



REVIEW

Effect of Different Temperature and Humidity on *Bemisia tabaci*

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ABSTRACT

Bemisia tabaci has many biotypes, and has become one of the main pests on vegetables, flowers, cotton and other crops, seriously influencing the safe production of crops. Temperature has a great influence on the survival, development, reproduction and behavior of *Bemisia tabaci*, which can affect the change of body temperature and metabolism of *B. tabaci*. It needs certain water to maintain normal life activities, such as digestion, nutrition transportation, and temperature regulation. There is a suitable humidity range for the growth and development of *B. tabaci* in different development stages. High humidity or drought have a great impact on the growth and development of *B. tabaci*, especially on its survival or reproduction. At the same time, the environmental temperature and humidity are the important factors that influence the geographical distribution and population change of *B. tabaci*.

1. Overview of *Bemisia tabaci*

1.1 Occurrence and Harm of *Bemisia tabaci*

Bemisia tabaci belongs to Homoptera, Aleyrodidae and Bemisia. It is one of the chief pests in the tropics and subtropics. Invasive *Bemisia tabaci* is one of the most important agricultural pests in the world. In 1991, American Science magazine called B-type Bemisia “super pest”. At present, Q-type Bemisia is also widely concerned because of its stronger resistance. At present, *Bemisia tabaci* is widely distributed in more than 90 countries and regions in the world. It is the main pest of cotton, vegetables, garden flowers and other plants in many countries. In recent years, with the rapid development of greenhouse and protected horticulture in China, *Bemisia tabaci*

exists in large numbers in some areas^[1,2].

As the invasion of *Bemisia tabaci* is harmful to agricultural production, it has become one of the most popular invasive species in the world^[3]. *Bemisia tabaci* Gennadius was first discovered in 1889 in Greece and was named *Aleyrodes tabaci* Gennadius^[4]. Before the 1980s, *Bemisia tabaci* mainly harmed cotton. *Bemisia tabaci* did harm to cotton production in some cotton producing countries, such as the United States, Brazil, India, Turkey, Iran and so on. Since 1985, it has gradually spread to vegetables and garden plants, especially to greenhouse plants in the United States and Europe. In 1991, *Bemisia tabaci* occurred in California and Arizona, and caused serious losses^[13].

In China, *Bemisia tabaci* was first recorded in 1949, principally distributed in Hainan, Guangxi, Guangdong, Yunnan, Fujian, Hubei, Sichuan, Shaanxi, Zhejiang, Ji-

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angxi, Beijing, Shanghai, Taiwan and other regions to the south of the Yangtze River Basin^[1]. But in recent ten years, with the extensive application of the agricultural vegetable greenhouse planting mode and the frequent transfer of vegetables and flowers, it has created more favorable conditions for the appearance and spread of *Bemisia tabaci*. In 2000, *Bemisia tabaci* occurred on a large scale in the north and south of China, and now it is one of the principal agricultural pests and invasive organisms in China. In Beijing, *Bemisia tabaci* caused serious damage to tomatoes, eggplants, cucumbers, melons and zucchinis, resulting in more than 70% of the loss of production^[7].

1.2 Morphological Characteristics of *Bemisia tabaci*

The individual development of *Bemisia tabaci* can be divided into three stages: egg, nymph and adult. The third instar nymph is usually called pseudopupa. The eggs of *Bemisia tabaci* are about 0.2 mm long, glossy, pear shaped, with egg handle. They are light yellow green at the beginning of labor, and turn to dark brown slowly before hatching. The nymphs are light green to yellow, and the nymphs of the first instar have feet and antennae, which can move; at the second and third instars, the feet and antennae of *Bemisia tabaci* degenerate into one segment, leaving only mouthparts, which are fixed on the plants for feeding. Pseudochrysalis is about 0.7 mm long, with thin or naturally drooping yellow brown markings and 1 pair of setae at the tail. Adults are largely parasitized on the back of leaves. Their body color is light yellow, wings are white and spotless. They are covered with white wax powder and 7 antennae. They are smaller than white planthopper in greenhouse. There are 2 longitudinal veins in the front wing and 1 longitudinal vein in the back wing. When they are still, their left and right wings close to each other in ridge shape, and there is an obvious seam on the back.

1.3 Biotypes of *Bemisia tabaci*

Bemisia tabaci is a complex species composed of many biotypes^[8], due to the differences of host plant adaptability, host range and virus transmission ability of *Bemisia tabaci*^[9,10,11]. The outbreak of *Bemisia tabaci* population first appeared in the United States. Entomologists have confirmed that the large-scale outbreak of *Bemisia tabaci* in the United States is not the original local population, but the new invasive species from other places^[12]. At the same time, many studies have shown that the pseudopupa of *Bemisia tabaci* may change due to different host plants. However, in terms of host range and spawning amount,

the newly invaded *Bemisia tabaci* showed a wide host range and large spawning amount, and transmitted many kinds of plant geminiviruses, such as pumpkin leaf curl virus and tomato necrosis dwarf virus, etc., which could cause physiological abnormalities of plants, including pumpkin leaf reaction and irregular ripening of tomatoes^[13,14]. It is the first method to distinguish the biotypes of *Bemisia tabaci* to study the esterase isozyme polymorphism of *Bemisia tabaci*^[5], in accordance with the polymorphism of esterase alleles in biotypes A and B of *Bemisia tabaci*, the researchers call the original population of *Bemisia tabaci* in the United States as type A, and the new invasive population as type B^[15].

At present, in terms of phylogenetic and systematic studies of *Bemisia tabaci*, there is sufficient evidence that it is a species complex containing at least 31 hidden species^[16,17]. 15 species of *Bemisia tabaci* including 13 native species and 2 Global invasive species have been reported in China. B and Q types of *Bemisia tabaci* invaded China in the late 1990s and around 2003, respectively, and rapidly replaced the local species in many areas and occupied a dominant position. After several years' spread and spread, B-type *Bemisia tabaci* broke out in various crops in southern China, which seriously endangered the safety of China's planting industry. Chu Dong et al.^[3] reported for the first time the Q-type *Bemisia tabaci* in Kunming, Yunnan Province, China. Since 2005, Q-type *Bemisia* has successively replaced B-type *Bemisia* in many areas, which may be related to the strong resistance of Q-type *Bemisia*^[18].

2. Effect of Temperature and Humidity on *Bemisia tabaci*

2.1 Temperature

2.1.1 Effect of Temperature on the Growth and Development of *Bemisia tabaci*

Suitable temperature is the necessary condition for the normal growth and development of *Bemisia tabaci*. There is a temperature range suitable for its growth and development in the development stage of *Bemisia tabaci*. High or low temperature have a great influence on its growth and development, especially on its survival and reproduction, causing the stop of growth and development, or even death. Therefore, the change of temperature not only affects the growth and development of individual insects, but also influences the behavior of insects.

In general, it can endure high temperature above 40 °C, and nymphs and adults still survive at 5 °C. When the temperature is suitable and the host is rich, the emergence of *Bemisia tabaci* is often large, especially in high tempera-

ture and dry season^[19]. The optimum temperature for the development of *Bemisia tabaci* is 26-28 °C, and the starting temperature for the development of each stage is different. The lowest starting temperature for the development of the second instar nymphs is 10.4 °C, and the starting temperature for the development of other nymphs and pseudopupae is about 12 °C. Temperature has a great effect on the development duration of various insect states of *Bemisia tabaci*. The development duration of *Bemisia tabaci* is the shortest at 30 °C - 33 °C, which is 14.4-15.1 days. The development duration of *Bemisia tabaci* that is lower or higher than this temperature will be prolonged. The development duration of *Bemisia tabaci* from egg to adult is the longest at 18 °C, which is 33.6 days; it is 23.1 days at 36 °C^[19].

Qupeng et al. pointed out that the survival rate of eggs and nymphs of the first instar was the lowest, the highest at 26 °C and the lowest at 32 °C. Qiu Baoli et al.^[20] also believed that the adult life of *Bemisia tabaci* was generally shortened with the increase of temperature. The adult life of female was 39.6 days at 20 °C and 12.8 days at 32 °C. The amount of eggs laid by the adults of *Bemisia tabaci* also decreased with the increase of temperature. The average oviposition of single female was 164.8 at 20 °C and 78.5 at 32 °C^[19].

2.1.2 Effect of Temperature on *Bemisia tabaci* Population

In term of the research on the effects of different temperatures on the population of *Bemisia tabaci*, the optimum temperature for the growth and development of *Bemisia tabaci* is 25 °C -28 °C. If the temperature is too high or too low, it will affect the development of the *Bemisia tabaci* population to varying degrees. In addition, temperature also affects the emergence behavior of *Bemisia tabaci*. Most of the adults of *Bemisia tabaci* emerge under light conditions. They mate within 1-8 hours after emergence in summer and within 3 days after emergence in spring and autumn. However, the effect of temperature on behavior other than oviposition behavior of *Bemisia tabaci* is rarely reported^[21]. The adult of *Bemisia tabaci* likes to lay its eggs on the back of the upper and middle leaves of the host plant after feeding on the leaf juice, and hatch into nymphs after 4 - 5 days under the suitable temperature.

2.2 Humidity

2.2.1 Effect of Humidity on the Growth and Development of *Bemisia tabaci*

The results showed that the adults of *Bemisia tabaci* mostly moved under the condition of 75% relative humidity

in the air, and there was no significant difference in the development period of *Bemisia tabaci* under different humidity conditions; The effect of air humidity on the survival of *Bemisia tabaci* was not significant except that it had no significant effect on the pre oviposition survival rate of adults. The survival rate of Xiang Yuyong et al. was significantly higher than that of 55% and 95% relative humidity ($P < 0.05$), which was 77.8%; Humidity has a significant effect on the longevity and oviposition of *Bemisia tabaci* adults. Under different humidity conditions, the longevity of adults is 75% RH > 55% RH > 95% RH, and the oviposition rate is 55% RH > 75% RH > 95% RH. It can be seen that the average humidity of 65% is conducive to the oviposition of adults, while the humidity of 75% is more conducive to their survival. The results of Horowitz also showed that there was no significant difference in life span and survival rate among adults of *Bemisia tabaci* under 30% RH, 80% RH and 90% RH, but the survival rate was the lowest under 21% RH. In accordance with the comprehensive temperature and air relative humidity, low-temperature drying is beneficial to the growth and reproduction of *Bemisia tabaci* population^[22].

3. Conclusion

The development rate of each stage of *Bemisia tabaci* is accelerated with the increase of temperature, but when the temperature is over 35 °C, the development slows down, and only a few can hatch and develop to the third age. The change of humidity and scour caused by rainfall may be important environmental factors for population regulation.

By understanding the effects of temperature and humidity on the growth and development of *Bemisia tabaci*, we can grasp the population dynamics in production. At the same time, it has an important guiding role in the prevention and control of *Bemisia tabaci*, such as prediction and prediction, cutting off the transmission path and effective agricultural prevention and control measures. Using modern quarantine technology, we can prevent the spread of *Bemisia tabaci* from causing serious harm to agricultural production.

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