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Economic Injury Levels of *Empoasca dolichi* Paoli on Groundnuts (*Arachis hypogaea* L.) in Zaria Area of Northern Nigeria

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ABSTRACT

Populations of *Empoasca dolichi* Paoli were studied during the rainy seasons of 2000 and 2001respectively to determine their economic injury levels (EIL) on groundnut in Zaria area, northern Nigeria. Groundnut (Variety RRB) was artificially infested with different population levels of *E. dolichi* at three different stages of plant growth. The growth stages of the plant at which infestations were made were R_1 (groundnut beginning bloom), R_4 (Full pod development) and R_7 (groundnut beginning maturity). The results showed consistent decreasing groundnut yield with increasing population of *E. dolichi*. Based on mean groundnut market values and insect control costs for 2000 and 2001, economic-injury levels determined were 1, 5 and 10 leafhoppers/plant for groundnut growth stages R_1, R_4 and R_7 respectively.

INTRODUCTION

Empoasca dolichi Paoli have been variously rated among the most important pests of groundnut and several other crops in different parts of the world (Paoli, 1936; Caswell, 1962; Metcalf, 1968; Park, 1979; Amin and Mohammed, 1980; Lynch *et al.*, 1985; Sithanantham *et al.*, 1994). McDonald and Raheja (1980) reported that *E. dolichi* is an important pest of groundnut in northern Nigeria. The economic significance of injury caused by species of *Empoasca* on groundnut is not known in Nigeria. The high population of these leafhoppers encountered on groundnuts has sometimes led to arbitrary control measures. The effect of such a concern on groundnut growers is the tendency to apply insecticides every time they feel threatened by an insect, even though economic loss might not have resulted.

This tendency can lead to an abuse of insecticides, which may have adverse economic and ecological consequences. Finding the economic injury level (EIL), the lowest population density that will cause economic damage (Stern, 1973), is therefore helpful in the selection and use of an appropriate insecticide at the correct time, with least disruption of the ecosystem.

The present study was carried out to determine the economic injury levels of *E. dolichi* on groundnuts in Zaria area of northern Nigeria.

MATERIALS AND METHODS

Colony Establishment

A culture of *Empoasca* species was established by collecting adult leafhoppers from groundnut plants in the field, using insect suction sampler and caging those specifically identified on healthy groundnut plants at R_1 stage (groundnut beginning bloom) in wooden cages. Each cage consisted of a wooden frame measuring 50 x 60 x 50 cm covered with screen mesh (0.1 cm diameter). The base was made of solid wood plank. Two seeds of RRB groundnut variety were planted in each pot measuring (18.5 cm diameter) which was kept in the cage. Empoasca sp. adults consisting of both male and female were transferred into the potted plants. These leafhoppers colonies were maintained in the screen house of IAR Samaru, Zaria and used for studies on the economic-injury levels of the leafhopper on groundnut.

Damage Potential Test

Preliminary studies were made in the screen house with groundnut variety RRB, to determine damage characteristics of a high-intensity of leafhopper populations and also to determine the estimates of the numbers of leafhoppers to be used for the field tests on the different growth stages. For stage R_1 infestation, 10 pots of soil were placed in 10 empty colony cages and planted with RRB groundnut variety, 5 seeds were sown in each pot. When the plants reached stage R_1, infestations of 4, 6, 8 and 10 leafhoppers per plant were made, with two cages per treatment. It was determined arbitrarily that leafhopper density at which 50% or more of the leaves in test cages showed hopper burn symptoms by the 10^{th} day would be a medium infestation (l_2). Following this, it was designated that the low infestation (l_1) would be half of l_2 and that the high infestation (l_3) would be 1.5 times l_2.

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Damage Density Relationship Tests

Preliminary investigations indicated that an intense leafhopper population was capable of causing noticeable damage on groundnut plants. Experiments were conducted to establish damage density relationships. This information subsequently could be used in calculating EIL. Tests were conducted in the rainy seasons of 2000 and 2001 at the Institute for Agricultural Research, Ahmadu Bello University Farm, Samaru, Zaria. Plot areas were fertilized according to soil test recommendations prior to planting with single super phosphate at the recommended rate of 300 kg/ha before ridging. Groundnut variety RRB was sown on 75 cm ridges. Each plot consisted of a single ridge measuring 1 m x 0.75 m and carried 5 stands of groundnut plant. Metal frames (1 m long, 0.75 m wide and 1.2 m high), covered with netting material were placed over the plots shortly after emergence. These cages were firmly secured to the ground to prevent leafhopper escape. Cages were placed approximately 3 m apart, and intervening plants were removed to avoid competition and to permit uniform lighting. The plots were infested with leafhoppers at three groundnut growth stages, i.e. R_1 (groundnuts beginning bloom), R_4 (full pod development) and R_7 (groundnut beginning maturity). Treatments included three infestation levels and an uninfested check replicated three times in a randomized block design. The infestation levels per plant were as follows: growth stage R_1 – 0, 5, 10 and 15; stage R_4 – 0, 30, 60 and 90 and stage R_7 – 0, 50, 100 and 150. The infestation dates for stages 1, 4 and 7 are shown in Table 1. Fourteen days after planting, the plants were sprayed with 30 g a.i./ha of Benlate and 125 g a.i./ha of Dithane M45 for the control of leaf spot diseases of groundnuts before caging. Adult *Empoasca dolichi* from colony cages maintained in the screen house were transferred to the field cages by means of a mouth aspirator. The cages were placed over the plots at planting and removed at harvest. The plants were harvested on October 18th, 2000, and October 24th, 2001 respectively. Caged plots were harvested by hand and threshed in the field. Weights were taken after all samples had dried in the laboratory for several days. Data from the tests were subjected to a regression analysis with the objectives of determining (1) the dependence of yield on leafhopper density, (2) the degree of yield leafhopper dependence and (3) the accuracy with which yield can be predicted from leafhopper numbers.

RESULTS

Damage Potential of *E. dolichi*

The damage potential test showed that *E. dolichi* is capable of causing noticeable damage on groundnut. It was observed that on the tenth day after infestation that about 50% of the leaves in the cages with 10 leafhoppers per plant showed symptoms of hopper burn (Fig. 1). Consequently, 10 leafhoppers per plant was the medium infestation (l_2) for stage R_1 to be tested on the field. As a result, the

low infestation (l_1) was 5 leafhoppers per plant and the high infestation (l_3) was 15 leafhoppers per plant. The screen house test procedure was basically the same for the 3 stages considered, except that higher leafhopper numbers per plant were tested at more advanced stages.

Fig. 1. Groundnut plant showing symptoms of the damage caused by *Empoasca dolichi*.

Economic Injury Levels

During 2000 and 2001, yields of groundnut plants infested at stages R_1, R_4, and R_7 with various densities of *E. dolichi* showed a consistent decreasing trend with increases in leafhopper numbers (Table 2). The regression of yield on leafhopper numbers was negative and linear. Tests showed that the quadratic element cx_2 of the regression equation $Y = a + bx + cx_2$ was insignificant. This indicated that the appropriate regression model for the yield–leafhopper relationship was $Y = a + bx$, where Y = the expected yield, a = the Y intercept, a constant representing the average yield of uninfested plots, b = the slope of the regression line, and x represents the number of leafhoppers present per plant. There were linear and highly significant correlations between the mean kernel yield and the *Empoasca* damage at the different growth stages of the plant. Thus at the different growth stages, increasing numbers of *E. dolichi* per plant resulted in decreasing kernel yields. For the stage R_1 infestation, $Y = 896 - 35.7x$. For the stage R_4 infestation $Y = 917 - 5.64x$. The regression of yield on leafhopper numbers showed trends similar to those of the R_7 infestation. The regression of yield was highly significant ($P=0.001$). The stage R_7 infestation ($Y = 902 - 2.56x$) led to observations similar in pattern to those of the previous stages. The regression of yields on leafhopper numbers was highly

significant (P=0.001) but the differences caused by the leafhopper numbers were not as high as those of the previous stages. The regression lines derived from the experiments are shown in Figs 2 – 4. The slope, b_1 tends to be steeper with younger plants than with the older ones (35.7x for the stage R_1 infestation, 5.64 x for the stage R_4 infestation and 2.56x for the stage R_7 infestation).

Table 1. Infestation of caged groundnut with *Empoasca dolichi.*

Groundnut growth stages	Date of infestation	Infestation levels			
		I_0	I_1	I_2	I_3
1	July 7th, 2000	0	5	10	15
4	August 9th, 2000	0	30	60	90
7	August 31st, 2000	0	50	100	150
1	July 3rd, 2001	0	5	10	15
4	August 4th, 2001	0	30	60	90
7	August 27th, 2001	0	50	100	150

Table 2. Kernel yield of groundnut infested at growth stages R_1, R_4 and R_7 by *E. dolichi.*

Treatment levels	Number of leafhopper per plant			Kernel yield (kg/ha)		
	R_1	R_4	R_7	R_1	R_4	R_7
T_1	0	0	0	903.33a*	916.41a*	917.31a*
T_2	5	30	50	702.59b	755.37b	755.87b
T_3	10	60	100	545.57c	566.58c	640.02c
T_4	15	90	150	360.56d	415.19d	531.72d
Mean				628.01	663.39	711.23
MSE				±35.93	±16.32	±30.66
CV (%)				5.72	2.46	4.31
SE				±14.67	± 6.66	± 2.52

*Treatments followed by the same letter were not significantly different at P>0.001.

Calculation of economic injury levels (EIL)

A. Cost of control with Cypermethrin (Sherpa plus) at 1 litre/ha = ₦800
For spraying twice = ₦800 x 2
= ₦1600
Application cost of 4-labourers/2 applications/ha at ₦100/labour
= ₦100 x 4
= ₦400
= ₦1600 + 400
= ₦2,000.00

Price of groundnut (₦/kg)

In 2000, the market price of groundnut was ₦120 per tiya (a tiya is a local measure which weighs 2.5 kg). In 2001, the market price was ₦180.00 per tiya. A grand mean of ₦150.00 per tiya was obtained for these years. Therefore the market price of groundnut per kg = ₦150 divide by 2.5 = ₦60. The amount of yield loss that constitutes economic damage is referred to as 'gain threshold' (Stone and Pedigo, 1972). The following formula is used to calculate gain threshold:

$$\text{Gain threshold kg/ha} = \frac{\text{Cost of pest control } ₦/\text{ha}}{\text{Market price of crop } ₦/\text{kg}}$$

In this particular case, the gain threshold

$$= \frac{₦2000}{\text{ha}} \div \frac{₦60.00}{\text{kg}} = \frac{₦2000}{\text{ha}} \times \frac{\text{kg}}{60}$$

$$= \frac{₦2000}{\text{ha}} \times \frac{\text{kg}}{₦60}$$

$$= \frac{33.33}{\text{ha}} \times \text{kg}$$

$$= 33.3 \text{ kg/ha.}$$

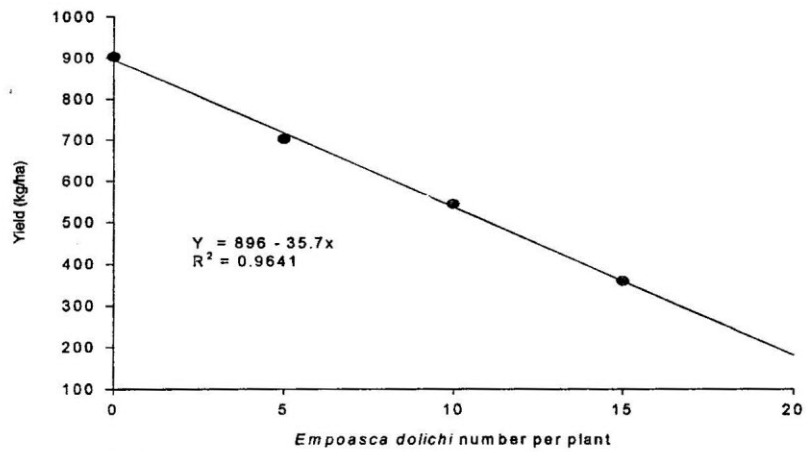

Fig. 2: Regression of groundnut yield on number of *E.dolichi* per plant at stage R_1

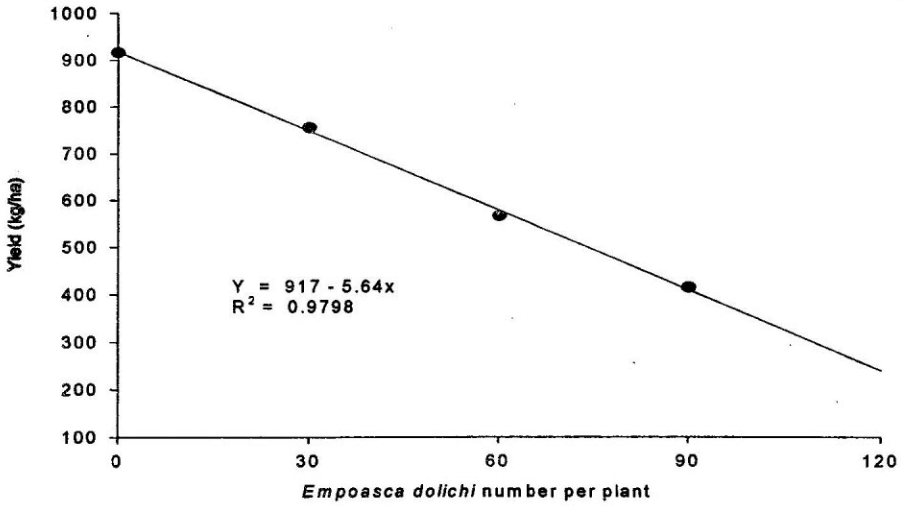

Fig. 3: Regression of groundnut yield on number of *E.dolichi* per plant at stage R_4.

The EIL for a given stage is the number of infesting leafhoppers that would reduce the yield by 33.3 kg/ha. Because Y = a + bx, it follows that bx = y – a = (a – y). But a – y is the reduction (the intercept minus the expected yield). Therefore x = 33.3. For the stage R_1 infestation bx = 35.7x = 33.3. Therefore, x = 33.3 ÷ 35.7 = 0.95 ≏ 1. Consequently, the EIL for the stage R_1 infestation of 1 leafhopper per plant at groundnut stage 1 is economically significant. For the stage R_4 infestation bx = 5.64 x = 33.3. Therefore, x = 33.3 ÷ 5.64 = 5.90 ≏ 6, i.e. the EIL for the stage R_4 of groundnut is 6 leafhoppers/plant. For the stage R_7 infestation bx = 2.56x = 33.3. Therefore, x = 33.3 ÷ 2.55 = 13.06 ≏ 13, i.e. the EIL for the stage R_7 groundnut is 13 leafhoppers/plant. The EILs for the groundnut growth stages are shown in Fig. 5.

DISCUSSION

Economic Injury Levels of *E. dolichi* on Groundnut

This study showed that groundnut plants of the RRB variety are capable of withstanding high levels of damage by the leafhopper, *E. dolichi*, if the pest population build-up does not occur earlier than growth stage R_4. The early infestation (R_1 stage) had the most pronounced effect on yield. At 15 leafhoppers per plant the pest populations reduced yield by ca. 50%. The differences in yield on the larger plants infested at R_4 and R_7 were less pronounced. These results are in agreement with those of other workers who have shown that young legume plants are more sensitive to leafhopper damage than older ones. Parh (1983) reported that

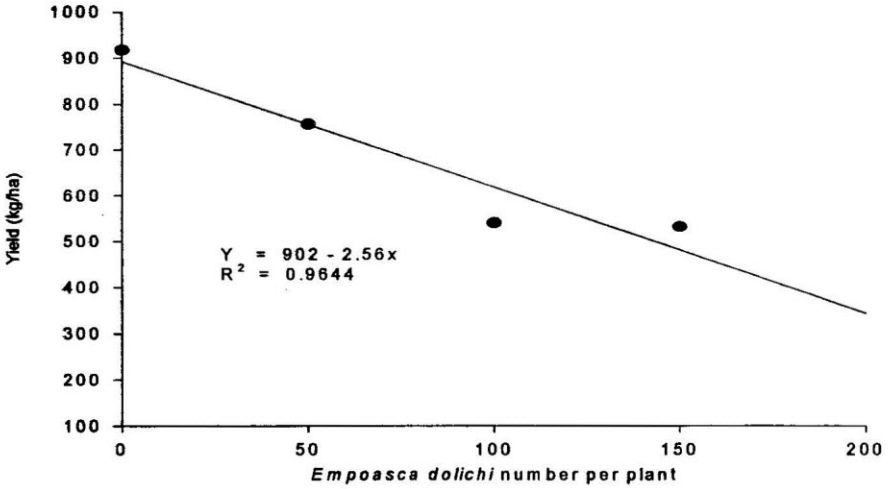

Fig. 4. Regression of groundnut yield on number of *E.dolichi* per plant at stage R_7.

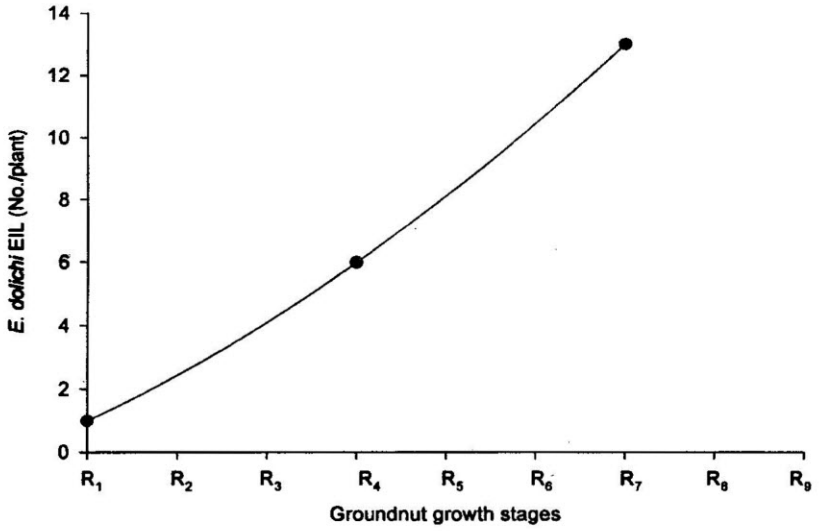

Fig. 5: Economic-injury levels for *E. dolichi* on groundnuts for a gain threshold of 33.3 kg/ha

the feeding of even small numbers of *E. dolichi*, of the order of 15 adults per cowpea plant, can effect a reduction in seed yield of about 28% for prima and 27% for Ife Brown among plants infested at 14 days old. Schoonhoven *et al.* (1978) obtained significantly lower seed yields from bean plants that were exposed to high population levels of *E. kraemeri* Ross and Moore in the early vegetative phase. Ellis (1984), showed that two leafhoppers per plant infested in early July, resulted in populations that reduced yield by ca. 50% and that the differences in yield on the larger plants infested in mid and late July were less pronounced and not significantly different. Similarly, Ogunlana and Pedigo (1974) showed that when young plants of soyabean in the two trifoliate leaf stage were infested with *E. fabae,* one nymph per plant was economically injurious in terms of seed yield. It therefore appears that, it is important to minimize serious *Empoasca* feeding damage to groundnut and other legumes when the plants are in the early vegetative stage. This can be done by monitoring the insect population on such plants and applying appropriate control measures as soon as injurious population levels per plant are attained. The EIL established in this study appear as constant for the different groundnut stages. It should be noted that EIL is a dynamic parameter, varying with a number of factors (Andow and Kiritani, 1983; Natarajan and Sundara Babu, 1988; Ogunlana and Pedigo, 1974; Pachori *et al.*, 1980; Pedigo *et al.*, 1986; Sylven, 1968). The low economic injury level proved the high damage potential and severity of the pest on groundnut. It would vary with the damages in crop variety, its market value, and the type, cost and efficacy of the insecticides.

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