

## ASSESSMENT OF ECONOMIC INJURY AND THRESHOLD LEVELS FOR KEY CEREAL APHID SPECIES IN EGYPTIAN WHEAT REGIONS

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### INTRODUCTION

Aphids are one of the major constraints of wheat production in Egypt. Aphids cause direct damage by feeding and indirect damage by transmission of viruses. Wheat yield loss due to aphids' infestation was estimated by up to 23 % in Upper Egypt (Tantawi 1985). *Rhopalosiphum padi* L., *R. maidis* F., *Schizaphis graminum* R. and *Sitibion avenae* F. were recorded as main cereal aphid species on wheat plants in Egypt (El-Hariry 1979) and recently the Russian wheat aphid, *Duraphis noxia* M. was added (Attia and El-Kady 1988). *R. padi* was found as the most abundant aphid species in Egyptian wheat fields (El-Heneidy 1994). Cereal aphids are also efficient vectors of different strains of Barley Yellow Dwarf Virus (BYDV) which has recently been identified in some parts of Egypt (ICARDA 1996).

Controlling aphids with insecticides has many risks, including destruction of native natural enemies and accelerated development of insecticide resistance in aphid species. In Egypt, this crop receives mostly 2 - 3 insecticidal applications during its growing season.

The use of economic thresholds as a basis for decision making is a fundamental component in integrated pest management (IPM). Stern *et al.* (1959) proposed the concepts of an economic injury level (EIL) and economic threshold (ETL) as a rational comparison of the economic costs and benefits of pesticide use. EIL is defined as the lowest population density (number) that will cause economic damage, where economic damage is the amount of damage that equals the cost of control (Stern *et al.* 1959 and Pedigo *et al.* 1986). Implicit in the EIL concept is that not all damage is economically significant and that in many instances a certain level of insect injury may be tolerated. It is also useful to maintain a distinction between injury and damage. Injury can be defined as the effect of insect activities on host physiology, damage as the measurable loss of host utility, which is usually measured by reduction in the commodity yield or quality. Consequently, not all injury causes damage, and damage threshold, or boundary, defines the level of injury where damage occurs (Bardner and Fletcher 1974 and Pedigo *et al.* 1986).

The EIL and ETL concepts have been successfully and widely applied to generate management guidelines for insect pests in many cropping systems. Also, aphids have been the subjects of much research on ecological relationships and population management. Many workers have contributed to the understanding of host-aphid relationships, and much has been done towards developing economic action levels for cereal aphids' infestation (Wratten, 1978, Robert *et al.* 1985, Kurppa, 1989, Hole *et al.* 1994, Li-Jiping *et al.* 1995 and Wetzel, 1995). However, in Egypt few studies have concerned with development of EIL and ETL

recommendations for cereal aphids in Egyptian wheat fields (**Ghanem and El-Adl, 1987 and El-Serafi et al. 1997**).

The objective of this study is to estimate economic injury and threshold levels for key cereal aphid species in different wheat regions in Egypt as bases for decision making recommendations for the pest control programs in wheat fields.

## MATERIALS AND METHODS

**Locations:** An experimental area of one feddan (= acre) was chosen annually in each of the three wheat regions; Shandaweel (Sohag Governorate, represented Upper-Egypt), Seds (Beni-Suef Governorate, represented Middle-Egypt) and Zagazig (Sharkia Governorate, represented the Delta) to carry out the proposed studies.

**Design:** A factorial design with 6 replicats per treatment was used annually during the wheat growing seasons 2000/01 and 2001/02. Tested parameters were: wheat plant growth stage, density and species of key cereal aphids and location. Plots were 6 x 7 m each. The key cereal aphid species; *R. padi*, *S. graminum*, and together were artificially introduced on wheat plants at the three growth stages: Stem elongation, Booting and Heading (the highest naturally infested growth stages (**El-Heneidy, 1994**)). Separate plots were used for each growth stage. All the experimental plots were planted at the recommended planting date, November 15 to 25 during the two seasons of the study, using the commercial variety, Sakha 69 at the three sites.

**Procedure:** Aphid rates of 0 (control), 20, 40 and 80 viviparous females per plant from each of *R. padi*, *S. graminum*, and together were introduced on the plants under field cages (30x30x150 cm.), covered with small-mesh cloths. Using cages for establishment of artificial populations can disrupt and damage plants growing in a canopy inside the plot. Therefore, screen-mesh size was as large as possible to minimize microclimatic changes while confining the pest (**Poston et al. 1985**). Six plants in each plot were infested at each pre-determined growth stage in the successive seasons. Infested plants were divided into two groups; the first was marked for sampling destructively for aphid numbers and the second was left for yield and yield component determinations. Marked plants were sampled weekly to determine the growth rate of the population (first group). Sampling continued until grain maturity or until aphid numbers declined to zero. At maturity, 3 plants / treatment, not destructively sampled for aphids numbers (second group), were harvested and transferred to the laboratory where the following data were taken: whole plant weight, heads were removed and weight of the remaining plant bio-mass, and number of heads per plant was determined. Heads were hand threshed, the number of seeds per head was counted, the weight of seeds per plant was determined and the weight of 100 individual seeds was also considered.

### **Economic Injury Level (EIL) Calculation:**

To deduce an EIL, the following parameters were estimated: rate of yield reduction, number of aphids, cost of aphid control procedures and market price of the crop. The regression model for the yield-aphid relationship was calculated using the following formula:  $y = a \pm b x$ , where:

y = expected yield,

a = y intercept, a, constant representing, the average yield of non infested plants,

b = slope of the regression line,

x = the number of transferred aphid to plant.

In our study, chemical control costs (cc/fed) was estimated using the recommended aphicide, Marshal 25 % (WP) at the rate of 125 gm /100 L. water. Calculation included the costs of control measures and 2001 market price of the crop. One kg marshal costs 80.0 L.E (= 13.5 \$ US). The wheat feddan requires 400 litter water solution + 500 gm of Marshal. Costs = 40 L.E.(= 6.7 \$ US) + application expenses about 20 L.E (= 3.3 \$ US). A total of 60 L.E (= 10 \$ US) /fed. was considered in calculations. Gain threshold was also calculated according to **Stone and Pedigo (1979)** formula:

Gain threshold = cost of pest control / market price of wheat Ardab. Gain threshold (Ardab/Fed.) = 60 /100 = 0.60 Ardab/Fed. Gain threshold means, the amount of yield loss that constitutes minimum economic damage.

#### **Economic Threshold Level (ETL) Calculation:**

To compute the ETL of key aphid species, infested wheat plants, the general model of **Chang (1982)** was applied:  $ETL = (cc / ec . y . p . yr . sc) . cf$  Where:

cc = the cost of control in unit of L.E / fed;

ec = % efficiency of control;

y = the yield in Ardab/Fed.;

p = the price of crop unit L.E/ Ardab;

yr = % yield reduction / one insect ( $yr = (yc - yt / yc) \times 100 / \text{insect no.}$ ) where: yc = yield of check in average;

yt = average yield for treatment.

sc = the survival coefficient = 1 (because aphids are viviparous insects that mean all individuals cause damage to plants).

cf = 1, 2 (the critical factor) this factor considers socio economic judgment, it can be adjusted according to environmental suitability by varying the cf between 1 and 2. cf have 1 under favorable conditions to the pest and 2 under the adverse conditions.

Data were statistically analyzed using multiple regression techniques to determine the contribution of each treatment to total yield.

## **RESULTS AND DISCUSSION**

Most EIL recommend management tactics directed at a single species without regard to the presence of other species (one or more) or the impact that such tactics aimed at one species may have on the second. In reality, there are usually two or more aphid species present at one time. Each has its own characteristic phonology and injury potential knowledge regarding the effect of multiple pest complexes or production and development of multiple species thresholds will markedly improve our ability to develop IPM systems.

#### **Estimation of EILs and ETLs**

Calculated ETLs and EILs at each growth stage, in different working sites for each of the two key cereal aphid species; *R. padi* and *S. graminum* are summarized in table (1). Higher EILs and ETLs values mean that wheat plant are more tolerant to the certain population of the aphid species. As indicated in the table, ETLs and EILs values fluctuated significantly according to different seasons, sites, growth stages, and aphid species. Obtained data agreed with the fact that ETL values are usually less than the EILs.

During the stem elongation growth stage, estimated EILs in the three locations and in the two seasons ranged between 4.84 - 8.56, 4.44 - 6.99, and 4.2 - 10.47 with the averages of 6.56, 5.74, and 6.50 aphids/plant for *R. padi*, *S. graminum*, and together, respectively. Correspondent estimated ETLs values were 3.87 - 4.93, 3.32 - 5.21, and 3.06 - 6.23 with the averages of 4.37, 3.96 and 4.02 aphids/plant, respectively (Table 1).

During the booting growth stage, estimated EILs in the three locations and in the two seasons ranged between 4.92 - 8.52, 4.48 - 6.57, and 4.32 - 7.72 with the averages of 6.72, 5.8 and 6.02 aphids/plant for *R. padi*, *S. graminum*, and together, respectively. Correspondent estimated ETLs values were 4.16 - 5.11, 3.5 - 5.04, and 3.01 - 5.38 with the averages of 4.67, 4.16 and 3.91 aphids/plant, respectively (Table 1).

During the heading growth stage, estimated EILs in the three locations and in the two seasons ranged between 4.95 - 7.76, 4.55 - 7.17, and 4.48 - 8.78 with the averages of 6.47, 5.92 and 6.13 aphids/plant for *R. padi*, *S. graminum*, and together, respectively. Correspondent estimated ETLs values were 4.45 - 6.31, 3.69 - 5.17 and 3.01 - 6.13 with the averages of 5.10, 4.41 and 4.39 aphids/plant, respectively (Table 1).

All the EILs and ETLs values were higher in first season than those in the second season. Generally, highest values were estimated at Sohag in the two growth stages; stem elongation and booting and at Sharkia in the heading growth stage. Beni-Suef showed the lowest values compared with the other two sites in all growth stages, particularly during the second season.

Generally, as shown in table (1), highest and lowest EILs and ETLs values in all locations were calculated for *R. padi* and *S. graminum*, respectively when each species was separate. Most of the highest EILs were recorded for *R. padi* during the stem elongation growth stage and then decreased downwards in the following growth stages; booting and heading. An opposite trend was found in ETLs values of the same aphid species. EILs values for *S. graminum* were almost equal in all locations, where they ranged between 4.44 – 7.17 aphids/plant, while ETLs values increased upwards (4.43 – 3.81 and 4.65 aphids/plant) toward the heading growth stage. Opposite to the trend of ETLs values in case of *R. padi*. This phenomenon reflects the competition between the two key aphid species *R. padi* and *S. graminum* when they are found on the same wheat plant. When both species presented together, EILs and ETLs values were very close in the three wheat plant growth stages in all locations. Respective values ranged between 4.2 – 10.47 and 3.01 – 6.23 aphids/plant.

Estimated EILs and ETLs values in all wheat locations in Egypt are flexible depending upon all the abovementioned tested parameters as well as changes in the cost of aphid control measures and market price of the crop.

Obtained results were almost in agreement with the findings of **Robert et al (1985)** in USA, who stated that the ETLs of *S. graminum* in winter wheat were less than 10 individuals per plant. In Sweden, **Larsson (1991)** estimated the ETLs of *S. avenae* and *R. padi* on winter wheat and barely and found that the yield response to treatment was significant when there were more than 10 aphids/tiller. In China, **Li-Jiping et al. (1995)** found that 10 aphids/ plant at heading stage was the ETL for cereal aphids on wheat. Also, in Germany, **Wetzel (1995)** reported that 10-15 individuals of *R. padi* and *M. dirhodum* per ear made injury level in winter wheat but by *M. avanae* the ETL was 3.5 individuals per ear.

## **Reduction in Grain Yield**

Grain yield data of the caged wheat plants under the stress of cumulated aphids' infestation were estimated in the three wheat locations. Results are summarized in table (2). Reduction in the grain yields, compared with the control fluctuated significantly according to different seasons, sites, growth stages, and aphid species. High values of grain yields mean less damage of the certain numbers of aphids introduced on the wheat plant. As indicated in table (2), grain yield values were higher in season 2002 than those in season 2001 in the control plots, in all sites and all plant growth stages. In the experimental plots, highest values (= lowest reduction) were recorded at Beni-Suef, followed by Sharkia and lastly by Sohag in season 2002. Wheat plants and consequently the grain yields affected negatively by the increase of aphids' number / plant in all cases. Highest reduction in the grain yields were counted when 80 aphid individuals / plant were introduced.

The impact of the stress of aphids' infestation on the grain yields (reduction in yields) during the stem elongation growth stage caused by *R. padi* was the least (25.1 - 75 %) compared with (26.2 - 81.8 %) by *S. graminum* and (28.1 - 84.2 %) by the two species together (Table 2). *S. graminum* caused much damage, particularly at Sharkia, while *R. padi* caused less damage at Sohag.

The impact of the stress of aphids' infestation on the grain yields during the booting growth stage caused by *R. padi* was also the least (21.2 - 72.2 %) compared with (22.4 - 78.9 %) by *S. graminum* and (26.5 - 82.6 %) by the two species together in all locations, particularly at Sohag (Table 2). Generally, the reduction was lower at this stage than that at the previous stage.

The impact of the stress of aphids' infestation on the grain yields during the heading growth stage caused by *R. padi* continued to be the least (9.8 - 72.7 %) compared with (21.3 - 77 %) by *S. graminum* and (22.2 - 78.8 %) by the two species together (Table 2). Highest reduction in the grain yields was recorded by *R. padi* at Sohag, while the lowest was found at Sharkia. Beni-Suef ranked always in the middle.

In conclusion, in all growth stages, the impact of the stress of cumulated aphids' infestation (reduction in grain yields) caused by *R. padi* alone was always the lowest, it ranged (21.2 - 75 %) compared with (21.3 - 80.8 %) by *S. graminum* alone and/or to (22.2 - 84.2 %) by the two species together. Generally, highest reduction in the grain yields, because of the aphids' infestation was found during the stem elongation growth stage, which means that early infestations in wheat fields during this growth stage are very critical and effects the yield significantly. A recommendation for monitoring cereal aphids' infestation during the stem elongation growth stage (mostly around late January to mid- February) should be considered. Also, the relatively estimated ETLs and EILs values are guide bases for chemical control decision making recommendations in wheat fields in different locations in Egypt.

**Kolbe and Linke (1974)** in Germany found that infestation of 20-30 aphids /ear from *S. avenae*, *R. padi* and *M. dirhodum* on winter wheat caused losses up to 10 %, these can go up to 30 % when the attack is prolonged and reaches levels of 150 aphids/ear. Aphid control and elimination of direct feeding damage during flowering and ear formation increased number of grains per ear. **Kurppa (1989)** in Finland studied the yield losses and control measures during the outbreak of *R. padi* (20 to 60 individuals per plant). The yield was decreased by the mean of 153 kg/ha. Yield loss due to *R. padi*, when arrival to the crop coincided with seedling emergence. As aphid arrival was delayed, yield loss decreased by 41 kg/ha per day of the delay. After

infestation had been initiated yield decreased by a mean of 30 kg/ha per day for the duration of infestation.

Regression coefficient and slopes of regression lines of all treatments during the two seasons of the study and in the three locations are presented in table (3). As indicated from the data, although *R. padi* is the most abundant and widely distributed cereal aphid species in Egyptian wheat locations (**El-Heneidy, 1994**), it showed less damages than *S. graminum*, which inserts toxic substances into the plant sap when feeding. *R. padi* seems to be more serious (causes much damage) in Upper-Egypt, while *S. graminum* is the most serious species in the Delta. This conclusion agrees with the results reported by **Ghanem and El-Adl (1987)**.

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### **SUMMARY**

Aphids are the most serious insect pests attack wheat plantations in Egypt. The use of economic thresholds as a basis for decision making is a fundamental component in integrated pest management (IPM). The objective of this study is to estimate economic injury (EIL) and threshold (ETL) levels for key cereal aphid species *Rhopalosiphum padi* L. and *Schizaphis graminum* R. in different wheat locations in Egypt. Tested parameters were: wheat plant growth stage, density and species of aphids and location. The study was carried out in three wheat locations; Sohag, Beni-Suef and Sharkia Governorates, represented Upper-, Middle-Egypt and the Delta, respectively during the wheat growing seasons 2000/01 and 2001/02. Infested plants were divided into two groups; the first was marked for weekly sampling for aphid numbers and the second was left for yield and yield component determinations. ETLs and EILs values fluctuated significantly according to different seasons, sites, growth stages, and aphid species. Respective highest ETLs and EILs values were estimated at Sohag in the growth stages; stem elongation (6.23 and 10.47) and booting (5.38 and 8.52) and at Sharkia in the heading stage (6.13 and 7.17 aphids/plant). Highest EILs were recorded for *R. padi* during the stem elongation growth stage and decreased in booting and heading stages. An opposite trend was found in ETLs values of the same species. EILs values for *S. graminum* were almost equal in all locations where they ranged between 5.7 - 5.9 aphids/plant, while ETLs values increased (3.96 - 4.16 - 4.41 aphids/plant) toward the heading stage. Opposite to the trend of ETLs values in case of *R. padi*. A negative correlation was found between the grain yields and increase of aphids' numbers/plant in all cases. In all growth stages, the impact of the stress of cumulated aphids' infestation (reduction in grain yields) caused by *R. padi* alone was always the lowest, it ranged (21.2 - 75 %) compared with (21.3 - 80.8 %) by *S. graminum* alone and/or to (22.2 - 84.2 %) by the two species together. A recommendation for monitoring cereal aphids' infestation during the stem elongation growth stage (mostly around late January to mid-February) should be considered to take the right decision for the pest control.

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