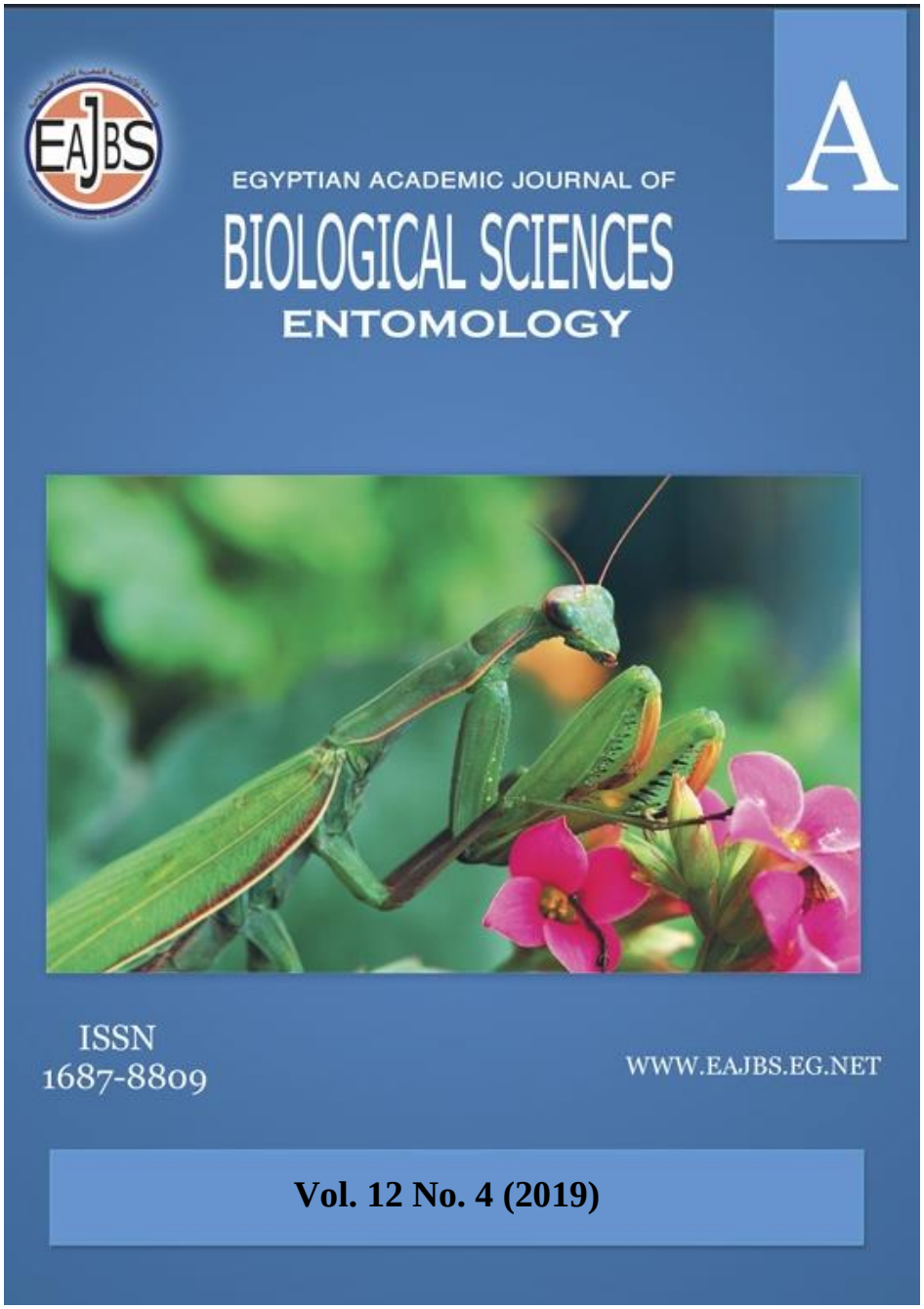

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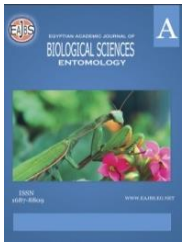

Dynamics of Aphids on Pepper Plant Depending on Its Natural Enemy *Coccinella Algerica* Kovar, 1977 at Bioresources Station (Biskra, Algeria)

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ABSTRACT

The importance of the damage caused by aphids on Solanaceae crop in greenhouse has stimulated the present research, regarding the monitoring of the aphid dynamics on the pepper in greenhouse according to its agent of spontaneous regulation within a framework of biological control.

This study permit to follow the fluctuations in the aphid populations, as well as those of their predator ladybug *Coccinella algerica* knowing that period of aphid activity (extends from March until the beginning of May) correlated with the period of activity of *Coccinella algerica* (which extends between the months of March until mid-June).

INTRODUCTION

The Ziban region occupies the first place in Algeria, it is known for its strong agricultural activity and the importance of its production maraîchaire first-greenhouse, In 2018, this sector has more than 130 103 in 2015 there were 90103 (Naouri *et al.*, 2015).

This strong dynamic acts on the main levers, the accession to the factors of production (soil and water) and the needs of the local markets. However, the maintenance and the reinforcement of the durability of this sector, most often rise of the must as a strong consomatrice of phytosaniatir products to curb the attacks of several pests and fungal or viral diseases

It is known that viruses are transmitted by several species of aphids, which cause considerable damage to the crop (Milaire, 1981). In addition, the excretion of honeydew is a source of attraction for ants, wasps and promotes the appearance of certain fungal species (Health Canada, 2009).

In the world, chemical control, although most effective, is no longer satisfactory, not only in relation to the sustainability of agro-ecosystems, but also because of the resistance of pests to these chemicals, imbalances in the environment (water pollution, soil and air contamination).

In addition, biological control is one of the alternatives to chemical control; it acts among others by means of living organisms antagonists, called biological control agents. Among the many insects, we can mention the ladybug algerica, *Coccinella algerica* L Kovàr 1977, autochthon species and which acts instantaneously to reduce the populations of pests at tolerable levels in the greenhouse or culture.

This type of ladybug is used in many biological control projects, to control several pests such as aphids, whiteflies or mealybugs. The usefulness of larvae as well as adults is recognized worldwide, as evidenced by the farms set up for greenhouse releases, their sales by specialized companies and the numerous studies carried out to get to know them better (Frank & Mizell, 2009).

Massive launches of autochthonous ladybugs can provide sufficient control of aphids. Nevertheless, this control method is confronted on the one hand with the high cost of mass rearing and on the other hand with the methods of introducing these auxiliaries into the agroecosystem.

This species of *Coccinella algerica* is mainly aphidiphagous (lablokoff-Khnzorian, 1982), it attacks several species of aphids, which provide their food by sucking plant sap, and when the number of aphids is large, can cause a stress for the plant, which results in a significant decrease in photosynthesis (Diaz-Montano *et al.*, 2007).

The objective of this work is therefore to study; dynamics of aphids on pepper plant depending on its natural enemy *Coccinella algerica* Kovar at Bioresources station.

MATERIALS AND METHODS

Experimental Device:

To test a biological control method, we have chosen a culture of the Solanaceae family represented by the hybrid pepper (*Capsicum annuum* F1) under a plastic greenhouse (l: 8 m XL: 50 m XH: 8 m). Installed on September 10^{th,} 2014 and a total of 24 sampled plants in the center of the greenhouse to avoid edge effects (Fig.1).

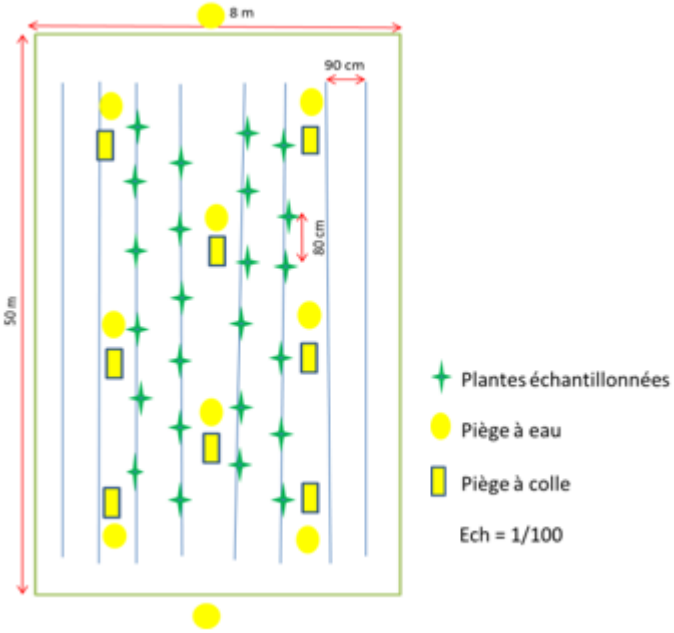

Fig. 1: Experimental device in the greenhouse

50m : Longueur de la serre expérimentale
90 cm : Espacement entre lignes
80 cm : Espacement entre les plantes
4 m : Hauteur de la serre

8m : Largeur de la serre

The sampled plants are divided into three levels; inferior, middle and superior (Fig. 2), at least two follow-ups were performed per week. When the population approaches alert threshold 3 to 4, a follow-up has been done to determine whether it is growing or not. One leaf per level is taken randomly, for the counting of wingless aphids, all stages combined for monitoring the dynamics of aphids during the vegetative cycle of the pepper culture

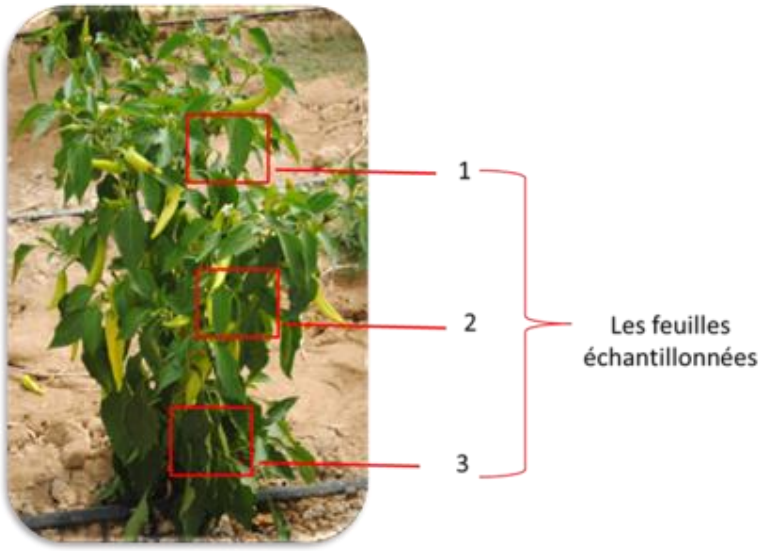

Fig. 2: Sampling leaves by plant

Follow-up Methods:

Aphid dynamics monitoring is based on two different methods:

1. Visual Tracking:

Monitoring is periodic on the basis of two observations per week (biweekly) throughout the vegetative cycle of the pepper culture.

To identify wingless adults for rapid intervention, as soon as aphids are observed on the upper leaves of labeled plants (24 plants / greenhouse), as well as to take notes of the time required for adult pest populations on traps decrease after introducing a predator, (Stroyan, 1961), (Taylor, 1981), (Leclant, 1978), and (Blackman and Eastop 1984).

2. Follow-up Using Sticky Yellow Traps and Water Cuvettes:

We set up a trap for 100 plants (8 traps per greenhouse) two (2) traps were placed six meters from each of the two entrances to the greenhouse and replaced once a month. The presence of winged aphids on platelets and bowls can be explained in two ways:

-Aphids migrated into the greenhouse from outside the greenhouse.

-The greenhouse is infested to the point where winged adults are emerging to ensure dispersal of populations on new host plants

Method of Release *Coccinella algerica:*

In order to be able to release *C. algerica* in the pepper greenhouse, mass rearing of the entomophagus was conducted in the controlled environment chamber. Individuals (larvae and adults) from breeding were released in the pepper greenhouse on the aphid infested plants.

1. Release of *C. algerica* Larvae:

The first release was made during the month of October, which involves introducing a limited amount of ladybug larvae so that a few successive generations of the auxiliary population act during the limited duration of the crop (Van Lenteren and Manzaroli, 1999), the larval density of (2nd and 3rd larval mate) was introduced (10-20 larvae per plant) depending on the infestation rate.

According to Rautapaa (1977), he recommends a ladybug larva for 20 aphids. The intervention points are visited twice a day and we note the presence of the larvae at the point of release.

2. Release of *C. algerica* Adults:

As for the release of adults, 270 individuals are introduced into the greenhouse during the months of February and March on infested plants or the infestation rate is respectively 37.5% and 45.83%. Weekly counts of the different life stages of the aphid and *C. algerica*, as well as mummified aphids.

Ladybug populations sampled in the field were first reared for 2 generations under controlled laboratory conditions and fed with *E. ceratoniae* eggs to minimize potential maternal effects.

After 15 days of release, we control the sampled plants which allow us to follow the impact of ladybird releases on the reduction of the aphid population in the greenhouse. Thus, the rate of the infestation is determined.

RESULTS

Dynamics of the Piper on the Culture of the Pepper:

1. According to Ecological Parameters (Temperature and relative humidity):

The first captures of winged aphid individuals occurred on November 17, 2014, and the result of the temporal flight activity of aphids during the vegetative cycle of greenhouse pepper culture is shown in the following graph:

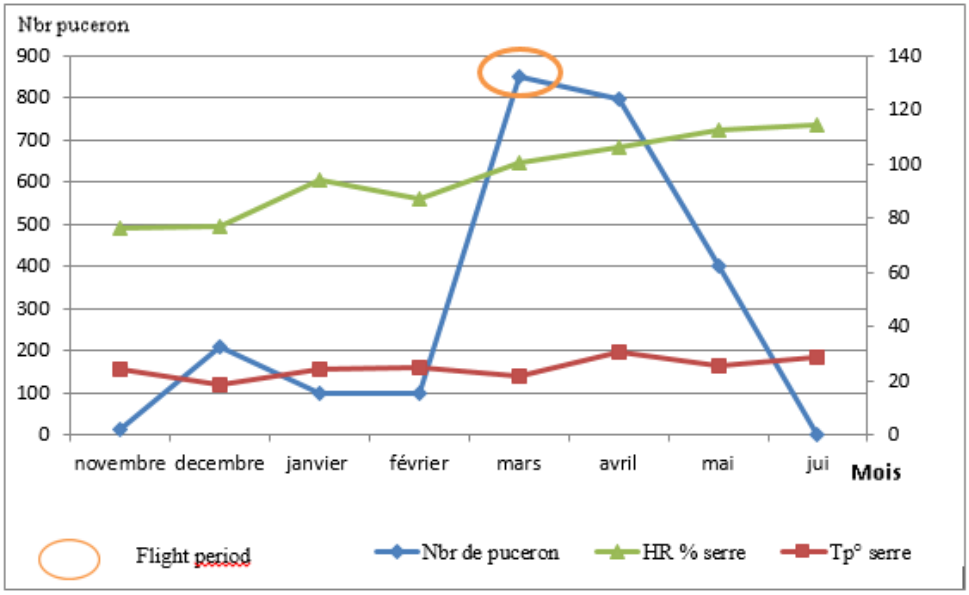

Fig. 3. Flight activity of aphids on greenhouse chillies as a function of temperature and relative humidity

In this study we have tried to specify experimentally the influence of climatic factors on the development and growth of aphids.

Our results indicate that the first generation of aphids occurs between mid-November and until the first half of January with a peak of 210 individuals of captured aphids including (T = 18.5 ° C and HR = 58, 18%).

The beginning of spring coincides with the arrival of the second generation of aphids which begins around mid-March with a peak of 850 aphid individuals of which (T = 22 ° C and HR = 78.48%), and a third generation was recorded around the third decade of April with a peak of 795 individuals including (T = 30.75 ° C and HR = 75.56%) (Fig.3).

2. According to Their Predator *C.algerica:*

During the year 2015, we were able to follow the fluctuations of aphid populations as well as that of the predatory ladybirds' *C. algercia* on peppers under greenhouse in the study station. Figure 28 shows that during this period, a maximum of aphids was counted totaling 2470 individuals. In comparison with their natural enemy *C. algerica*, a maximum of 121 individuals were recorded during this period.

However, it should be noted that the multiplication of ladybugs has been synchronized with the appearance of aphids. As a result, ladybugs overgrow during the period (mid-February to mid-May) with a peak of 498 ladybugs and 850 aphid individuals.

The availability of aphids in March on pepper allowed the ladybug to complete its entire life cycle. Indeed, a sharp fall in aphid populations (795 individuals) was noted from mid-May (Fig. 4).

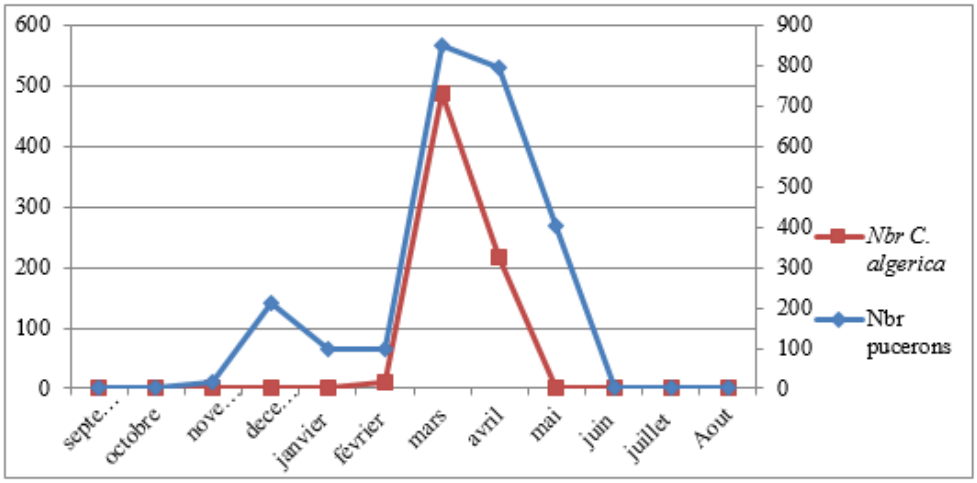

Fig. 4. Flight activity of aphids on greenhouse pepper and their natural enemy

3. Release of *C. algerica* in the Study Greenhouse:

According to the studies of predatory efficiency and the possibility of breeding the natural enemy *C. algerica* carried out in the laboratory followed by releases of the latter on pepper under greenhouse, we can draw this curve, which represents the results of the releases in the pepper greenhouse (Fig.5).

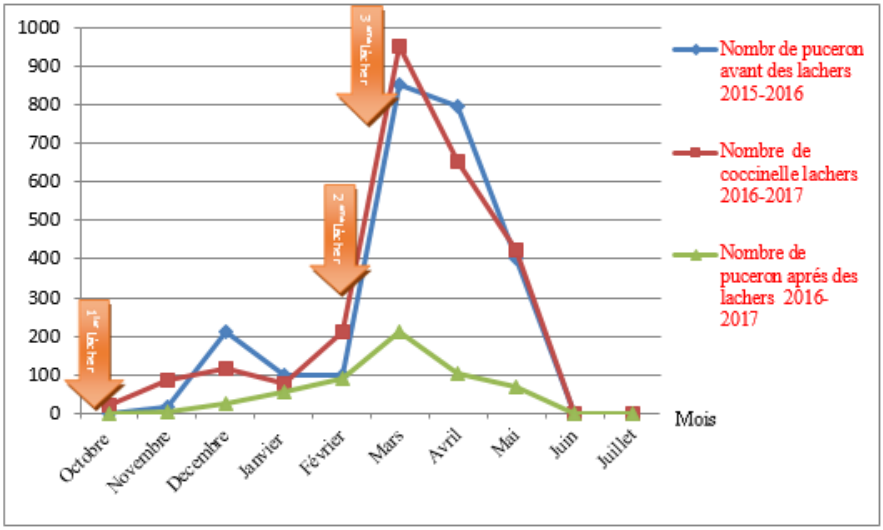

Fig. 5. Monthly evolution of aphid population according to *C.algerica* under greenhouse

Monthly aphid surveys indicate that all species develop very significantly from December to January and from March to May. Another period of less intense activity occurs in the fall (October-November), with peaks of 850 individuals per plant (mid-March) and 210 individuals per plant (mid-December).

In addition, the first colonies of aphids appeared on the pepper around early November with a low average density with 6 individuals per plant. For good efficacy, the first release should occur at the beginning of the aphid spawning period (after 20 days of planting), with 20 (L2 and L3) larvae on the infested feet. One larva per infested plant where the total infestation rate is 2.77%. The density of ladybird larvae increases progressively with that of aphids to reach a maximum of 115 individuals for ladybugs (all stages combined), 210 aphid individuals before release and 25 individuals aphids after release.

Complementary releases in the last week of February with 270 adult ladybirds or the number of aphids exceeded 250 per plant.

After release, there is an increase in the density of aphids to 850 individuals per plant in mid-March where the infestation rate is 37.5%. After the third release of 660 adult ladybugs (just after emergence) o% where the infestation rate is 45.83% synchronization of two populations (aphid and ladybug) is observed.

Indeed, during the entire period from April to June, there is a sharp drop in aphid populations, their density gradually decreasing until they cancel in late July when temperatures often exceed 30 ° C.

DISCUSSION

Dynamics of Pepper:

1. According to Ecological Parameters (Temperature and Relative Humidity):

According to Iperti and *al.* (1989), climatic factors determine the limits of the summer - wintering phase and the breeding season and control the degree of dispersal and population size.

Our analysis focused on the relationship between aphid densities and climate bills in the first generation of aphids that occurred between mid-November and the first fortnight of the month of November. January with a peak of 210 individuals of captured aphids where (TP = 18.5 °C and HR = 58.18%). The improvement of the climatic conditions and especially, the rise of the thermal threshold in the beginning of spring favoring the arrival of the second generation of aphids which starts towards mid-March with a peak of 850 individuals of aphids where (TP = 22 ° C and HR = 78.48%), and a third generation was recorded around the third decade of April with a peak of 795 individuals including (TP = 30.75 ° C and HR = 75.56%).

According to the work of Boukoftane and Benrima (2018), which indicate that the fluctuations of Aphis citricola, and Aphis gossypii, within the orchard to a relationship with thermal variations of maximum temperatures, during the first and third sap thrust. Altuntaş and *al.* (2010), indicates that global warming will affect their rate of development by changing the number of generations per year, the abundance of their populations, their range, and their winter survival (Zhou and *al*. (1995); Estay *et al.* (2009)).

2. According to Their Predator *C. algerica:*

The monitoring of the fluctuations of aphid populations, as well as of their natural enemies on pepper under greenhouse shows that the number and the activity of development of ladybugs are linked with the numbers of their prey (aphids) which develop at the expense freshly developed vegetation (Sahraoui, 2018).

In fact, the first individuals of *C. algerica* invest aphids in mid-February when the

density of ladybugs increases gradually with that of aphids to reach in mid-March a maximum of 498 individuals for ladybugs, and 850 individuals for aphids. A decrease in the density of aphids is observed from mid-March under the predatory action of ladybugs. Indeed, during the whole period from May to June, we are witnessing a total absence of ladybug activity due to the absence of aphid populations because of the scarcity of young shoots and the action of their natural enemies. Begin to decrease gradually to reach their minimum and cancel themselves in mid-May, in summer, and under the effect of high temperatures where temperatures often exceed 30 ° C and the scarcity of food.

Ben Halima *et.al.,* (2011), mention that *C. algerica* is a multicivoltine ladybug that evolves with three annual generations developing from September to May, an optional winter quiescence that depends on the nature of agroecosystems and climatic conditions and a summer diapause. The work of Aroun et *al.,* (2015), show that there is no difference between the flight periods of the two species (aphid and ladybug)

3.Impact of Releases of *C. algerica* on the Aphid Population:

For an efficient regulation of the populations of a pest, it is necessary for the intervention of their predators to intervene early in the chronology of phytophage outbreaks (Sahraoui *et al.,* 2012). They must also be able to develop their predation abilities on small numbers of prey (Guénard, 2007). The effectiveness of biological pest control is highly dependent on the abundance of beneficial (Chang and Snyder 2004, Östman 2004).

The first preventive release with 2nd and 3rd instar larvae should take place at the beginning of the aphid spawning period (mid-October), where the total infestation rate is 2.77%, the density of ladybug larvae Increases gradually with that of aphids to reach a maximum of 115 individuals for ladybugs, and 210 aphid individuals before release and 25 individuals of aphids after release.

While the complementary releases are made in the last week of February with 270 adult ladybugs or aphids exceeding 250 per plant, populations continue to increase once the number of individuals reaches 250 individuals per plant. an average of 24 plants sampled. After a few days, the numbers of aphids decrease following the effective action of this species of ladybug.

Moreover, after 2 weeks, the aphid numbers have gone down again because of the slowing down of the activity of the ladybird larvae that turn into nymphs (aphid consumption is zero). During this period the release of *C. algerica* was repeated and this time at the adult stage (350 ladybug individuals) for a slow and progressive struggle, we notice that the populations decrease until the end of May. Aphid populations remained very low during the trial period. So the strong presence of *C. algerica* has created a direct impact on the aphid population.

Studies by Khoualdia *et al.,* (1996) and Lebdi-Grissa (2005) on orchards of grenadiers in southern Tunisia show that, as a result, the average infestation rate and the number of *Ectomyelois ceratoniae* before the release of *Trichogramma cocaeciae* is important compared to the post-lethal one. Then the release shows a very significant reduction in its infestation rate. It is also effective in reducing the damage of the borer in palm groves.

General Conclusion:

The results of this study show that there is: Including the period of activity of aphid in correlation with the activity period of *Coccinella algerica* which extends from March until the second week of the month of June where the ambient temperature for the multiplication of the aphid varies between 17 °C and 22 °C and a relative humidity average of 49% to 55% with the activity period of aphid extends from March until the first week of May.

In addition to these results, it is important to remember different points to ensure the effectiveness of the release of *Coccinella algerica:*

The massive release of *Coccinella algerica* can provide sufficient control of aphids which offers an interesting alternative to chemical treatments.

Thus the release must be done on a moderate aphid population. If the populations have exploded, previously achieve a preventive and successive release of *Coccinella algerica*.

Indeed, Rebhi (2008) demonstrate that *C. algerica* has summer diapauses which extend from the end of May until the first week of September. This entry into diapauses takes place once the environmental factors are unfavorable for resistance to high temperature and scarcity of prey.

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