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Review

Global climate change and its impact on biodiversity, pest management and food security in Iraq - a review

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ABSTRACT:

The global climate changes through the usual climatic conditions such as temperature, wind patterns and precipitation characterize regions of the earth. The frequency and magnitude of overall climate changes in the long run have tremendous impacts on the natural ecosystems. The consequences of global climate change include the spread of agricultural pests and the emergence of new pests and the emergence of changes in the dates of emergence, which affects the decline in the production of agricultural crops, which adversely affect food security.

In recent years, many impacts of global climate change on the insect environment have been recorded within Iraq's agro-ecosystem, many invasive pests have entered and some of them have changed and they have caused serious damages to agricultural production. In 2006 there was a widespread outbreak of the Mediterranean fruit fly *Ceratitis capitata*, which caused significant losses exceeding 80% of the *citrus* crop and some other fruits. In 2010, for the first time, the spread of tomato leaf miner *Tuta absoluta*, which caused extensive destruction of the tomato crop. Between 2011 and 2013, several types of date fruit stalk borer were recorded following the genus Oryctes, which caused severe damage to the palm trees and fruit. In 2016, it was recorded for the first time, the spread of fruit fly peach *Bactrocera zonata* in orchards in Iraq. In 2017, for the first time, the spread of the black Mexican insect *Saissetia miranda*, which invaded Iraq's agricultural ecosystem and caused damage to fig trees and fruit. Also, in 2018-2019 the spread of the banded conical snail *Cochlicella barbara* was recorded, which is an agricultural pest and a carrier of pathogens that infects human beings and young ruminants. Global climate change has affected the transformation of some species from a non-pest situation into a pest to adapt the climate to their livelihood. It also affected the shift of the level of infection in some pests to the status of the epidemic.

Keywords:
Global climate, Biodiversity, Agricultural pests, Insects.

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INTRODUCTION

Global climate changes and their impact on insect pests

The effects of climate change on our environment are unpredictable, but can be documented with careful study. There are important aspects of global warming and an important effect on warming that play an important role in the evolution of insects by

• Physiology of insects

• Insect ecology

Globally, insects cause an economic loss of 13.6% annually, in the Arab world, the incidence of agricultural pests caused a loss of 35-50% of the total agricultural production (AACCYC, 2014; ECCI, 2013; Firake *et al*., 2013). In India, the annual economic loss caused by insects is estimated at 17.5 % and is valued at $ 17.28 billion in eight crops (cotton, rice, maize, sugar cane, rapeseed, mustard, peanut, legumes and grains), this insect loss is similar to increasing crop diversity with insects caused by global climate change and a single temperature rise in the Philippines has led to a 10 % decrease in rice production. The high average temperature of 6°C led to a decrease in maize production by 36% in the European union countries (Rosenzweig and Lglesias, 2001).

The Mayfly *Ephemera danica* is often used as an indicator of environmental quality since the larvae of this insect live in water and are affected by water quality such as pollution, oxygen content and water temperature. The temperature of the insect's body depends on the temperature of the surrounding environment being cold-blooded, it was found that the rise in water temperature of 1^{o}C in winter and 2^{o}C in summer during the last 20 years led to changes in the life aspects of this insect, adults that appear one year later are 8-10 mm smaller than their predecessors. This decrease in the size of the insect has led to fewer eggs because the change in water temperature has made it less adaptable to the new environment and therefore it may either extinct or show new species of mayflies (Karappaiah and Sujayanad, 2012).

As for mosquitoes, it requires slow-moving water for breeding purposes and one of the reasons for the low population of mosquitoes is low humidity. Stagnant water shortages, climate changes affecting rain, humidity is the most important factor for mosquito expansion rather than temperature. Some important aspects in the life of insects that have been studied globally by their impact on global climate changes:

• Pollinated insects, flowering plants, hibernation, stillness, and plant host.

• Reproductive ability.

• Ability to deploy.

• Interaction with the host.

• Exchange of benefit (pollination of flowers), mismatch occurs between plants and pollinators.

• Mutual harm (competition).

Figure 1. Infestation by Mediterranean fruit fly larvae *Ceratitis capitata*

Table 1. Effect of increasing carbon dioxide on the life aspects of some insects (Petty, 2004)

S. No	Increase in Co_2	Decrease in Co_2
1	Rates of insect evolution	Food consumption in butterflies
2	Weighing and lengthening of virgins of some tunnel makers	Predatory susceptibility to powders
3	Response to warning pheromones in aphids	Reproduction of aphids
4	Fat concentration	Carbon bases for plant defenses against insects
5	Parasitism	Metabolism of the gypsy moth saw fly
6	Effect of gene transfer in the bacteria *Bacillus thuringiensis*	Growth and development of larvae of saw fly
7	Nitrogenous bases for plant defenses	Growth and metabolic rate of willow beetle
8	Control of grain aphids using adhesive traps	The weight of the virgin of the blue butterfly
9	-	Nutrition and growth rate of tobacco beetle
10	-	Fertilization and offspring in aphids
11	-	Effect of foliar treatment of the use of bacteria *Bacillus thuringiensis*

• One-sided utilization (predation or herbivore).

Plant resistance to pests, biocides, natural enemies, synthesis of chemicals related to pest management is changing as a natural consequence of global climate change (Insect and climate change, 2011) (Table 1).

Global climate changes and population dynamics of insect pests

Global climate change and global warming are evident in terms of increases in global average temperatures, changes in rainfall pattern, extreme weather events and increased levels of carbon dioxide and these long-term changes will affect animals and plants and the dynamics of insect pest populations, diversity, activity and abundance of natural enemies, increased crop losses which will affect food security (Karappaiah and Sujayanad, 2012).

There are several aspects in this area

1. Direct effects of climate standards on population dynamics

The effect of upper and lower temperature limits on species in terms of determinants of critical limits of evolution, reproduction, hibernation, death during winter and flight ability (Karappaiah and Sujayanad, 2012).

Figure 2. Tomato borer *Tuta absoluta* infection in greenhouses

Figure 3. Adult and larval palm borer of the genus Oryctes and the damage caused to palm trunks

2. Reproduction and development

Insects respond directly and are affected by the conditions of increasing the temperature, especially reproduction and that the rise of heat more than the upper limits of the development of the insect will lead to decreased growth rates and reproducibility and changes in distribution and spread (if the plant host exists). Overheating may result in the mating ability of some insect pests (Sharma, 2010).

3. Hibernation and winter death

The dormant phase of the necessary factors for some types of insects for the purpose of completing

Figure 4. Adult and larvae of *Bactrocera zonata* peach fly

Figure 5. Eggs and adult insects of black Mexican insect *Saissetia miranda*

their life cycle and to pass the low temperatures in the winter, and that the conditions of high temperature may be useful for some species to resist freezing and sometimes not useful for other species that requiring low temperature for hibernation or increased freezing resistance (Samways *et al*., 1999).

4. Migration and movement

The ability of insects to fly is an important factor for the spread of herbivorous insects, influencing the timing of the process of mating, the creation of plant host and the formation of insect colonies. The effects of heat on fly vary between species and according to seasons and regions. Each type of insect has temperature limits that affect its ability to fly or change from winged to wingless, such as in aphids, as well as the time of getting out and activity and timing of hibernation. Global climate change has affected many insect pests, their emergence and spread (Dubas Bug, palm borers, *Tuta absoluta* tomato leaf mine) (Khalaf and Khudhair, 2015; Khalaf and Alrubaei, 2016; Razzak *et al*., 2010; Al-Jboory, 2007).

5. The direct effect of increasing the temperature on the insect pests

The rise of temperature may affect any stage of the life cycle of the insect as well as the distribution, spread, survival, reproduction and development (ECCI,

Figure 6. Banded conical snail (*Cochlicella Barbara*)

2013; Karappaiah and Sujayanad, 2012).

6. Effect of temperature on the survival rates of insects

The effects of temperature during the winter varies from one insect to another, for example increase in the number of generations of aphids from 1 - 5 at the temperature of 2^{o}C in winter (warmth) and another type of insects where the laying of eggs increase at a temperature of 35 - 40^{o}C, but the survival rate of this egg decrease and also less period for pre-laying eggs. In a section of predators, the rise in temperature from 32 to 35^{o}C reduces the search period for prey but this decreases after 35^{o}C. It was found in some insects that the incubation period of eggs is 10 days at 25^{o}C, but amounted to 8 days at 27 - 28^{o}C. In addition to that the insects do not come out after hibernation unless collected thermal units necessary for its survival. This has been the subject of thermal unit accumulation as an indication of the emergence of insects to start the application of control programs (Karappaiah and Sujayanad, 2012).

7. Effect of heat on insect growth rate

The rate of pest development is more responsive to changes in temperature. In the green bugs, the number of generations' increases at 2°C compared to 1°C. The infection of aphid's changes when there is a change in the thermal units accumulation and when the thermal accumulation unit reach 200 thermal units more attacking plant families (ECCI, 2013).

8. The impact of heat on multi-generations

Climate change is the main cause of changes in the dynamics of pest species and their populations. The first effect of warming is on the number of generations of insects during the year, this relationship is very complicated because it enters the egg laying period, hibernation and other phonological effects (Karappaiah and Sujayanad, 2012; Sharma, 2010).

9. Global warming and the spread of species

This relationship may be positive or negative depending on the types of pests. In some species the global warming helped to increase their spread and the other species declined or extinct in a certain area (Firake *et al*., 2013).

10. Rainfall and drought

Changes in rainfall in the Sahara have a significant impact on the migration of locusts, and rainfall in summer has a direct impact on soil moisture and drought, especially on insects that spend all or part of their life cycle in the soil surface. The response of root-eating insects increases in dry summer seasons. The conditions of dryness of the soil surface affect the vitality of the eggs of some insects and reduce hatching, especially high drought conditions (Karappaiah and Sujayanad, 2012).

11. Direct effects of climate change on the relationship between insect pests and their plant hosts

The quality of plant nutrients in plant tissue has an effect on plant-feeding insects; this is increased by increasing the nitrogen content, low water levels and concentrations of secondary compounds. The carbon dioxide in the atmosphere is one of the defenses of the plant host and its resistance to the multicultural insect colonies. The nutrition and metabolism of some insect larvae are higher at the level of carbon dioxide between 550 and 700 ppm. As well as the ratio between carbon and nitrogen has the greatest impact on insects with plant nutrition (Petty, 2004).

12. The impact of climate on the relationship between insect pests and natural enemies

The effects of climate on the relationship between the rate of development of insects and natural enemies and heat affects the predator search factor for prey and the time of captivity and this effect is indirect. The systems of biological control of insects depends on: temperature, parasites, predators and density of the population of the pest and the success of this system depends on the above said factors. It was found that the eggs of a predator increases when the attack efficiently increases at the time of catching prey and the tempera-

ture increases to 32°C and after 35°C it begins to decrease as well as the effects of climate change on the synchronization between the presence of host and prey (Samways *et al*., 1999).

Invasive pests of the agricultural ecosystem in Iraq

In recent years, many invasive insect pests of the agricultural ecosystem in Iraq have been recorded:

1. Mediterranean fruit fly *Ceratitis capitata*

This pest spread in orchids during 2006 and caused great damage in the fruits of citrus fruits, apricots, persimmons and some other fruits (Al-Jboory, 2007) (Figure 1).

2. **Tomato borer *Tuta absoluta***

This pest entered the Iraqi environment during 2010 and has caused great damage in the production of tomato crops. This is the first registration of this pest in the agricultural ecosystem of Iraq (Razzak *et al*., 2010) (Figure 2).

3. Palm borers

In 2013, for the first time, several species were recorded, especially the genus Oryctes, whereas only one species was registered since 1911. These types cause damage to palm trees and fruit and transmit pathogens from the affected palm to the healthy plants (Khalaf *et al*., 2012; Khalaf and Al-Taweel, 2015; Khalaf *et al*., 2013) (Figure 3).

4. Peach fruit fly (*Bactrocera zonata*)

Record of the spread of this pest in the agricultural ecosystem in Iraq during 2016, this pest caused serious damage to the fruits of peaches and other fruits of almonds, it was considered an invasive pest of the agricultural ecosystem in Iraq (Abdulrazzak, 2016) (Figure 4).

5. Mexican black scale (*Saissetia miranda*)

Record of the entry of *Saissetia miranda* to the Iraqi environment during 2017 and its spread on fig trees, which caused damage in the trees and fruits. As indicated entry from neighboring countries of Iraq, it is noted that it is registered for the first time in the agricultural ecosystem of Iraq (Khalaf *et al*., 2019) (Figure 5).

6. Banded conical snail (*Cochlicella barbara*)

This snail record in 2018 - 2019 was the first record at the Iraq. This snail is an agricultural pest on grain crops, especially wheat, which leads to poor quality and makes it not suitable for human consumption and export. Due to the entry of snails through harvesting machines because the size is close to the size of wheat grains, therefore rejects consignments containing this type of snails (Al-Doori, 2018; Khalaf, 2019). The health hazard of this snail lies in the fact that it is an intermediate host of a threadworm that transmits pathogenic bacteria which cause respiratory diseases to the human beings and young ruminants (Khalaf, 2019) (Figure 6).

CONCLUSION AND RECOMMENDATIONS

Through the researches and studies carried out on invasive pests of the agricultural ecosystem in Iraq and changes in the dynamics of endemic pests, it is clear that there is a change in the dates of their appearance and the disappearance of another pests and some of them turned to the level of the epidemic. This is evidenced by the impact of changes in the global climate and the lack of an effective quarantine and border control system.

From it we can recommend:

- Adopt an effective quarantine system at border entry points and permanent border controls to limit the entry of shipments of agricultural crops and food containing quarantine pests.
- Adopt a sophisticated surveillance system at border points for neighboring countries likely to enter pests to Iraq.
- Relying on specialists with experience in border crossing points for the purpose of screening agricultural crops that are likely to be infected with pests

that are not present in the Iraqi environment.

- The Ministry of planning in its investment plan and financial allocations mentioned a note to cover the completion of investment projects in the field of invasive pests to the Iraqi environment and the impact of global climate changes on the dynamics of insects in the agricultural ecosystem in Iraq.

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