

# Current situation and temporal distribution of green leafhopper (*Empoasca* sp: Hemiptera: Cicadellidae) in citrus orchards of Moulouya perimeter

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**Abstract**— The purpose of this work was to assess the green leafhopper [*Empoasca* sp, Cicadellidae] population fluctuations in six Citrus Orchards of Moulouya perimeter and to investigate the relationship between fluctuations of population dynamics, and the occurrence of damage caused by leafhoppers on citrus fruits. To monitor the populations, samples were taken using yellow sticky traps hung on Citrus trees and hedges (*Cupressus* trees) in each orchard, and by a sweep net in adjacent weeds (mainly Solanaceae, Amaranthaceae, and Chenopodiaceae), during three years (2016, 2017 and 2018). The traps were changed and captured specimens counted in the laboratory every two weeks during the survey period. In the packinghouse, the unmarketable fruits (sorting gaps) were observed to determine the rate of defects caused by leafhoppers. The results showed the occurrence of three peaks of adult flight in Citrus Orchards. Spring, late summer and autumn adult generations varied little over years and occurred simultaneously in all Citrus orchards, suggesting massive migrations. Weeds in Citrus orchards and its surrounding were colonized by leafhoppers and from which, adults may continuously migrate to Citrus trees. Traps in Citrus trees and hedges showed a high level of adult captures and could be considered as overwintering refuge of leafhoppers as evergreen trees. The rate of blemished fruits by leafhoppers was 10.21% of total observed defects, and the fruits from orchards with a high level of captures showed a high level of blemishes in the unmarketable fruits.

**Index Terms** — Blemishe, Citrus fruit, Damage, Leafhopper, Occurrence.

## 1 INTRODUCTION

THESE are 13 621 species of leafhoppers and 148 known leafhopper vectors of phytopathogens worldwide [6]. Several leafhoppers, such as *Empoasca kreameri*, *Circulifer tenellus*, *Empoasca decipiens*, *Nephotettix cincticeps*, *Empoasca fabae*, are considered serious agricultural pests [2][8],[4], [5]. In the Northeastern Morocco, Citrus crop is a major fruit trees and is subjected to many insect pests' attacks. In recent years, many producers have noticed that citrus orchards are colonized in the autumn, just before harvest, by large populations of green leafhoppers (*Empoasca* sp.) and cause damage on Citrus fruits. Those leafhoppers are difficult to monitor due to their size, flying and jumping abilities. Our work aimed to acquire basic knowledge on population dynamics (density over time) and ecology in Citrus orchards, their adjacent weeds and hedges (*cupressus*) in Moulouya perimeter and assess the relationship between the number of fruits with blemishes and number of leafhoppers captured.

## 2 MATERIAL AND METHODS

### 2.1 Field and laboratory study

The field study was conducted in six different Citrus orchards with *cupressus* Hedges and abundance of adjacent weeds in Moulouya perimeter. To monitor populations of leafhoppers in the field, samples were taken with 6 yellow sticky traps, of 25\*25 cm, hung on the trees at 1.5m height in each Citrus orchard (Three traps for Citrus trees and three for *Cupressus* trees) following the methodology described by Miranda et al. and Oliveira et al.[7],[9]. For the adult sampling, sweep net were used in adjacent weeds in a linear distance of 30 m and a meter of wide (with three replications for each orchards in each sampling), during three years (2016, 2017 and 2018) from April to November. The traps were changed and captured specimens in traps and sweep net counted in the laboratory every two weeks during the survey period. The identification of the pest was limited to the genus *Empoasca* sp. and we considered whatever the species of green leafhopper present; the blemishes in fruits are identical. To determine the origins of

variability and assess the spatial (over orchards and over species) and temporal (over years) fluctuations of leafhoppers, the dependence of average leafhoppers on years and/or orchards and/or species was tested for captures.

## 2.2 Statistical analysis

The mean densities of adult leafhoppers were statistically analyzed through analysis of variance (ANOVA) and compared among species, orchards and for overall years, followed by a separation of means by Honestly Significance Difference test of Tukey (HSD). Differences were considered as significant when  $p < 0.05$ . The null hypothesis was  $H_0$ : "captures are independent of orchards and species (spatial variability) and/or a year (temporal variability) effect". The data analysis was performed by SPSS 25.0 software.

## 3 RESULTS AND DISCUSSION

### 3.1 Spatial and temporal occurrence of leafhoppers

The perusal of the data obtained from different seasons indicated that Leafhoppers are present in citrus orchards along eight months of the survey during the three years of study with no significant difference of occurrence between all monitored orchards (HSD test  $p$  values  $> 0.05$ ). The largest number of *Empoasca sp.* population in all orchards monitored was recorded in May and June for each species (Fig.1) (318.67; 468 and 332 in citrus, cupressus and weeds respectively) which could be explained by the Mowing of adjacent fields of Lucerne, and weeds which cause green leafhoppers to move into citrus. The peak of population densities occur during spring, late summer and early autumn. This occurrence coincides with weed growth and the fruits ripening in September and October, when captures reached 270.33; 295 and 260 in Citrus, cupressus and weeds respectively (Fig.1). Furthermore, there was a decrease of occurrence in late July and August (34 ; 55 and 55.33 in citrus, cupressus and weeds respectively in August) which coincides with chemical sprays operated by growers against aphid, thrips, and medfly in this period. In addition, Leafhopper numbers in the early of summer (warm) was higher than in the rest of season (hot), this may be due to the weather condition which affect the mobility of leafhoppers as reported by Habekuss *et al.* [3]. A significant similarity (HSD test) of occurrence patterns was noted between Citrus and weeds ( $p$  value = 0.955). However, cupressus showed a significant difference in occurrence pattern with citrus ( $p$  value = 0.012) and weeds ( $p$  value=0.027) (Fig.1).

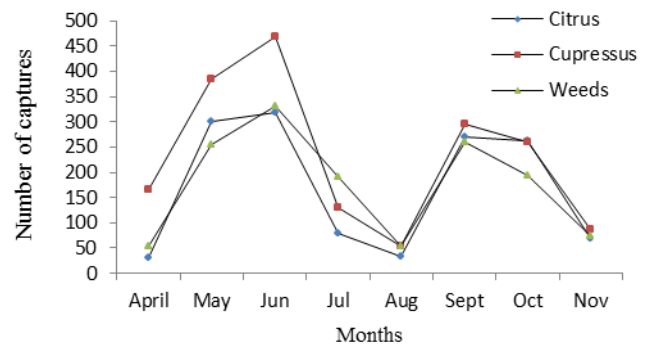


Fig 1. Spatial occurrence of leafhoppers for all three years

It has been known for a long time that *Empoasca sp.* carries out its cycle on different hosts and overwinters on conifers and other evergreens different species from those it attacks other host plants. Citrus is an evergreen species and an overwintering refuge, at the same time it is a crop attacked by leafhoppers after their overwintering in weeds and cupressus. In the Cantone Ticino, Cerutti *et al.* [1] observed how the migration takes place in mass from the beginning of May from the plants on which it overwinters onto crops as soon as they sprout. The analysis of variance test showed that there were significant differences in leafhopper number from one year to another (rejection of  $H_0$ ). Within each year, the numbers of leafhoppers observed at the different developmental stages of the plants were significantly different ( $F$  values = 1,327 at 53 df,  $Pr > F = 0.005$ ).

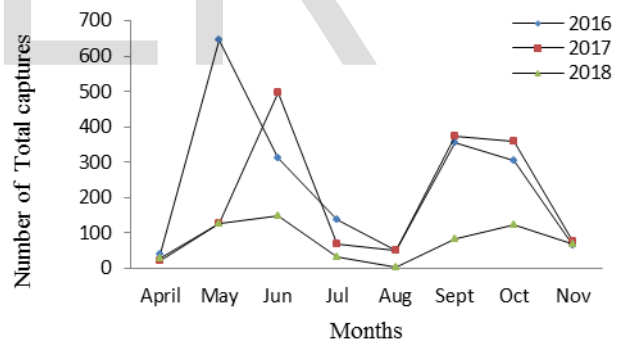


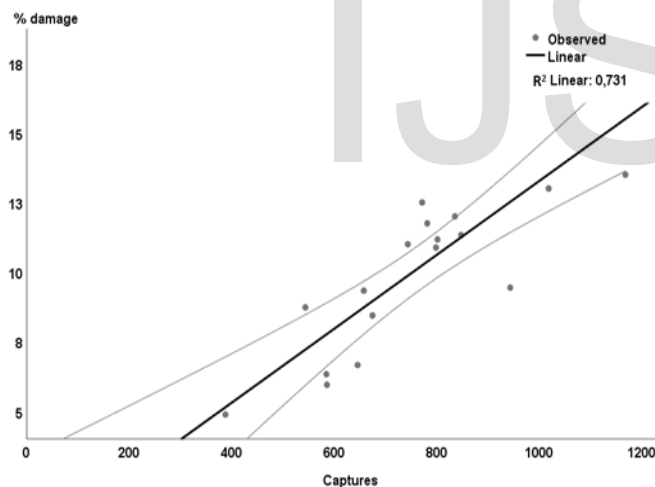
Fig 2. Temporal occurrence of leafhoppers each year for all crop species

The population density of leafhoppers from all orchards in 2016–2018 showed significant similarity based on HSD test ( $p$  value = 0.150) of occurrence during 2016 and 2017 but 2018 was significantly different from 2016 and 2017 (Fig.2). In our study conditions, we concluded that Green leafhopper is a potential pest of citrus in Moulouya perimeter mainly in groves with high densities of weeds and cupressus hedges. During late summer and autumn, leafhoppers may migrate to citrus groves to spend the winter in the shelter of the trees doubling populations with those already overwintering in

citrus trees. The same result was obtained by Van Helden in 2000, who concluded that this phenomenon induces recombination of populations between and especially in the different orchards of the area considered [10].

### 3.2 Effect of green leafhoppers occurrence on percentage damage of citrus fruits

By observing damage caused by leafhoppers on fruits, our results suggest that the green leafhopper feeds on fruit by puncturing rind cells, causing yellowish to light brown, roundish scars on fruit. The multiple regression test was performed to characterize the relationship between green leafhoppers captures and percentage cull caused by blemishes of this pest in the packinghouse. The results showed a power correlation ( $r^2= 0.731$ ) (Fig.3) and fruits harvested from orchards with a high level of leafhoppers captures showed a high rate of blemishes on the unmarketable fruits in the packinghouse, the mean of this rate achieved 10.21%. The regression of damage on leafhopper numbers was positive and linear. This indicated that the appropriate regression model for the damage – leafhopper relationship was  $y = -0.05 + 0.01x$ , where  $y$  = the damage, -0.05 is the “y” intercept, a constant representing the average damage, 0.01 is the slope of the regression line, and “x” represents the number of leafhoppers captured. There was a highly significant relationship between the mean of captures and the *Empoasca sp.* damage ( $r^2=0.731$ ). The regression line derived is shown in Figure.3.



**Fig. 3.** Relationship between leafhoppers (expressed as captures) and percentage of damage

## 4 CONCLUSION

Cicadellidae represents a serious threat to Citrus Production in Moulouya perimeter and may have economic importance as occurred in some citrus producing countries. Further detailed studies on biology and population dynamics are recommended to acquire knowledge to implement IPM (Integrated Pest Management) strategies to control this pest in Citrus orchards and to reduce leafhoppers damage on citrus fruits. The control

of infested orchard weeds during limited citrus plant growth may also promote the infestation of fruit. Controlling weeds during spring and summer will cause green leafhoppers to migrate into citrus trees as evergreen trees.

## Acknowledgements

The authors express their deep gratitude to the organization committee of the International Conference of Scientific Research and Doctoral Studies (ICSRDS 2019) for their help in the preparation of this work, and to the orchards owners and growers who authorized us to set up traps in their orchards and collect mature fruits during the whole period of this study.

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