the *Etiella* population density was high in the dry season. According to Mangundojo[4], however, its population density was high in the wet season. Such a difference in *Etiella* population densities between the two seasons could be explained by the quantity of host plant mass in the area in each season.

Stone[10] and Singh and Dhooria[9] reported that adults of *Etiella zinckenella* were active fliers. Fig. 12 suggests the size of the area which could possibly be covered by one monitoring field to predict the occurrence of the *Etiella* incidence, indicating that one monitoring field should be set approximatly every 14,000 ha.

The authors are very grateful to Dr. S. Nasu, Team Leader of the ATA-162 Project, for his valuable advice and encouragement, Dr. M. Satta Wigenasentana, Director of Food Crop Protection for his invaluable assistance, and Dr. S. Miyai, the short-term expert of the Project, for his critical readings of the manuscript. Many thanks should also go to Miss Daniar Triwulandari, Messrs. Oya Kusmaya, Amsor, Yayan Kurniadi, Agus Supriyatna, Taufik Mustofa, Mamat, Ita and Dulhalim for their cooperation in the field work.

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(Received for publication, Dec. 24, 1991)