Bonitet assessment of graft-rootstock combinations of apple tree varieties in the conditions of the Central Chernozem region

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Abstract. The study and analysis of the condition of garden plantings is the most important stage in assessing their profitability and determining the feasibility of further production. Bonitet assessment and inventory are one of the options for such an assessment. The paper presents various methods of assessing graft-rootstock combinations of apple trees in the conditions of the Central Chernozem region. The bonitet class of garden plantings has been determined, the growth characteristics of trees and their relationship with the sub-tree inventory and bonitet assessment of graft-rootstock combinations have been analyzed.

1. Introduction

The use of digital technologies in the cultivation of agricultural crops in terms of the use of automated control systems and decision support systems allows for monitoring about 60% of crop losses. The use of precision farming technologies that are used at all stages of crop cultivation are one of the key elements of this control system [1].

Studies in the field of intensive horticulture determine the need to optimize the amount of solar radiation received by fruit trees during their growth. Besides, timely allocation of the area of infection reduces the loss of production and the area of distribution. Detection of defective poorly developing rootstocks in the early stages will allow a specialist to choose a less expensive way of solving the problem, for example, increasing the supply of nutrients, treatment with growth regulators, etc. These factors determine the need for research on the formation of a fruit tree crown in the process of its growth and development.

Currently, planting fruit trees in Russia has been actively promoted due to the active import substitution. This requires a large amount of planting material, since planting is carried out using intensive technologies with a high density of trees per hectare (more than 1000 trees). In addition, there is a high need for garden-friendly land, since fruit trees grow in one place for more than ten years, and during this time they are exposed to all kinds of stress factors, both during the growing season and in winter. Minimizing the aftereffects of stress and preserving the yield and its high quality is possible through the use of highly adaptive varieties and rootstocks, the most favorable zones for their cultivation, as well as various agrotechnological techniques [1-3].

It is believed that the methodology and categories of this scientific approach have been successfully tested for the intensification of field cultivation, but are not yet fully implemented in horticulture [3].

The existing methods for diagnosing the stability and productivity of productive garden agrocenoses are labor-intensive and long-term, although it is the state of plantings that allows us to assess the plots
used, especially in the regions where conditions do not allow for large areas to be cultivated, and microzones have to be used in horticulture [4, 5].

Data on the condition of plants and plantings in general have so far been obtained as a result of expeditions involving surveys of large areas. A quarterly survey of all plantings is carried out in farms. Previously unused areas are studied on the basis of historical data using expeditionary biological methods, and the assessment is based on the presence and condition of existing wild fruit crops [5]. A large amount of data is paper-based and requires subsequent manual processing [4, 6].

The purpose of our research is to carry out the bonitet assessment of the stability of graft-rootstock combinations of scab-immune apple varieties growing in the Michurinsky district of the Tambov region. We have also set the task of developing methodology for using quadrocopters in the inventory of garden agrocenoses and to determine the compliance of the bonitet classes established during expeditions and using digital technologies.

2. Materials and methods
Expedition surveys were conducted in 2019-2020 in the plantings of scab-immune varieties, selected by the Federal Research Center named after I.V. Michurin. The trees were planted in the Research Educational Center named after V.I. Budagovsky of Michurinsk State Agrarian University in autumn of 2016 in a 6x3 m planting scheme. Rootstock 54-118. The inventory of plantings and determining bonitet classes have been carried out using the methodology of V.A. Potapov et al. [7], L.V. Bobrovich [1].

3. Results and Discussion
The acute shortage of fresh fruits and the need for the fastest possible return of the crop by plantings on the one hand, and the need to obtain environmentally safe products on the other hand, create the need to use different varieties in plantings of different types. A comprehensive description of plantings in specific soil and climatic conditions is necessary in order to recommend certain varieties and designs to producers.

The inventory and bonitet assessment of plantings of scab-immune varieties was carried out during their entry into fruiting, when the features of growth processes and biometric indicators become the most typical for a variety.

An expedition survey of the plantings showed that the plants are in excellent condition, as evidenced by the high class of the bonitet (Table 1).

| Variety      | Surveyed planting spots, pcs. | Normally developed trees, pcs. | Inventory score on a 100-point scale, points | Bonitet Class | Name  |
|--------------|-------------------------------|--------------------------------|---------------------------------------------|---------------|-------|
| 1. Akademik Kazakov | 429                           | 385                            | 89.7                                        | I high        |       |
| 2. Vympel   | 429                           | 423                            | 98.6                                        | I high        |       |
| 3. Vishnevaya | 344                           | 314                            | 91.3                                        | I high        |       |
| 4. Byлина   | 516                           | 498                            | 96.5                                        | I high        |       |
| 5. Fregat   | 516                           | 495                            | 95.9                                        | I high        |       |
| 6. Flagman  | 430                           | 402                            | 93.5                                        | I high        |       |

For the Vympel variety, the inventory score is close to the maximum – 98.6 points out of 100. The Akademik Kazakov variety has an inventory score below 90 points, and the condition of the Vishnya variety is estimated slightly above 90 points – 91.3. It should be noted that poor development and death
of trees was often associated not with the biological characteristics of a variety, but with mechanical damage.

In our research we have also analyzed the growth characteristics of trees and their relationship with the sub-tree inventory and bonitet assessment of graft-rootstock combinations (Figure 1).

![Figure 1. Growth characteristics of graft-rootstock combinations, November 2020](image)

Variatel differences in the crown habitus are clearly traced. The varieties Akademik Kazakov and Vympel form the most voluminous crown, significantly surpassing the other varieties in both height and width of the crown. The most sprawling crown, with an angle of branch union of almost 90°, is characteristic of the variety Akademik Kazakov. The most compact crowns in the conditions of the studies areas are formed by trees of the Vishnya variety.

By the fourth year of life, the average height of trees makes 170 cm with a crown width of 110 cm. The same compact crown is characteristic of the Bylina variety, which forms the most elongated, oval crown. The crown of the Fregat variety is 110 cm wide, but it is more spreading than that of the Bylina variety, an angle of branch union is almost 90°, the shoots are thick. Trees of the Flagman variety form an oval, elongated crown. Such biological and varietal characteristics should be taken into account when using drones and drawing conclusions about the development of plants. A high bonitet class indicates a high stability of the combinations in specific cultivation conditions, while the growth characteristics can vary greatly.

The results of application of this method provide quite informative indicators that assess the state of the garden, but its use requires significant time and labor. To reduce these costs, it is planned to use a quadrocopter that takes pictures of the object from a distance of up to 500 m (in some cases, the distance to the object can be reduced to the minimum allowed). In addition, video recording can be performed with the help of quadrocopters. The flight duration is from 18 minutes under normal weather conditions [8-10].

The video signal is transmitted over a digital channel in HD format and stored on a removable media. To obtain reliable data determined by the research purpose, the quadrocopter should fly over the garden at an extremely low altitude – from 2 m, depending on the age of the garden, while the flight speed should not exceed 1 m/s. Images of the garden and trees are obtained using the DJI Zenmuse X3 camera.
4. Conclusion
The conducted research and comparison of the methods confirms the need for different approaches to assessing the state of plants in the garden and the stability of garden agrocenoses in general. The use of drones will allow improving the process of inventory and bonitet assessment and to get a large amount of data on the state of specific graft-rootstock combinations in real time.

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