Resistance of citrus crops in Abkhazia to damage by the woolly whitefly *Aleurothrixus floccosus* (Maskell)

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**Abstract.** Citrus crops are the most important among subtropical crops in the Republic of Abkhazia. In 2019-2020 a new pest was discovered in the citrus agrocenosis of Abkhazia – the woolly whitefly *Aleurothrixus floccosus* (Maskell). The pest has been identified in all regions of the country. The degree of damage to mandarin on industrial plantations reaches 50% and more. An assessment of the resistance of 79 varieties of citrus crops from the collection of the Institute of Agriculture of the Academy of Sciences of Abkhazia to damage by a woolly whitefly (Gulrypsh district of the Republic of Abkhazia) was carried out. The degree of damage to citrus genotypes was different. It was found that the most affected varieties are *Citrus limon* (L.) Osbeck, as well as *C. × meyeri* and *C. aurantifolia* Sw. Tangerine, orange varieties (*Hamlin*, *Maro* and *Grushevidny Koroliok*) and pompelmus varieties (*Mato Buntan*, *Natsu mican*, *Meteleva*) are the least damaged.

1. Introduction

In modern agriculture of the Republic of Abkhazia, citrus crops occupy a leading place, among which satsuma mandarin (*Citrus reticulata* subsp. *unshiu* (Marcow.) D. Rivera & al.) Is the main industrial crop. Mandarin agrocenoses occupy more than 90% of the areas occupied by citrus crops [1]. Less common crops are lemon (*Citrus limon* (L.) Osbeck), orange (*Citrus sinensis* (L.) Osbeck) and grapefruit (*Citrus paradisi* Macfad.).

Pests play a significant role in the cultivation of citrus crops [1-5]. The extent of their distribution and development affects the quantity and quality of the crop. More than 50 pest species have been recorded on citrus crops in the Black Sea region of the Caucasus [2; 5-7]. The harmfulness of phytophages on citrus crops is different. Only 20 pests species negatively affect the growth, development and fruiting of citrus crops, of which 14 can be attributed to frequently occurring ones. Most species belong to the sucking pest. The five most harmful species in recent years include citrus rust mite *Phyllocoptruta oleivora* (Ashm.), citrus cottony scale *Chloropulvinaria auranti* Ckll., citrus whitefly *Dialeurodes citri* (Ashmead), citrus leafminer *Phyllocnistis citrella* Stainton, brown marmorated stink bug *Halyomorpha halys* (Stål) [5].

Woolly whitefly *Aleurothrixus floccosus* (Maskell) – is a neotropical species (probably from South America). The pest has a wide invasive range: the USA, the Canary Islands, Africa, the Middle East, India, Singapore, Taiwan, the Philippines, and Japan. In the early 1970s *A. floccosus* was reported in
Spain and southern France, and it was later recorded in Morocco, Portugal, Italy and Malta [8]. It is absent in Australasia and Hawaii [9]. *A. floccosus* is a serious pest of citrus in many parts of the world [8, 10]. Until our research, the woolly whitefly was not detected in Abkhazia.

It is known that the species and varietal resistance of tree crops is one of the main mechanisms of perennial plantations stability [11]. In the system of managing the agrocenoses phytosanitary state, an important role is played by measures for the use of varieties resistant to unfavorable biotic factors [12]. They are a powerful lever with the help of which it is possible to regulate the pests number in the long term and provide protection of plants from them without the chemicals use [13]. Resistance of variety can be considered with complete confidence as an element of integrated plant protection [14].

For some pests of citrus crops in different regions, the attractiveness of the citrus genotypes was investigated. These data were then used to build plant protection systems [15; 16].

The purpose of current research is to assess the degree of damage by the woolly whitefly – a new invasive pest – of various citrus crops varieties grown in the Republic of Abkhazia.

2. Materials and methods

The study of the pests species diversity on citrus crops was carried out in the genetic collection of citrus crops of the Institute of Agriculture of the Academy of sciences of Abkhazia (Gulrpysh district) and in industrial satsuma mandarin gardens in all districts of Abkhazia in the period from 2015 to 2020.

Regular surveys were carried out from April to October using the route method, monthly [17; 18]. The assessment of the varieties resistance to pests was carried out according to generally accepted methods [19; 20] in collection plantations, where plants of different genotypes were in the same field conditions.

The degree of damage to plants by the *A. floccosus* was assessed using a scale:

- 0 – no damage;
- 1 point – damage covers up to 5% of leaves;
- 2 points – damage covers up to 5-25% of leaves;
- 3 points – damage covers up p to 26-50% of leaves;
- 4 points – damage covers up to 51-75% of leaves;
- 5 points – damage covers up to 76-100% of the leaves.

When assessing the degree of damage, from 3 to 7 plants of each genotype were examined, the average damage score was determined as an arithmetic mean.

3. Results

In the course of regular phytosanitary surveys, wax-coated whitefly colonies began to be detected in satsuma mandarin agrocenoses, as well as on lemons and oranges. Visually, they significantly differed from other whiteflies known in Abkhazia (from *Trialeurodes vaporariorum* Westwood, *Dialeurodes citri* (Ashmead) and others). When studying morphological characters, it turned out that the new whitefly is *Aleurothrixus floccosus* (Maskell).

For the first time on the territory of Abkhazia, woolly whitefly colonies were discovered by us in the spring of 2017 in satsuma mandarin gardens in the Sukhum district (Gumista village). This indicates that the first foci of the pest were already on the territory of Abkhazia in 2016. However, the identification of the species was carried out only in 2020.

In 2020, the pest was already found in industrial plantations of mandarin in all regions of the country (table 1).

During the year, the first woolly whitefly colonies were observed in June, followed by a rapid increase in the pest population. The maximum development of the colony was reached by September, when more than 50% of the leaves were damaged in the industrial mandarin plantings in most districts of Abkhazia. When populating citrus trees, all other things being equal, the pest prefers to populate the
leaves of the shoots of the last growth. All other things being equal, the pest chooses leaves on the last growth shoots.

**Table 1.** Damage to mandarin (*Citrus reticulata* subsp. *unshiu*) by woolly whitefly *Aleurothrixus floccosus* (Maskell) in industrial gardens, Abkhazia, 2020.

| District of Abkhazia | April | May | June | July | August | September | October |
|---------------------|-------|-----|------|------|--------|-----------|---------|
| Gal                 | 0     | 0   | 0    | 1.9  | 2.8    | 4.0       | 4.0     |
| Tkuarchal           | 0     | 0   | 0.5  | 2.1  | 3.0    | 3.8       | 3.8     |
| Ochamchira          | 0     | 0   | 0    | 1.9  | 3.1    | 3.1       | 3.1     |
| Gulrypsh            | 0     | 0   | 0.5  | 2.0  | 3.3    | 4.0       | 4.0     |
| Sukhum              | 0     | 0   | 0.5  | 2.0  | 3.0    | 3.2       | 3.2     |
| Gudauta             | 0     | 0   | 0    | 1.0  | 2.1    | 3.0       | 3.0     |
| Gagra               | 0     | 0   | 0.5  | 2.1  | 2.9    | 3.3       | 3.3     |

It is noted that an increase in the woolly whitefly population has led to a decrease in the citrus whitefly *Dialeurodes citri* population.

The citrus crops collection in the Institute of Agriculture of the Academy of Sciences of Abkhazia has 100 genotypes. Of these, 79 genotypes were examined for damage by the woolly whitefly. All citrus species, varieties and hybrids included in the study were damaged by the pest. The degree of damage of various genotypes was different.

The genotypes of the lemon group turned out to be the most attractive for the woolly whitefly among others (table 2). Average degree of damage was 3.2. The most affected were the Novoafonsky, Novogruzinsky, Novozelandsky and Meyer's lemon varieties. The least damaged varieties were Interdenato and Uvarovsky (average score 2.5).

**Table 2.** Resistance of lemon genotypes (collection of Institute of Agriculture of the Academy of Sciences of Abkhazia) to woolly whitefly, Abkhazia, Gulrypsh district, 2020.

| Degree of damage | Varieties of *C. limon* (point) |
|------------------|---------------------------------|
| 2.1 – 3.0        | Interdenato (2.5), Uvarovsky (2.6), Pavlovsky (2.7), Ponderosa (2.7), Santa Teresa (2.8), Del Brasil (2.8), Odishi (2.8), Maikopsy (2.9), cv. Chakyvadze (3.0), Villa Franka (3.0), Kuznera (3.1), Udarnik (3.3), Hybrid 24517 (3.4), Turetsky (3.5), Ital’yansky (3.5) |
| 3.1 – 4.0        | Hybrid 31575 (3.6), Hybrid 31375 (3.6), Kropnoplodny (3.6), Novozelandsky (3.7), Novogruzinsky (3.9), Novafoamy (3.9), C. meyeri Yu.Tanaka (3.9) |

*A. floccosus* damaged the genotypes of the mandarin group to a somewhat lesser extent (table 3). The average score for damage to the mandarin group was 2.3. The most resistant were tangerine, mandarin varieties of the Abkhaz selection *Olympiyskiy* and *Kolkhidskiy*, clementine (*Citrus clementina* Hort. ex Tan.), hybrid 7381. Calamondins (*Citrofortunella mitis* (Blanco) J. Ingram & H.E. Moore) were most damaged.

Other citrus genotypes were damaged to a lesser extent (table 4). Thus, the average damage score for pompelmus was 1.7, for grapefruits and oranges – 2.0. The most resistant to damage by woolly whitefly genotype of citrus crops – *C. maxima* cv. *Mato Buntan*. The closely related species *Fortunella marginala*, represented by cv. *Nagami*, is quite resistant to the pest.

4. Discussion

It is obvious that *A. floccosus* has adapted to the territory of Abkhazia. The aggressive behavior of the pest, leading to the displacement of other species of insects, raises concerns. The question of its biology and trophic connections remains to be clarified.
Table 3. Resistance of mandarin genotypes (collection of Institute of Agriculture of the Academy of Sciences of Abkhazia) to woolly whitefly, Abkhazia, Gulrypsh district, 2020.

| Degree of damage | Varieties of mandarin genotypes (point) |
|------------------|----------------------------------------|
| 1.1 – 2.0        | *Citrus tangerina* Tanaka (1.3); *C. reticulata* subsp. *unshiu*: Olimpiysky (1.5), Kolchidsky (1.6), Hybrid 7381 (1.6), Kitaisky №1 (1.8), Kitaisky №2 (1.9), Izeki Wase (1.9), Kodorsky (1.9), Tkhinsky (2.0), Ochi Wase (2.0), Hybrid 6315 (C. reticulata subsp. unshiu × C. sinensis) (2.0); C. × *clementina* (1.6); *C. reshni* Tan. cv. Cleopatra (1.7) |
| 2.1 – 3.0        | *C. reticulata* subsp. *unshiu*: Yubileyny (2.2), Apsny (2.4), Hybrid 17025 (2.4), Millenium 1 (2.4), Millenium 2 (2.5), Krasnodarsky-83 (2.5), Chemomorsky (2.5), Slava Vavilova (2.5), cv. Tsvizhba (2.6), Iveria (2.6), Pioneer 80 (2.8), Kowano Wase (2.8), Miygava Wase (2.8), Sentjabrsky (2.9), Krasnodarsky (2.9), cv. Sabekia (2.9), Sochinsky 23 (2.9), Kokhorsky (3.0), Krunoplodny (3.0), Unshiu Shirokolistny (3.0); *C. junos* Siebold ex Tanaka (2.5) |
| 3.1 – 4.0        | *Citrofortunella mitis* (Blanco) J. Ingram & H.E. Moore (3.3) |

Table 4. Resistance of citrus genotypes (collection of Institute of Agriculture of the Academy of Sciences of Abkhazia) to woolly whitefly, Abkhazia, Gulrypsh district, 2020.

| Degree of damage | Varieties of citrus genotypes (point) |
|------------------|---------------------------------------|
| 0 – 1.0          | *Citrus maxima* (Burm.) Merr.: Mato Buntan (0.3) |
| 1.1 – 2.0        | *C. maxima*: Meteleva (1.1), Natsu mican (1.4), Variegata (1.5); *C. paradisi* Macfad.: Hybrid 7368 Gray (1.7), Hybrid 7391 Gray (1.7); *C. sinensis* (L.) Osbeck: Moro (1.3), Hamlin (1.5), Grushevsky Koroliok (1.5), Krasnomjasy (2.0); *Citrus japonica* Thunb. (syn. *Fortunella margarita* (Lour.) Swingle): Nagami (1.6); *C. aurantium* L. (1.8) |
| 2.1 – 3.0        | *C. maxima*: Gulripshsky (2.5), Sambocan (2.5), Schaddock (2.6); *C. paradisi*: Seeds (2.1), Yubileyny (2.3); *C. sinensis*: Thomson Navel (2.2), Abkhazsky (2.8), Washington Navel (2.9); C. × *bergamia* Risso & Poit. (2.8) |
| 3.1 – 4.0        | *C. aurantifolia* (Christm.) Swingle (3.4) |

The available literary sources provide some information about the varietal preferences of the woolly whitefly. The preference of one or another genotype depends on the assortment of citrus crops and the region of their cultivation. Thus, differences in damage to orange varieties in Nigeria are indicated [21], while in Ethiopia, no differences in damage to different citrus species were found [22]. There is evidence that with a high degree of polyphagy *A. floccosus* in Japan does not attack citrus fruits at all [23], and in the Mediterranean region feeds only on these crops [24].

The results of studying the varietal attractiveness of citrus crops for the woolly whitefly in the conditions of Abkhazia showed that the pest is selective in relation to the species and varieties of citrus crops. The data obtained are significant for understanding the biology of the pest, planning the implementation of protective measures. Obviously, in the future, when building a protection system for citrus crops collection of the Institute of Agriculture, the main attention should be paid to lemon varieties.

5. Conclusion

Thus, all genotypes of citrus crops preserved in Abkhazia are damaged by the woolly whitefly. In the presence of different genotypes, lemon genotypes are the most attractive to the pest. When constructing plant protection systems, it should be assumed that the preferred crops for the pest are lemon and mandarin.
The effectiveness of plant protection products against the woolly whitefly will be further studied.

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