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Dynamic distribution of *Aphis gossypii* Glover (Homoptera: Aphididae) and incidence of viral disease in different zucchini (*Cucurbita pepo* L.) cultivars

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ABSTRACT

China is the country with the highest level of zucchini production globally. However, the cultivation of resistant zucchini varieties in China is still limited, and there is still a need to isolate more varieties of high quality. This study aimed to evaluate the abilities to resist aphids (*Aphis gossypii* Glover) and viral diseases in different varieties of zucchini. There were few aphids in variety SX-FRI08 and the lowest number in variety Algeria, while variety HeiYuan exhibited the highest number. Regarding the ability to resist diseases, a clearly lower disease index of aphid-spread viral diseases was exhibited in variety HeiYuan than in the other five varieties, while the disease index of variety Algeria was relatively high. In conclusion, the ability to resist aphids was not consistent with the ability to resist disease in zucchini. Varieties with a slow transformation rate and mild disease phenotype in the late growth stage had strong ability to resist disease.

1. Introduction

Zucchini (*Cucurbita pepo* L.) is a common vegetable cultivated in northern China, with its cultivation area being second only to cucumber among all melon vegetables (Liao et al., 2005). In zucchini fields, pests with sucking mouthparts, especially *Aphis gossypii* Glover, have been considered to be the main cause of plant damage, seriously influencing zucchini production (Messing and Klungness, 2002). As major pests all over the world, aphids not only cause direct damage by feeding, but also lead to infection by acting as viral vectors (Brault et al., 2007). It has been reported that *Myzus persicae* Sulzer, *Aphis gossypii* Glover, *Aphis spiraecola* Patch, and *Uroleucon ambrosiae* Thomas could transmit zucchini yellow mosaic virus from zucchini to *Cucumis melo* L. (Orozco-Santos et al., 1995). Therefore, there is an urgent need to establish new techniques for preventing aphid infestation and for treating it when it occurs.

Chemical pesticides have long been widely used as an effective approach for preventing aphid infestation (Ayala et al., 1996). However, the accumulation of pesticide residue due to overuse of chemical pesticide has become a major issue (Wu, 2005). Various strategies have been applied to avoid the use of chemical pesticides, such as improving planting, environmental interventions, and introducing natural enemies. As reported previously, potato, sugar beet, and soybean intercropping had good effects on controlling soybean aphid in Heilongjiang, China (Shi, 2012). In addition, reflectorized spray mulch can also reduce the loss of zucchini yield induced by aphid-vectored viral diseases (Stapleton et al., 1994). Moreover, polyphagous invertebrate predators could control cereal aphids and prevent reductions of wheat yield and quality (Holland and Thomas, 2008). Basically, the natural ability to resist threats that plants have acquired over the course of evolution is considered the most ideal strategy to control pests in the absence of pesticide (NS et al., 2006). The resistant plant varieties are not only effective for preventing aphid infestation, but also benefit the continuous development of agriculture, as well as helping to protect the environment by reducing the need to use pesticides (Zhang, 2005). Recently, with the development of molecular marker technology, the promotion of vegetable quality through gene improvement has become increasingly effective, which has greatly contributed to the establishment of aphid- and disease-resistant plants in modern

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agricultural breeding (Carena, 2008). China is the country with the highest level of zucchini production globally. However, the cultivation of resistant zucchini varieties in China is still limited, and there is still a need to isolate more varieties of high quality. In this study, a total of six zucchini varieties were isolated, and their abilities to resist aphids and viral diseases were identified and compared. Our findings may reveal the relationship between aphids and viral diseases in zucchini, which could provide useful information for cultivating resistant varieties and preventing plant diseases and infestation by insect pests.

2. Materials and methods

2.1. Plants and field experimental design

The seeds of six varieties of zucchini seeds, namely, Algeria, SX-B2, HeiYuan, SX-FRI08, ZaoQingYiDai (ZQ), and SX-O4-08, were provided by the Horticulture Institute of the Shanxi Academy of Agricultural Sciences (Shanxi, China).

Field experiments were conducted on experimental farmland at Shanxi Agricultural University, Shanxi Province, China, in 2008. A total of 30 plants of each variety were planted in a plot (area: 3×6 m; row space: 70×70 cm). A randomized block design with three replications was used. The growth areas of zucchini were covered with mulching film in double rows and protected with guard rows. Conventional field management was applied, and no pesticide was sprayed during the growing season.

2.2. Aphid sampling

To quantify the aphid populations on six zucchini varieties, five plants at similar growth stages in each plot were selected by a parallel jump sampling method for aphid sampling. When there were fewer than three leaves, the number of all aphids was recorded. When there were more than three leaves, the number of aphids on each of the three more recently emerged spread leaves was accurately recorded. If the aphids numbered more than 100, a visual estimation method was used. Only *Aphis gossypii* was counted. This survey was performed once every 3 days from May 18th to July 8th for 18 sampling dates.

2.3. Viral disease investigation

The incidence of viral diseases was determined when viral disease symptoms were observed. An increase in disease severity on lobus cardiacus was regarded as disease progression. This was surveyed once every 3 days from June 11th to July 14th. The classification criteria of disease severity are shown in Table 1. The viral disease severity is expressed using the disease index:

$$\text{Disease index} = \frac{\sum(\text{number of diseased plants} \times \text{related level})}{\text{Total plant number} \times \text{highest level}} \times 100$$

3. Results

3.1. Dynamic distribution of aphids on six zucchini varieties

In general, the number of aphids on six zucchini varieties dramatically increased on June 11th, with a peak on June 17th, and then dropped quickly until June 23rd. Among the six varieties, the total number of aphids was found to be highest on variety HeiYuan and lowest on Algeria. The occurrence of aphids in all varieties at the peak time was ranked as follows: HeiYuan > SX-B2 > ZQ > **S**X-O4-08 > SX-FRI08 > Algeria (Fig. 1).

3.2. Dynamic occurrence of viral disease in six zucchini varieties

The overall incidence of chlorotic type in six varieties first increased and then decreased. Early disease onset was found in the varieties Algeria, SX-B2, HeiYuan, and ZQ, and late disease onset was found in the varieties SX-FRI08 and SX-O4-08. Meanwhile, the varieties Algeria, SX-B2, and HeiYuan exhibited an early incident peak, while SX-FRI08 and ZQ exhibited a late one. Early chlorotic symptoms always transformed into a more severe disease stage, thereby reducing the percentage of chlorotic symptoms. The ability of zucchini varieties to resist diseases of the chlorotic type showed the following order: SX-O4-08 > ZQ > SX-FRI08 > Algeria > SX-B2 > HeiYuan (Fig. 2A).

For the mosaic type, the incidence markedly increased on June 20th and then dropped quickly on July 5th. The disease onset was early in variety SX-B2 and late in Algeria and SX-FRI08. Meanwhile, the incidence rate was low in variety Algeria and high in variety ZQ. On June 20th, the chlorotic symptoms of varieties Algeria, SX-B2, HeiYuan, and SX-O4-08 began to transform rapidly to the mosaic type, leading to more severe disease symptoms. The varieties with a late peak of chlorotic type also exhibited a late incidence of mosaic

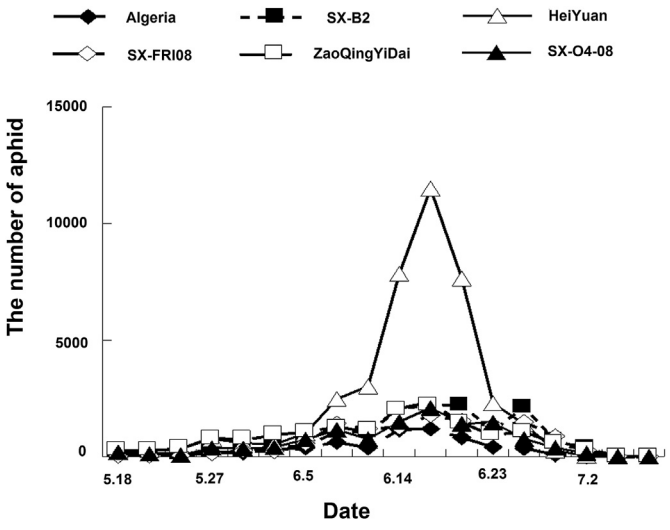

Fig. 1. The dynamic distribution of aphids (number) on six zucchini varieties.

Table 1
Classification criteria of viral disease in zucchini.

Classification	Criteria
Grade 0	No symptoms
Grade 1 (chlorotic type)	Imbalance chlorosis and obscure faint yellow spots in lobus cardiacus
Grade 3 (mosaic type)	Small mosaic spots of varying shades in lobus cardiacus
Grade 5 (shrinkage type)	Abnormal lobus cardiacus in unobvious chicken-feet shape
Grade 7 (chicken-feet type)	Severe abnormal lobus cardiacus in linear chicken-feet shape.