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Research Article

Action Thresholds of *Empoasca terminalis* (Homoptera: Cicadellidae) on Soybean in South Sulawesi, Indonesia

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Abstract

Empoasca terminalis Dist. (Homoptera: Cicadellidae) is a new but increasingly important pest of soybean in South Sulawesi province of Indonesia. Farmers are dependent mostly upon insecticide use for the control of the leafhopper. Insecticide is applied on a schedule basis, usually once in 2-3 days and not on the basis of action thresholds. Action threshold is used to prevent over-treatment and under-treatment of the intended crops. Therefore, the purpose of the current study was to determine the action thresholds of *E. terminalis* on two varieties with different levels of resistance to the insect: Mahameru (susceptible) and Gepak Kuning (resistant). Besides that, it was also sought to know the number of insecticide applications required for each action threshold on each variety. Results showed that the action thresholds of *E. terminalis* were 10 and 5 nymphs per 16 leaves for resistant and susceptible cultivars, respectively. On Mahameru and Gepak Kuning the numbers of insecticide applications necessary to maintain the action thresholds were 5-7 and 1-2 times during the season, respectively. Therefore, total number of insecticide applications based on the action thresholds can be reduced substantially in comparison with the farmers practice which is one application for every 2-3 days or up to 16 applications during the season.

Key words: Leafhopper, *Empoasca terminalis*, action thresholds, soybean

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Empoasca terminalis Dist. (Homoptera: Cicadellidae) has been reported as a pest on soybean (Parsai and Tiwari, 2002), a minor pest on sesame, groundnut (Biswas and Das, 2011) and mungbean (Chhabra *et al.*, 1981). Since it was reported for the first time causing substantial damages to soybean in 2007, *E. terminalis* has become increasingly important pest on soybean in South Sulawesi province of Indonesia. Survey conducted in 2008 showed that the insect can kill up to 24% of plant population and cause yield loss up to 70% on susceptible cultivar (Mahameru) during a dry condition and without insecticide applications (Nasruddin, 2010). The leafhopper has now spread and caused yield losses in all major soybean-growing areas in the province (Nasruddin *et al.*, 2014).

Both adults and nymphs of the leafhopper draw plant sap directly from the vascular tissues, disrupting the photosynthate movements (Nielsen *et al.*, 1990). The feeding activity causes physical injuries due to mechanical blockage by damaged cells and sheath saliva and physiological disorders due to salivary toxins produced by the insect. The crop physiological disruptions are reflected as "Hopperburn" symptoms on the leaves (Kabrick and Bacus, 1990; Nielsen *et al.*, 1990; Ecale and Backus, 1995). Reduced photosynthesis and transpiration rates can be so substantial that they result in quality deterioration, stunting of plants, loss in plant vigor, low yield and stand longevity, reduced seed number and weight and nutrient level as well (Hower and Byers, 1977; Hutchins and Pedigo, 1990).

Currently, soybean growers depend heavily upon insecticide use to control the leafhopper populations. Control decisions are mostly based on personal preference without scientific considerations. Soybean growers apply insecticide every 2-3 days to control the insect. Four insecticides recommended for leafhopper control on other crops: λ -cyhalothrin, profenofos, deltamethrin and chlorpyrifos applied at recommended rates, were effective in suppressing *E. terminalis* populations (Nasruddin, 2011). However, insecticides application decision should only be based upon action thresholds to prevent excessive or under-use of insecticides. An action threshold is a predetermined point at which the use of control measures is justified in order to avoid economic losses (Pedigo, 1996). In addition, the amount of insecticide used can be further reduced by planting resistant cultivars because resistant cultivars can tolerate higher numbers of leafhoppers than the susceptible ones, hence greater action thresholds can be applied (Kaplan *et al.*, 2008). Several commercially available cultivars are resistant to the

insect such as Gepak Kuning, Gepak Ijo, Tidar and Kaba. These cultivars suffered yield losses ranged from 2.5-6.2%, while susceptible cultivar (Mahameru) suffered yield loss of 36.2%, when no control measures were applied (Nasruddin *et al.*, 2014b). Thus the primary objectives of the current study were to determine: (1) The action thresholds of *E. terminalis* on resistant and susceptible soybean cultivars and (2) The number of insecticide applications per season needed for each action threshold on each cultivar.

MATERIALS AND METHODS

Studies were conducted in soybean growers fields in the Sub-district of Marioriwana, district of Soppeng (East coast) and in the sub-district of Simbang, district of Maros (West coast), South Sulawesi province, Indonesia. Planting date was March 1, 2015 and June 3, 2015 in the East and West coasts, respectively. Plots were 12 rows wide and 6 m long and separated from adjacent plots by 1 m bare space. Planting space used was 40 cm between rows and 20 cm between plants within a row. Treatments consisted of two cultivars: Mahameru (susceptible) and Gepak Kuning (resistant) and four action thresholds: 1, 5, 10 and 20 nymphs per middle and upper leaves were arbitrarily chosen. The treatments were arranged in a complete randomized block design with three replications of a plot each. Foliar insecticide, a deltamethrin (Decis 25 EC) used at label's recommended rate of 25 g A.I ha⁻¹, was applied using back pack sprayers with a spray volume of ca. 400 l ha⁻¹. Insecticide was applied when the number of nymphs reached the prescribed action thresholds.

During the study, pest infestation was almost exclusively *E. terminalis*, other pests such as *Spodoptera litura* and *Bemisia tabaci* were in very low and negligible populations. Thus, insecticides were applied solely for the trial treatment purposes. Treatments were evaluated by counting potato leafhopper nymphs on 16 middle and upper leaves from 16 different plants in each plot. Middle and upper leaves were sampled because more than 80% of the leafhoppers is concentrated on those parts of the plant (Nasruddin, 2010). Nymphs were sampled because they show very low inter-plot movement (Kieckhefer and Medler, 1964); while adult leafhoppers are very mobile between plots (Decker, 1959). Besides that, nymphs are much more injurious to plants, such as potatoes than are the adults (Sanford and Webb, 1977). Plots were sampled for leafhopper counts one day before the spray dates unless weather necessitated delays of the insecticide application.

Hopperburn damages were rated on twenty plants randomly selected from each plot on April 15, 2015 and July 19, 2015 in the East and West coast, respectively. The following 0-5 scale was used to assess the rate of hopperburn injury: (0) No visible symptoms, (1) Slight cupping of leaves, (2) Slight cupping of leaves with yellowing of leaf margins, (3) Many leaves cupped and yellowed, (4) Plants stunted and showing leaf scorch and (5) All leaves with severe hopperburn and plants severely stunted. The scale was adopted from the one used for scoring foliar damage caused by the potato leafhopper (*Empoasca fabae* H.) on soybean (Schrofsma *et al.*, 1998).

At the end of the season, 10 plants from each plot were sampled to determine the yield (gram per plant). The plants were harvested and then individually placed in separate plastic bags. Pods were dried under the sun for 2-3 days before the seeds were weighed to determine the yield weight (g) per plant. The dry bean (c.a. 18% water content) weight per plant was used to calculate the equivalent yield per ha.

Nymph counts, hopperburn score and yield weight were individually subjected to a one-way analysis of variance at $p = 0.05$. If a significant difference among treatments was detected, the treatment means were separated using a Tukey's HSD test ($p = 0.05$) (BioStat, 2009).

RESULTS

For both cultivars (Mahameru and Gepak Kuning), in both locations (East and West coasts), there was a general trend that as the prescribed action thresholds increased, the average number of nymphs per 16 trifoliates, hopperburn rate and percentage of yield loss also increased; while the average yield decreased (Table 1). For the susceptible cultivar (Mahameru), the average number of nymphs, hopperburn score and yield weight were not significantly different between action

thresholds of 1 and 5 nymphs per 16 trifoliates. However, when the action threshold was raised to 10 nymphs per 16 trifoliates, those variables became significantly different. However, for the resistant cultivar (Gepak Kuning), the number of nymphs for the action thresholds of 5 and 10 nymphs per 16 trifoliates were not significantly different each other but significantly different from the thresholds of 1 and 20 nymphs per 16 trifoliates. Significant differences were detected in the hopperburn score and yield weight when the action threshold was elevated to 20 nymphs per 16 trifoliates. In both cultivars, percent yield loss increased as the action threshold increased. However, for each action threshold tested, yield loss in susceptible cultivar was higher than in resistant cultivar, which were 26.4-27.8 and 6.4-7.4%, respectively.

For resistant cultivar (Gepak Kuning) and susceptible cultivar (Mahameru), 0-6 and 2-10 insecticide sprays were applied, respectively, depending on the action threshold at which treatments were prescribed (Fig. 1 and 2). For action threshold of 1 nymph per 16 trifoliates, 6 sprays and 7-10 sprays were needed on resistant and susceptible cultivars, respectively. The treatment with action threshold of 5 nymphs per 16 trifoliates was sprayed 2 times and 5-7 times for resistant and susceptible cultivars, respectively. One to 2 and 4 insecticide sprays were applied for the treatment with 10 nymphs per 16 trifoliates for the resistant and susceptible cultivars, respectively. No application was needed on resistant cultivar when the action threshold was raised to 20 nymphs per 16 trifoliates because the threshold had never been reached for the whole season in both sites, east and west coasts. However, for Mahameru, 2 sprays were necessary to maintain the nymph population below the action threshold of 20 nymphs per 16 trifoliates.

DISCUSSION

The results showed that for each action threshold tested, the average number of nymphs per 16 trifoliates and

Table 1: Number of nymphs per 16 trifoliates, hopperburn score and yield of soybean plant at four different thresholds for two cultivars in East and West coasts

Cultivars	Action threshold	East coast			West coast		
		Nymphs per 16 trifoliates	Hopperburn score (%)	Yield (t ha ⁻¹)	Nymphs per 16 trifoliates	Hopperburn score	Yield (t ha ⁻¹)
Mahameru	1	1.6 ^a	0.0 ^a	1.80 ^a	1.7 ^a	0.0 ^a	1.90 ^a
	5	3.9 ^a	1.2 ^a	1.76 ^a	4.1 ^b	1.4 ^a	1.81 ^a
	10	7.0 ^b	3.6 ^b	1.64 ^{ab}	8.2 ^c	4.1 ^b	1.56 ^b
	20	13 ^c	4.4 ^b	1.30 ^b	14.1 ^d	4.7 ^b	1.40 ^b
Gepak Kuning	1	0.8 ^a	0.0 ^a	2.65 ^a	0.7 ^a	0.0 ^a	2.71 ^a
	5	2.3 ^b	0.0 ^a	2.61 ^a	2.5 ^b	0.2 ^a	2.69 ^a
	10	3.6 ^b	0.1 ^a	2.56 ^{ab}	3.5 ^b	0.2 ^a	2.61 ^a
	20	6.1 ^c	0.4 ^b	2.48 ^b	8.1 ^c	0.5 ^b	2.51 ^a

Means within the same column with different letters differ significantly ($p < 0.05$) by a Tukey's test

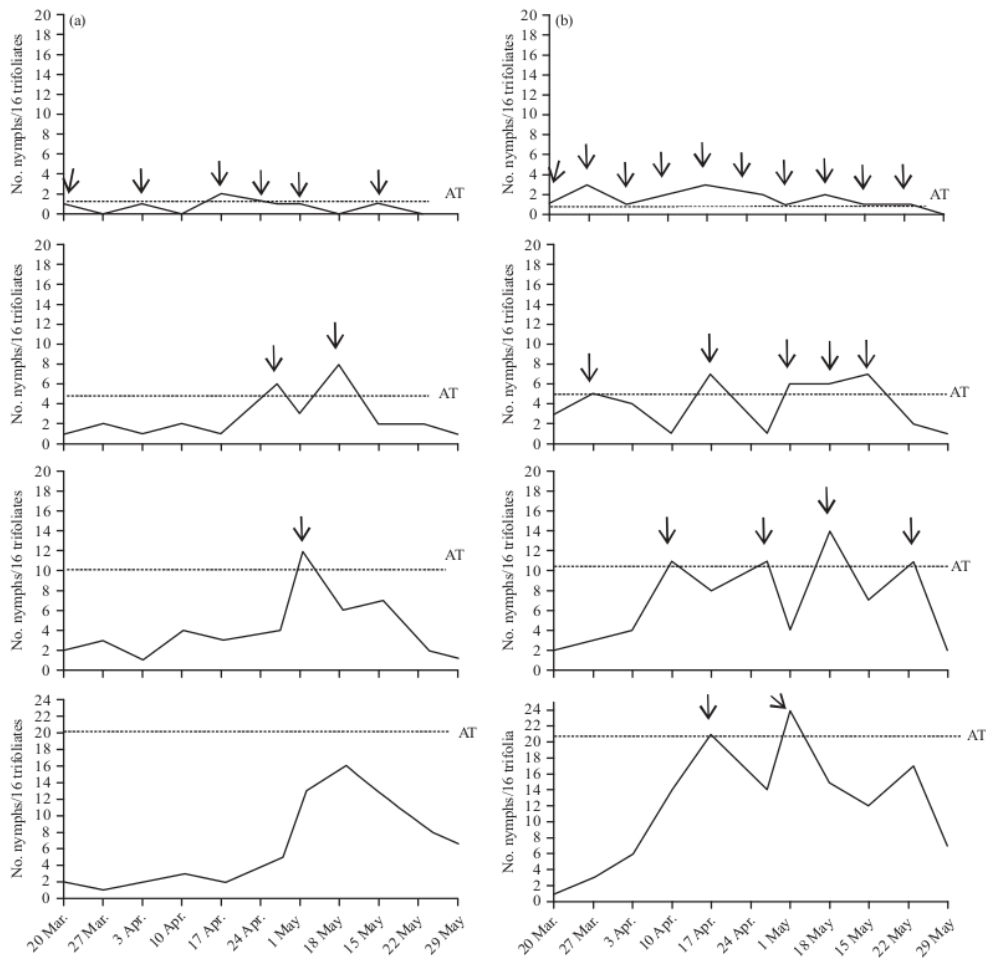


Fig. 1(a-b): Population fluctuations of *Empoasca terminalis* (west coast) on (a) Resistant soybean cultivar (Gepak Kuning) and (b) Susceptible cultivar (Mahameru). Insecticide sprays based on different Action Thresholds (AT), arrows indicate insecticide applications

hopperburn score were significantly lower on Gepak Kuning than on Mahameru. In addition, the average yield loss in resistant cultivar was lower than in susceptible cultivar, which were 6.4-7.4% and 26.4-27.8, respectively. The findings are consistent with our previous report that Mahameru and Gepak Kuning are susceptible and resistant to *E. terminalis*, respectively. Resistance in Gepak Kuning against the insect is most likely based upon antibiosis and non-preference mechanisms (Nasruddin *et al.*, 2014).

Foliar insecticide (Decis 25 EC, a deltamethrin) used at recommended rate of 25 g A.I. ha⁻¹ successfully suppressed the insect population below each action threshold after application (Fig. 1 and 2). This insecticide is one of those

chemicals that have been recommended for controlling leafhoppers in many commodities such as leafhoppers on ornamental plants (Karren and Roe, 2000), floriculture and ornamental nurseries (Bethke *et al.*, 2000) and on soybean (Nasruddin, 2011).

Our results showed that the greater the action threshold, the less number of sprays needed. This is in agreement with Cancelado and Radcliffe (1979) reporting that five sprays were applied for *Empoasca fabae* on potato when action threshold of 1 nymph per 105 leaves was prescribed. However, when the action threshold was elevated to 3-10 nymphs per 105 leaves, only one spray was necessary for the whole season.

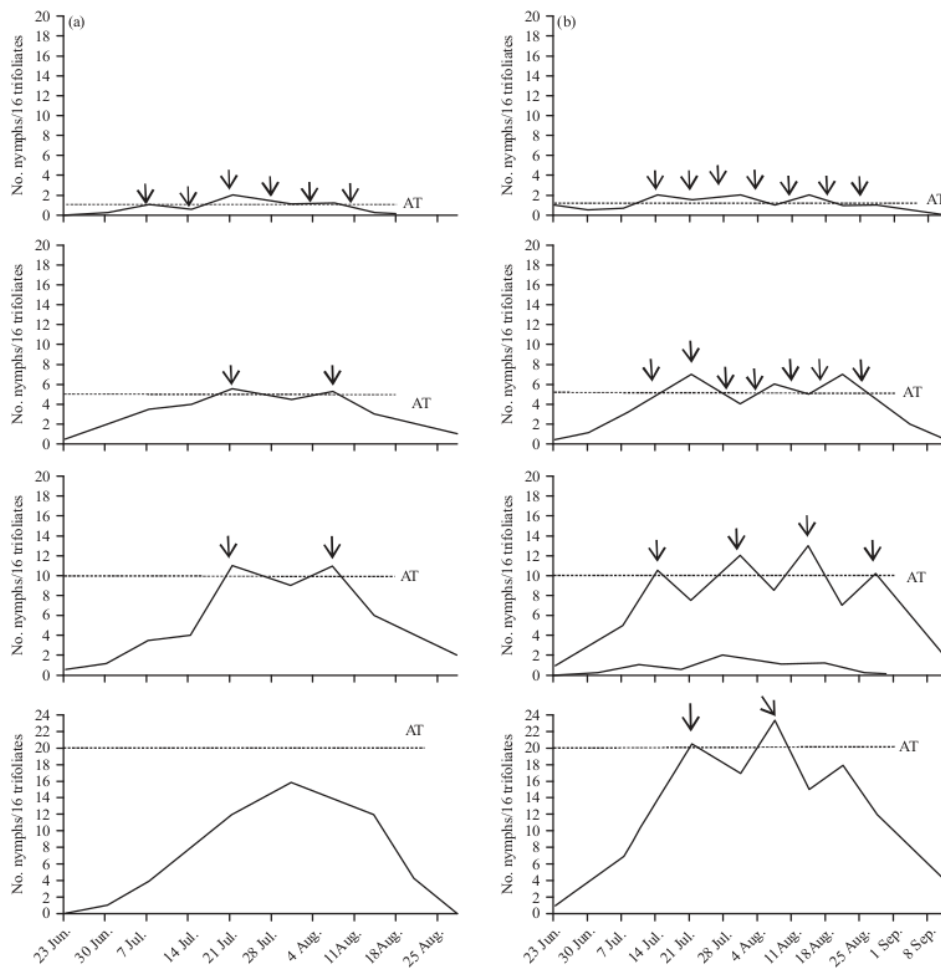


Fig.2(a-b): Population fluctuations of *Empoasca terminalis* (east coast) on (a) Resistant soybean cultivar (Gepak Kuning) and (b) Susceptible cultivar (Mahameru). Insecticide sprays based on different Action Thresholds (AT), arrows indicate insecticide applications

The results of this study suggested that 5 nymphs per 16 trifoliates is the appropriate action threshold for *E. terminalis* on susceptible soybean cultivar in South Sulawesi. This is due to a significant reduction in yield became obvious at the action threshold of 10 nymphs per 16 trifoliates. On the other hand, higher number of nymphs can be tolerated on resistant cultivar, hence 10 nymphs per 16 trifoliates can be used as action threshold because significant reduction in yield only became evident at the action threshold of 20 nymphs per 16 trifoliates. By using action thresholds of 5 and 10 nymphs per 16 trifoliates for susceptible and resistant cultivars, respectively, effective control of the insect can be achieved

with only 4 and 1-2 sprays per season for susceptible and resistant cultivars, respectively. Timing of insecticide applications is crucial and must be based on regular (weekly) scouting results and not by scheduled spray approach of 2-3 days which is commonly practiced by farmers in South Sulawesi. This confirmed that insecticide application interval of 2-3 days between applications, or up to 16 sprays during a planting season, practiced by farmers are unnecessary. Scheduled insecticide applications, in most cases, are not only economically unsound due to high application costs, but also could pose hazards to non-target organisms and the environment (Pedigo, 1996).

For susceptible cultivar, plants should be sprayed when the population is 5 nymphs per 16 trifoliate; while for resistant cultivar (Gepak Kuning), insecticide application is necessary when the population reached 10 nymphs per 16 trifoliate. These results agreed with Cancelado and Radcliffe (1979) and Kaplan *et al.* (2008), reporting that resistant potato cultivars could tolerate greater population of *E. fabae* than the susceptible ones. Besides that the number of sprays necessary for each prescribed threshold was higher on the susceptible cultivar than the resistant cultivar. The use of resistant cultivar reduced the need for insecticide applications (Ghidui *et al.*, 2011). Therefore, by using resistant cultivars, farmers can reduce the amount of chemical application costs, potential insecticide's detrimental effects on the consumer and environment and at the same time increase their profits as well.

CONCLUSION

The present study established two thresholds for the control of *E. terminalis* on soybean. Action thresholds of 5 and 10 nymphs per 16 trifoliate are suggested for the control of the insect pest on susceptible and resistant soybean cultivars, respectively. By using the thresholds, total numbers of sprays per season can be reduced to only 4 applications for susceptible cultivar and 1-2 applications for resistant cultivar. The use of the action thresholds helps growers to better time for pesticide applications and thus it prevents excessive use or under-use of insecticides from occurring. Therefore, insecticides are only used when necessary to prevent pest population from reaching economic injury level as a principal basis of integrated pest management.

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