Fruiting indicators of the apple tree growing in the creeping form in the Botanical garden named after Vs. M. Krutovsky

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Abstract. Study of the fruiting indicators of the apple tree growing in the creeping form in the Botanical garden named after Vs. M. Krutovsky resulted in the distinguishing of the cultivars characterized by the high annual yield, apples mass and sizes. The distinguished cultivars can be recommended for growing in the given and similar climate conditions.

1. Introduction
Apple tree is a key fruit crop in Siberian gardens that occupies 65-75 % of the fruit plantings, and the 1st in harvesting.

The quantity of the world grown cultivars varies from 25,000 to 35,000 in different ratings. There are nearly 350 apple tree cultivars appropriate to the geographical location on the territory of our country. Common Siberian assortment of apple trees can be divided into 3 different in genetic aspect groups of cultivars – rennets, semi-fruiting (polukulturki), and large-fruiting [2].

Apple tree fruits are consumed fresh and processed; they contain sugars, organic acids, mineral salts and microelements, they are endowed with biologically active substances as well. Apples contain vitamins and antioxidants [5]. They are also useful for humans because of fiber content [3].

Economic and biological properties of the fruit trees are determined not only by the genetic peculiarities of the apple tree species and cultivars, but also by the environment the phenotypes are formed in. Geographical factors (latitude, longitude, terrain of the region, etc.) significantly determine the zone climatic conditions influencing the fruiting, chemical content, keeping quality and other fruits properties [14]. Thus, from north-west to south-east within a country some cultivars increase their fruiting periodicity with the yield decreasing as a result [4].

The Botanical garden named after Vs. M. Krutovsky where the study was made in is located in Krasnoyarsk on the right bank of the Yenisey River in the estuary of the Laletina River. The garden territory is situated on the junction of the Kansk – Rybinskaya basin and forest – steppe zone of Western Siberian flatland with foothills of the Eastern Sayan. It causes the strongly continental climate conditions [1]. There was studied the memorial part of the garden the apple trees grow in a creeping form in. The form invented by Vs. M. Krutovsky in the beginning of 20th century is called Arctic or Krasnoyarsk stanian. The Botanical garden apple trees collection has 39 large – fruited cultivars of different geographical and selection origin [7, 8, 9, 10]. The trees are maximum 115 years old.

2. Methods and materials
The fruiting periodicity was determined according to the common method [13] by annual calculation of the fertile trees.
The yield estimation was done with method of model branches \[11, 12\] including the calculation of the fruits only on model branches average for the given tree and simultaneous clockwise determination of such branches on the tree. Fruits mass was determined by weighing method on the laboratory scale.

The tree yield (in kilogrammes) was determined by multiplying of an average fruit mass on a tree by their quantity.

Processing of the experimental material was done by the mathematical statistics methods with the help of Microsoft Excel programme.

3. Results and discussion
Vs. M. Krutovsky initiated the creation of the collection of domestic apple tree cultvars (Malus domestica Borkh) in 1904. Apple tree cultvars are differentiated in fruits size, form and mass, their gustatory qualities, ripening period and storage time, fruiting periodicity.

According to the ripening period and storage time the apple tree cultvars of the memorial part of the Botanical garden named after Vs. M. Krutovsky can be classified into winter cultvars (64 %) and summer ones (36 %). 6 cultvars (White Transparent, Bismarck, Grushovka moskovskaya, Golden schip, Nobilis, Papirovka) constitute more than a half of the total amount of the apple trees (55 %).

Apple tree is prone to fruiting periodicity that develops with aging. Among the apple tree cultvars presented in the collection of the Botanical garden named after Vs. M. Krutovsky Grushovka moskovskaya shows the abrupt periodicity according to literary data \[6\].

Analysis of the fruiting in 2013-2018 revealed the maximum of the fruiting trees (254 trees, 99 %) in 2018 (table 1). The year of 2017 is characterized by the lowest fruiting, adverse weather conditions in the beginning of vegetation (low temperatures and snowfalls).

| Cultivar               | 2013 Quantity | 2014 Quantity | 2015 Quantity | 2016 Quantity | 2017 Quantity | 2018 Quantity |
|-----------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| White Transparent     | 20 / 100      | 19 / 95       | 19 / 95       | 20 / 100      | 17 / 85       | 20 / 100      |
| Bismarck              | 28 / 97       | 29 / 100      | 29 / 100      | 28 / 97       | 23 / 82       | 27 / 96       |
| Grushovka moskovskaya | 16 / 84       | 19 / 100      | 18 / 95       | 18 / 95       | 5 / 26        | 19 / 100      |
| Golden schip          | 13 / 72       | 16 / 89       | 17 / 95       | 18 / 100      | 8 / 40        | 20 / 100      |
| Nobilis               | 19 / 86       | 18 / 82       | 22 / 100      | 22 / 100      | 3 / 13        | 22 / 100      |
| Papirovka             | 31 / 91       | 21 / 62       | 34 / 100      | 33 / 97       | 21 / 62       | 34 / 100      |

Analyzing the percentage of the White Transparent fruiting trees we can state that 100 % of fruiting was observed in 2013, 2016 and 2018, in 2014 and 2018 95 % of trees gave fruits. Nobilis cultvar gave 100 % of fruiting 3 times within the studied period (in 2015, 2016 and 2018). In 2013 86 % of this cultvar trees gave fruits, in 2014 – 82 %, in 2018 – only 13 %.

All the apple trees (100 %) of the Bismarck, Grushovka moskovskaya, Golden schip and Papirovka cultvars gave fruits twice: Bismarck in 2014 and 2015, Grushovka moskovskaya in 2014 and 2018, Golden schip in 2016 and 2018, Papirovka in 2015 and 2018.

The figure 1 shows that White Transparent and Bismarck have the most stable fruiting (more than 80 % of the trees have annual fruiting). Papirovka fails on this indicator (62 % of trees gave fruits for 2 years, the percentage of fruiting trees constituted 91 % and 97 % for 2 years and for 2 years – 100 %).
The following scale was used for intensity determination: 0-200 fruits – low fruiting intensity, 201-400 fruits – average intensity, 400 and more fruits – abundant intensity. There was established that within the studied period of 2013-2018 the abundant fruiting was observed in 2016 and 2018 when the percentage of the trees with the quantity of more than 400 fruits constituted 40 % and 47 % respectively. The year of 2017 had the poorest harvest – only 128 trees gave fruits that constituted 50 % of the total trees amount. That year the low fruiting trees prevailed (58 %). The abundant fruiting trees constituted 8 %. The low fruiting prevailed in 2014 and 2015 (table 2).

Table 2. Analysis of apple tree fruiting intensity.

| Year | Fruiting trees | Abundant intensity | Average intensity | Low intensity |
|------|----------------|--------------------|-------------------|--------------|
|      | Number of trees | Number of trees | Number of trees | Number of trees |
| 2013 | 234            | 96                 | 41                | 60           | 26            | 78            | 33            |
| 2014 | 220            | 39                 | 18                | 66           | 30            | 115           | 52            |
| 2015 | 249            | 24                 | 10                | 99           | 39            | 126           | 51            |
| 2016 | 250            | 102                | 40                | 61           | 25            | 87            | 35            |
| 2017 | 128            | 11                 | 8                 | 43           | 34            | 74            | 58            |
| 2018 | 254            | 119                | 47                | 92           | 36            | 43            | 17            |

While analyzing the yield of the large-fruited apple tree cultivars during the studied period there was revealed that the following cultivars - White Transparent, Bismarck and Papirovka- have higher fruiting intensity. The average yield of White Transparent varies from 1,29 to 3,02 kg/m² of crown projection, Bismarck – 1,63-4,27 kg/m² of crown projection, Papirovka – 0,93-2,97 kg/m² of crown projection (table 3).
Table 3. Apple tree yield in 2013 – 2018.

| Cultivar         | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------------------|------|------|------|------|------|------|
| White Transparent| 1.30 | 1.37 | 1.64 | 1.57 | 1.29 | 3.02 |
| Bismarck         | 2.34 | 2.32 | 1.63 | 2.57 | 2.18 | 4.27 |
| Grushovka moskovskaya | 1.43 | 1.04 | 0.50 | 1.28 | 0.45 | 1.22 |
| Golden schip     | 1.26 | 0.72 | 0.67 | 1.14 | 0.79 | 1.23 |
| Nobilis          | 2.29 | 0.40 | 1.40 | 1.94 | 0.99 | 2.95 |
| Papirovka        | 1.89 | 1.02 | 1.37 | 1.47 | 0.93 | 2.97 |

Despite the fact that productive age of apple trees is 40-50 years old many trees showed a good yield being 114 years old (at time of the study).

Conclusion
As a result of the study there was established that all the apple trees of the Botanical garden named after Vs. M. Krutovsky have a high yield over the age of 100. There were selected the cultivars for growing in the given and similar natural and climatic conditions (White Transparent, Bismarck, Papirovka).

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