Analysis of taxation assessment results and development of a method for applying digital technologies in the assessment of garden agrocenoses stability

Z N Tarova, L V Bobrovich, I P Krivolapov, A Yu Astapov, A A Korotkov and K S Grechushkina
Michurinsk State Agrarian University, Michurinsk, Russia

E-mail: ivan0068@bk.ru

Abstract. The authors analyze the results of tree taxation of different apple trees varieties on the territory of I V Budagovsky research and development center at Michurinsk State Agrarian University. The plantation valuation and the establishment of locality class were carried out using the methodology of Michurinsk State Agrarian University. Studies have shown that class quality of the garden can be characterized as high – from 85 to 100 points, which corresponds to the first class of quality. Thus, all graft-rootstock combinations are normally developed, while it was found that within the studied population for a number of graft-rootstock combinations the percentage of normally developed trees is on the verge of transition to a lower quality class. The authors proposed a method for developing a program to automatically determine the state of each tree based on using digital recognition technology, the proposed technology will significantly reduce time and labor costs and exclude the subjective assessment factor.

1. Introduction
Currently, areas in the field of agricultural production are actively developing, this fact makes it possible to change traditional technologies to high-tech production, data obtained from various sensors and automated control devices (meteorological observations, sensors for monitoring the state of animals, positioning sensors, etc.) allow to elicit certain patterns for growth and development of plants and animals, operation of agricultural machinery, and therefore try to control the basic processes in the agricultural sector.

According to preliminary estimates, the total minimum economic effect from the introduction of IoT technology in the agricultural sector for the period up to 2025 may amount to about $ 6.4 billion due to optimization of personnel costs, loss reduction of crop, fuel and lubricant materials [1,2].

Gardening, being the most complex industry in terms of technology for growing, storing and processing products, still has the status of the most important, since the products manufactured in the industry form the basis for ensuring a healthy diet for the population. Therefore, when it comes to import substitution, the priority is primarily determined by gardening [3, 4].

Underperformance of gardening at the present stage is due to many agroecological and socio-economic problems, and, in particular, unfavorable climate and environmental conditions over a large territory of the country. Most of the extensive gardens were established in the last century and the yield capacity of plantings does not reach their potential. By now the area of planting gardens using intensive and super intensive technologies is increasing, new rootstocks and varieties are being used [5].
To organize technological operations in the gardens cultivated with the use of the above-mentioned technologies, production workers need information about the quality condition of trees in a particular plantation or its part. The valuation procedure, which is carried out on the basis of plantation taxation, can provide technologists with such knowledge. The assessment system was proposed at the end of the last century by A S Devyatov (1985) and in the application to apple plantations was significantly expanded and modified by the staff of Michurinsk State Agrarian University [6,7].

L V Bobrovich [7] recommended to use the methodology of one-point subtree taxation and a 100-point assessment scale of valuation with subsequent gradation into 4 classes: 1. 86-100 points – “high”; 2. 71-85 points – “good”; 3. 56-70 points – “satisfactory”; 4. less than 56 points – “unsatisfactory”.

M V Pridorogin [8] recommends taking into account structural and ecological features of garden landscape when evaluating gardens, which will allow a comprehensive assessment of gardens and territories they occupy.

This kind of data is usually obtained as a result of expeditionary research involving surveys of vast areas, quarterly rounds of all plantations of the farm, marks in the corresponding journal, followed by manual data processing [7, 9].

Research in the field of intensive gardening determines the need to optimize the amount of solar radiation received during the growth and development of a fruit tree, and the timely isolation of the disease infection section allows to reduce loss of production and distribution area. Detection of defective weakly developing rootstocks in the early stages will allow the specialist to choose a less costly way to correct the situation (increase the supply of nutrients, treatment with growth regulators). These factors determine the need for research on training of a fruit tree crown during its growth and development.

Digitalization and automation of the largest number of technological processes is becoming a requirement of the 21st century. Development of new Internet products, significant achievements in creation of various robots, use of drones create conditions for the transformation of methodological approaches to solving issues of assessing the fruit plantations state grown according to any of the technologies adopted in the economy.

The purpose of our research is to conduct a taxation assessment of the garden of graft-rootstock combinations and to develop a technique for using a quadcopter for taxation of garden agrocenoses with possibility of using an automated recognition system.

2. Materials and research methods

Plantings taxation and quality class establishment were carried out using the methodology developed by V A Potapov and L V Bobrovich [6].

The research was carried out on the basis of V I Budagovsky research and development center, located at the address: Michurinsk, Tambov region, Russia, within the boundaries of the educational farm “Komsomolets”.

This center was created in 2014 with the aim of forming modern cultivation areas for various crops and breeds using the latest technologies for fruit and berry production for the effective conduct of educational process at a high professional level [10].

For the research we used a sector of an apple orchard of graft-rootstock combinations with an area of 2 hectares (figure 1).

The structure of the sector is as follows:

- Rows 1-4 (sector “Model Garden”): planting according to the scheme 6×3 (the distance between the rows is 6 meters, between the trees – 3 meters), the length of the field is about 170 meters, the number of trees planted in the indicated rows is 55 pieces, all varieties planted in the spring of 2015 at the age of two years, the distribution of varieties is as follows:
  - Row 1 – “Lobo”
  - Row 2 – “Spartan”
  - Row 3 – “Martovskoe”
  - Row 4 – “Antonovka”
Figure 1. Apple orchard of graft-rootstock combinations with an area of 2 hectares.

Rows 5-9 (sector “An intensive garden without support on low-growing rootstocks 54-118”): planting according to the scheme 5×2, the sector’s length is also about 170 meters, the number of trees planted – 85 pieces, all varieties were planted in the spring 2015 at the age of two years, the distribution of varieties is as follows:

- Row 5 – “Lobo”
- Row 6 – “Lobo”
- Row 7 – “Zhigulevskoe”
- Row 8 – “Podarok Grafskomu”
- Row 9 – “Mechta”: 25 trees; “Bogatyry”: 25 trees; “Mel’ba”: 35 trees.

3. Findings and analysis

Tree-by-tree taxation was carried out on the territory of V I Budagovsky research and development center at Michurinsky GAU. These sectors have traditionally housed industrial apple tree plantations of instructional farm “Komsoomlets”, since agroclimatic conditions and soils in the northeastern part of the Central Chernozem Reserve are suitable for fruit trees cultivation of both in private farms and on an industrial scale. Particular attention is paid to the selection of highly winter-resistant breeds and varieties adapted to local conditions. The features of local microclimatic conditions are that frosts are replaced by thaws, there are snowless periods when the air temperature drops to -20°C and below. During the growing season there are periods when, against the background of high temperatures, there is no long rainfall. During the research it was noted that in 2018 and 2019 the amount of precipitation was 450.3 and 445.0 mm, respectively, against the background of high temperatures of the growing seasons.

It can be seen from the data presented in the figures, the quality of the garden can be characterized as high – from 85 to 100 points, which corresponds to the first class of quality. It can be concluded that all graft-rootstock combinations are normally developed, although the indicated scatter of the score indicates that within the studied population, for a number of graft-rootstock combinations, a number of normally developed trees are on the transition verge to a lower quality class. So, the combinations “Sinap Orlovsky” and “Martovskoe” on the rootstock 62-396 and “Podarok Grafskomu” at 54-118 received the lowest taxation marks for the high class of quality: 85 and 86 points. Slightly higher scores at 89 points were noted for “Spartan” and “Vishnevoe” combinations on the rootstock 54-118. The greatest resistance was observed in the early ripening variety “Mechta” on the rootstock 62-396: 100 points. As for the various planting schemes, it can be noted that for the “Lobo” variety, as with planting schemes 6×3, 5×2 on the rootstock 54-118, and 4.5×1.5 on the rootstock 62-396, quality class is characterized as high – from 91 to 96 points. The highest quality was achieved when with the rootstock 54-118 using
planting pattern of 5×2. The “Martovskoe” variety showed that when the planting was thickened (4.5×1.5) and the rootstock 62-396 was used, the quality was lower – 86 points than in the case of using rootstock 54-118 and the planting scheme 6×3, where it was 92 points.

Figure 2. The results of the expeditionary survey of the garden in 2015, planting 2018-2020 (rootstock 54-118 with different planting schemes).

Figure 3. The results of the expeditionary survey of the garden in 2015, planting 2018-2020 (rootstock 62-396 with different planting schemes).
The application of this method is a quite informative indicator assessing the garden state, but its use requires a significant investment of time and labor. To reduce these indicators, it is planned to use the quadcopter DJI Inspire 1 2.0, which is available at the Engineering Center of Michurinsk State Agrarian University; this device is controlled remotely using the appropriate program on the tablet.

The quadcopter shoots a subject from a distance of up to 500 m (in some cases the distance to the subject may be reduced to the minimum allowable). In addition, using a quadcopter you can perform thermal imaging. Flight duration is from 18 minutes under normal weather conditions.

The video signal is transmitted over a digital channel in HD format and saved to removable media device.

The overflight of the garden should be carried out at an extremely low height of 2 m, while the flight speed should also not exceed 1 m/s.

First, it is necessary to configure and calibrate the equipment.

Garden and tree images can be captured using the DJI Zenmuse X3 Camera (figure 4) for the DJI Inspire 1 2.0.

![Figure 4. DJI Zenmuse X3 gimbal with a video camera.](image)

The DJI Zenmuse X3 is a high quality 4K camera in the shape of a smoothly rotating “eye”. The main advantage of this camera is that the device is integrated with the Zenmuse H4-3D 3-axis gimbal on brushless motors, which the manufacturer uses to complete the “Phantom” family. The gimbal ensures smooth shooting around its axis, even when shaking and making sudden movements.

On the basis of the images obtained, it becomes possible to visually evaluate the tree and compare it to a standard, however, in this case, the human factor is of great importance, which can lead to a certain error.

To eliminate the human factor, it is proposed, to obtain a number of reference trees of each variety on the basis of the images, which will form the basis of the program for image recognition, that is, the program compares the obtained photos with the base of standards, which at the initial stage will have the following groups of trees, depending on the taxation assessment 100, 90, 80 .. 10 points, in the future the capabilities of this software can be expanded by detailing the taxation, as well as adding new parameters, such as crown volume, leaf condition, etc.

To implement this direction and image processing, it is possible to use a number of online services, for example, Supervisely online service, which is a free platform for processing various images.

To process the received images, it is possible to use Python scripting language. This programming language is universal and suitable for solving a variety of tasks and many platforms. It is used in web development, desktop and mobile applications development, game programming, analytics and machine learning.

Python is an interpreted language that does not compile, that is, it is a plain text file before being run. You can program on almost all platforms; the language is well designed and logical.

Development based on this language is many times faster, because you have to write less code than in Java, C and other languages.
4. Conclusion
The studies have shown that such a methodological method as appraising plantings based on tree taxation, which was previously mainly used to assess the crop state after any critical periods (unfavorable winter conditions, unfavorable growing season conditions), or to assess the possibility of further exploitation of age plantations and etc., should be used when testing and selecting new grafted-rootstock combinations. In the early stages of tree growth in the garden, this allows you to assess their complex resistance to environmental factors.

At the same time, the development and implementation of technologies and software that allows you to quickly assess the condition of trees in the garden and exclude the subjective human factor will significantly speed up the process of garden assessing and determine measures for its further development.

In addition, when using modern means, the researcher has an opportunity to obtain a large amount of data on the parametric characteristics of the crown, depending on the variety, rootstock, planting scheme, and even the effect of landscape features on the trees state.

References
[1] Fedorenko V F, Mishurov N P, Buklagin D S, Goltyapin V Ya and Golubev I G 2019 Digital agriculture: state and development prospects: scientific. Edition (Moscow: Rosinformagrotech) p 316
[2] Minakov I A and Nikitin A V 2019 Agricultural market development: Trends and prospects International Journal of Innovative Technology and Exploring Engineering 9(1) 3842-7
[3] Nikitin A V, Trunova S N and Voropaeva V A 2019 The assessment of the effectiveness of the implementation of scenarios for the sustainable development of agriculture International Journal of Innovative Technology and Exploring Engineering 8(10) 3002-5
[4] Kuzin A I, Kashirskaya N Y, Kochkina A M and Smagin B I 2019 Plant protection and foliar fertilizing technology of apple (Malus domestica Borkh) International Journal of Engineering and Advanced Technology 8(6) 3613-20
[5] Kuzin A I, Trunov Yu V and Solovyev A V 2018 Effect of fertigation on yield and fruit quality of apple (Malus domestica Borkh.) in high-density orchards on chernozems in Central Russia Acta Horticulturae 1217 343-9
[6] Potapov V A and Bobrovich L V 1999 Methodology for appraising low-growing gardens on the basis of taxation Intern. scientific-pract. conf. "Weak gardening" I 69-72
[7] Borisova O A, Tarova Z N, Bobrovich L V, Matsnev I N and Podmarkov A V 2018 Evaluation of the resistance of variety-rootstock combinations of apple trees in industrial gardens Soils and their effective use: materials of Int. scientific-pract. conf. ded. to the 90th anniversary of Dr of Agricultural Sciences, Honored Scientist of Russia, Prof. V V 224-8
[8] Pridorogin M V 2010 Valuation of fruit plantations taking into account the structure, systems and ecology of the garden landscape Bulletin of Michurinsk State Agrarian University I 22-8
[9] Tarova Z N, Bobrovich L V, Borisova O A and Kukhtikova N V 2019 Growth characteristics of grafted-rootstock combinations of apple trees in the conditions of the Novgorod region Priority directions for the development of horticulture (The first Potapov readings): materials of National scientific-pract. conf. ded. to the 85th anniversary of Prof., Dr of Agricultural Sciences V A Potapov 278-81
[10] Astapov A Yu, Prishutov K A, Krivolapov I P, Astapov S Yu and Korotkov A A 2019 Unmanned aerial vehicles for estimation of vegetation quality Amazonia Investiga 8(23) 27-36