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Authors: Chu, Dong, Zhang, You Jun, and Wan, Fang Hao
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CRYPTIC INVASION OF THE EXOTIC BEMISIA TABACI BIOTYPE Q OCCURRED WIDESPREAD IN SHANDONG PROVINCE OF CHINA

DONG CHU12*, YOU JUN ZHANG3 AND FANG HAO WAN4
1High-tech Research Center, Shandong Academy of Agricultural Sciences, and Key Laboratory for Genetic Improvement of Crop Animal and Poultry of Shandong Province, Jinan 250100, China
2Key Laboratory of Crop Genetic Improvement and Biotechnology, Huanghuaihai, Ministry of Agriculture, the People’s Republic of China, Jinan 250100, China. 3Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, Beijing 100081, China
4State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100081, China

ABSTRACT

Bemisia tabaci (Gennadius) is an important agricultural pest worldwide. The pest is a species complex composed of numerous biotypes, among which biotypes B and Q are the 2 most invasive and widely distributed. Our previous study found that the ratio of the biotype Q has been increasing and displacement of biotypes B by Q has been occurring on cotton and eggplant in Shandong Province of China during the past several years. To determine whether biotype Q has been increasing on other hosts and possible displacement of biotypes has been occurring in the province as a whole, we further surveyed B. tabaci biotypes B and Q on cultivated and wild host species near cotton or eggplant fields in 7 locations of Shandong Province during 2005-2008 with cleavage amplified polymorphic sequence (CAPS) of the mtCOI (mitochondrial cytochrome oxidase subunit I) marker. This research showed biotype Q has been increasing on all kinds of host plants and the displacement of biotypes B by Q has been occurring in the province as a whole. The displacement mechanism should be further researched and such knowledge might guide the application of the insecticides or adjustment of the crops to effectively control the pest.

Key Words: Bemisia tabaci, biotype Q, mitochondrial cytochrome oxidase marker

RESUMEN

Bemisia tabaci (Gennadius) es una plaga importante a la agricultura mundial. La especie es un complejo de especies compuesta de biotipos numerosos, entre ellos los biotipos B y Q son los 2 mas invasivos y distribuidos ampliamente. Nuestro estudio anterior encontró que la proporción de biotipo Q ha ido incrementando y el desplazamiento del biotipo B por el Q ha ido ocurriendo sobre algodón y barenjena en la Provincia de Shandong en China durante varios de los años pasados. Para determinar si el biotipo Q se ha ido incrementando sobre otros hospederos y si el posible desplazamiento de biotipos ha ido ocurriendo en toda la provincia, también muestreamos los biotipos B y Q de B. tabaci sobre especies de hospederos cultivados y silvestres cerca de campos de algodón y berenjena en 7 localidades en la Provincia de Shandong durante 2005-2008 usando el metodo escisión de la secuencia polimórfica amplificado (ESPA) del marcador subunidad I de mtCOI (oxidasa citocromo mitocondrial). Esta investigación mostró que el biotipo Q se ha ido incrementando sobre toda clase de plantas hospederos y el desplazamiento de biotipo B por el Q ha ido ocurriendo en toda la provincia. El mecanismo del desplazamiento debe ser investigado y este conocimiento puede guiar la aplicación de insecticidas o un ajuste de los cultivos para controlar la plaga efectivamente.

Bemisia tabaci (Gennadius) is an important agricultural pest worldwide. It damages crops through direct feeding and vectors many plant viruses. The pest has been considered as a species complex that includes many genetic groups that are morphologically indistinguishable. Some are labeled as biotypes or host races because of differences in host range, geographical distribution, transmission ability of plant virus, and other biological characteristics. Biotype B is believed to originate from the Middle East-Northern Africa and have spread into many...
countries or regions over the past 2 decades. Bio-
type Q may have originated in the Mediterra-
nean countries and circumstantial data shows
that this biotype has been introduced into many
non-Mediterranean countries or regions during
the past several years (Chu et al. 2005; Ueda
2006; Brown et al. 2007).

_Bemesia tabaci_ outbreaks in the mid-1990s in
both Southern China and Northern China and
subsequent research showed that the whitefly
occurring in most of China was biotype B (Wu et
al. 2002). In 2003, biotype Q was found in Kun-
ming of Yunnan Province and then subsequently
found in Beijing and Henan (Chu et al. 2006).
Many populations of _B. tabaci_ in Shandong
Province, one of the most important agricultural
provinces of China, have proved to be biotype B,
but biotype Q was discovered in 2006 by use of
mitochondrial cytochrome oxidase subunit I (mt-
COI) sequence (Chu et al. 2007). It is important
to monitor the spreading and the density of the
biotype Q because it possesses greater resistance
to many insecticides than biotype B in many
countries (Dennehy et al. 2005; Horowitz et al.
2005). The biotypes of _B. tabaci_ on cotton and
eggplant in 6 locations within Shandong Prov-
ince was determined with _mtCOI_ sequences and
biotype B-specific primers (Chu et al. 2010), which
showed that the ratio of the biotype Q has been in-
creasing and displacement of biotypes B by Q has
been occurring during the past 4 years (2005-2008)
on these two crops. To determine whether biotype
Q has been increasing on other hosts and possible
displacement of biotypes has been occurring in the
province as a whole, we further surveyed _B. tabaci_
biotypes on cultivated and wild host species near
cotton or eggplant fields in 7 locations of Shandong
Province during 2005-2008.

**MATERIALS AND METHODS**

_Bemesia tabaci_ biotype was determined with
the cleaved amplified polymorphic sequences
(CAPS) of _mtCOI_ amplified with new primers
(C1-J-2195/R-BQ-2819). Adult whiteflies were
collected from different plants including crops
and weeds in 7 locations, DeZhou, ZiBo, Shou-
Guang, JiNan, LiaoCheng, LinYi and ZaoZhuang
in Shandong Province during 2005-2008 (Table 1).
The adults were placed in tubes with 95% ethanol
and stored at -20°C. Individual
adults were ground and DNA was extracted. The

![Fig. 1. Composition changes of B. tabaci biotypes B and Q in Shandong Province during 2005-2008](image-url)
### TABLE 1. DATA ON WHITEFLY COLLECTION AND BIOTYPE DETERMINATION BASED ON THE MARKERS.

| Location | Year | Host plant          | Total individuals | Number of biotype | Percentage of biotype (%) |
|----------|------|---------------------|-------------------|-------------------|---------------------------|
|          |      |                     |                   | B                | Q                         |
|          |      |                     |                   |                  | B           | Q                 |
| DeZhou   | 2006 | Cotton              | 31                | 23               | 8                       | 74.2        | 25.8              |
|          |      | Eggplant            | 61                | 34               | 27                      | 55.7        | 44.3              |
|          |      | All host plants     | 92                | 57               | 35                      | 62.0        | 38.0              |
|          | 2007 | Tomato              | 21                | 7                | 14                      | 33.3        | 66.7              |
|          |      | Cotton              | 71                | 17               | 54                      | 23.9        | 76.1              |
|          |      | Eggplant            | 45                | 7                | 38                      | 15.6        | 84.4              |
|          |      | Zucchini            | 37                | 18               | 19                      | 48.6        | 51.4              |
|          |      | All host plants     | 174               | 49               | 125                     | 28.2        | 71.8              |
|          | 2008 | Cotton              | 27                | 0                | 27                      | 0.0         | 100.0             |
|          |      | Japanese hop        | 30                | 0                | 30                      | 0.0         | 100.0             |
|          |      | Eggplant            | 30                | 0                | 30                      | 0.0         | 100.0             |
|          |      | All host plants     | 87                | 0                | 87                      | 0.0         | 100.0             |
| ZiBo     | 2006 | Cotton              | 45                | 32               | 13                      | 71.1        | 28.9              |
|          |      | Morning glory       | 20                | 5                | 15                      | 25.0        | 75.0              |
|          |      | Eggplant            | 25                | 23               | 2                       | 92.0        | 8.0               |
|          |      | All host plants     | 90                | 55               | 35                      | 61.1        | 38.9              |
|          | 2007 | Cotton              | 75                | 2                | 73                      | 2.7         | 97.3              |
|          |      | Eggplant            | 48                | 7                | 41                      | 14.6        | 85.4              |
|          |      | All host plants     | 123               | 9                | 114                     | 7.3         | 92.7              |
|          | 2008 | Japanese hop        | 28                | 0                | 28                      | 0.0         | 100.0             |
|          |      | Cotton              | 29                | 0                | 29                      | 0.0         | 100.0             |
|          |      | Eggplant            | 30                | 6                | 24                      | 20.0        | 80.0              |
|          |      | All host plants     | 87                | 6                | 81                      | 6.9         | 93.1              |
| ShouGuang| 2006 | Chinese cabbage     | 60                | 23               | 37                      | 38.3        | 61.7              |
|          |      | Rosebush            | 17                | 16               | 1                       | 94.1        | 5.9               |
|          |      | Eggplant            | 30                | 1                | 29                      | 3.3         | 96.7              |
|          |      | All host plants     | 107               | 40               | 67                      | 37.4        | 62.6              |
|          | 2007 | Tomato              | 49                | 0                | 49                      | 0.0         | 100.0             |
|          |      | Cucumber            | 24                | 0                | 24                      | 0.0         | 100.0             |
|          |      | Pepper              | 25                | 0                | 25                      | 0.0         | 100.0             |
|          |      | Japanese hop        | 66                | 1                | 65                      | 1.5         | 98.5              |
|          |      | Cotton              | 98                | 13               | 85                      | 13.3        | 86.7              |
|          |      | Pumpkin             | 62                | 0                | 62                      | 0.0         | 100.0             |
|          |      | Eggplant            | 57                | 3                | 54                      | 5.3         | 94.7              |
|          |      | Sweet pepper        | 24                | 0                | 24                      | 0.0         | 100.0             |
|          |      | Chinese cabbage     | 41                | 1                | 40                      | 2.4         | 97.6              |
|          |      | All host plants     | 446               | 18               | 428                     | 4.0         | 96.0              |
|          | 2008 | Japanese hop        | 29                | 0                | 29                      | 0.0         | 100.0             |
|          |      | Cotton              | 25                | 0                | 25                      | 0.0         | 100.0             |
|          |      | Eggplant            | 30                | 0                | 30                      | 0.0         | 100.0             |
|          |      | All host plants     | 84                | 0                | 84                      | 0.0         | 100.0             |
| JiNan    | 2005 | Cotton              | 24                | 24               | 0                       | 100.0       | 0.0               |
|          | 2006 | Eggplant            | 28                | 28               | 0                       | 100.0       | 0.0               |
|          |      | Cotton              | 31                | 31               | 0                       | 100.0       | 0.0               |
|          |      | All host plants     | 59                | 59               | 0                       | 100.0       | 0.0               |
|          | 2007 | Cotton              | 47                | 18               | 29                      | 38.3        | 61.7              |
|          |      | Japanese hop        | 24                | 1                | 23                      | 4.2         | 95.8              |
|          |      | Cotton              | 29                | 0                | 29                      | 0.0         | 100.0             |
|          |      | Eggplant            | 19                | 4                | 15                      | 21.1        | 78.9              |
|          |      | All host plants     | 72                | 5                | 67                      | 6.9         | 93.1              |
| LiaoCheng| 2005 | Cucumber            | 33                | 33               | 0                       | 100.0       | 0.0               |
|          |      | Cotton              | 39                | 38               | 1                       | 97.4        | 2.6               |
|          |      | All host plants     | 72                | 71               | 1                       | 98.6        | 1.4               |
mtCOI fragment (about 620bp) was first cleaved by the restriction endonucleases VspI (Khasdan et al. 2005) and then the uncut fragment was cleaved by the restriction endonucleases StuI (Ueda 2006). All of the mtCOI that could be cut by VspI should be biotype Q and mtCOI cut by StuI should be B.

**RESULTS AND DISCUSSION**

Our results shown in Fig. 1 and Table 1 revealed the following: In 2005, the biotype of *B. tabaci* populations in JiNan, LiaoCheng, ZaoZhuang were determined and biotype Q was only found in LiaoCheng in very low proportion (1.4%). In 2006, biotype Q was found in DeZhou (38.0%), ZiBo (38.9%), ShouGuang (62.6%), LiaoCheng (37.1%) and was absent in JiNan, LinYi and ZaoZhuang. By 2007, biotype Q dominated in most locations, DeZhou (71.8%), ZiBo (92.7%), ShouGuang (96.0%), LiaoCheng (92.4%), and biotype Q also was found in JiNan (61.7%) and LinYi (5.6%). In 2008, Q biotype comprised 100.0%, 93.1%, 100.0%, 97.7%, 89.1% and 100.0% of the *B. tabaci* population in DeZhou, ZiBo, ShouGuang, JiNan, LiaoCheng, LinYi and ZaoZhuang, respectively.

The present results are consistent with previous research on cotton and eggplant (Chu et al. 2010). These results suggest that the changes of *B. tabaci* biotypes occurred not only on the cotton and eggplant but also on the other plants including crops and weeds in Shandong Province during the past several years.

The displacement mechanism of biotypes Q and B remains uncertain, though the increase of biotype Q in many countries may be due to application of insecticides because biotype Q possesses greater resistance to insecticides than biotype B, but ecological and economic factors should be also considered. For example, the host plants that biotype Q preferred also might mediate the competi-

| Location | Year | Host plant | Total individuals | Number of biotype | Percentage of biotype (%) |
|----------|------|------------|--------------------|-------------------|---------------------------|
|          |      |            |                    | B     | Q | B     | Q |
| JiNan    | 2006 | Winter squash | 27                | 23     | 4 | 85.2 | 14.8 |
|          |      | Cotton      | 28                | 13     | 15 | 46.4 | 53.6 |
|          |      | Morning glory | 11               | 10     | 1  | 90.9 | 9.1  |
|          |      | Eggplant    | 26                | 13     | 13 | 50.0 | 50.0 |
|          |      | Cucumber    | 24                | 14     | 10 | 58.3 | 41.7 |
|          |      | All host plants | 116             | 73     | 43 | 62.9 | 37.1 |
|          | 2007 | Cotton      | 54                | 0      | 54 | 0.0  | 100.0 |
|          |      | Eggplant    | 51                | 8      | 43 | 15.7 | 84.3 |
|          |      | All host plants | 105            | 8      | 97 | 7.6  | 92.4 |
|          | 2008 | Japanese hop | 30                | 1      | 29 | 3.3  | 96.7 |
|          |      | Cotton      | 30                | 0      | 30 | 0.0  | 100.0 |
|          |      | Eggplant    | 26                | 1      | 25 | 3.8  | 96.2 |
|          |      | All host plants | 86              | 2      | 84 | 2.3  | 97.7 |
| LinYi    | 2006 | Cotton      | 28                | 28     | 0 | 100.0 | 0.0 |
|          |      | Eggplant    | 29                | 29     | 0 | 100.0 | 0.0 |
|          |      | Cucumber    | 8                 | 8      | 0 | 100.0 | 0.0 |
|          |      | All host plants | 65             | 65     | 0 | 100.0 | 0.0 |
|          | 2007 | Cucumber    | 13                | 11     | 2 | 84.6 | 15.4 |
|          |      | Cotton      | 21                | 21     | 0 | 100.0 | 0.0 |
|          |      | Eggplant    | 20                | 19     | 1 | 95.0 | 5.0 |
|          |      | All host plants | 54             | 51     | 3 | 94.4 | 5.6 |
|          | 2008 | Cotton      | 26                | 1      | 25 | 3.8  | 96.2 |
|          |      | Eggplant    | 20                | 4      | 16 | 20.0 | 80.0 |
|          |      | All host plants | 46             | 5      | 41 | 10.9 | 89.1 |
| ZaoZhuang| 2005 | Cucumber    | 30                | 30     | 0 | 100.0 | 0.0 |
|          | 2006 | Cucumber    | 29                | 29     | 0 | 100.0 | 0.0 |
|          | 2008 | Pepper      | 26                | 0      | 26 | 0.0  | 100.0 |
|          |      | Japanese hop | 29                | 0      | 29 | 0.0  | 100.0 |
|          |      | Cotton      | 29                | 0      | 29 | 0.0  | 100.0 |
|          |      | Eggplant    | 24                | 0      | 24 | 0.0  | 100.0 |
|          |      | All host plants | 108            | 0      | 108 | 0.0 | 100.0 |
tion of B and Q. Multiple introduction of biotype Q from the other provinces or regions through human activities or natural sources should not be neglected.

Overall, our present result showed that the biotypes of B. tabaci changed greatly and B. tabaci biotype Q has been increasing on all kinds of hosts during the past several years. The displacement of biotypes B by Q has been occurring in the province as a whole. The speed of the displacement of biotypes B and Q was fast and essentially a cryptic invasion (Geller et al. 1997) because the biotypes are morphologically indistinguishable. The displacement mechanism should be further researched and such knowledge might guide the application of the insecticides or adjustment of the crops to effectively control the pest. Differentiation of B. tabaci biotypes is important, and molecular markers are important discrimination tools.

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