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Refrigeration Potential of Fruit Trees Introduced in West Georgia

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Abstract

The paper explores the challenges related to the development of agricultural technology services in the humid subtropical region of Georgia, with a focus on the Gvara-Khutsubani demonstration nursery of fruit tree crops, which tests both introduced and local varieties of fruit trees and subtropical crops. This contributes to the diversification of the gene pool of these crops in the region. Additionally, this initiative has the potential to increase the value chain and export refrigeration capacity of the fruit tree nursery.

Rubinola, Gold Rush, Champagne Reinette, Fuji Kiku, Forlaid, Ariva, Georgian Sinapi, Topaz, Summerland, Conference, Abbot Vettel, and Carmen, were subjected to experimental studies. During the studies, the phenological phases of 9 apple and 3 pear varieties were observed, along with biometric indicators, yield, cold storage potential of raw materials, and respiration intensity.

Keywords: Phenological phases: Gene pool; Fruit Trees

Introduction

Fruit cultivation has been a key contributor to the economy of national agriculture, and in many regions, it remains a primary source of enhancing the material well-being and cultural advancement of local communities.

The testing of both introduced and local varieties of fruit trees and subtropical crops in the Gvara-Khutsubani demonstration nursery of vine and fruit crops under the Agricultural Technology Development Service of the N(N)LE the Agroservice Center represents a significant and commendable development. This initiative contributes to the diversification of the gene pool of these crops in the region.

Since the second half of 2022, a research project focusing on the morpho-biological characteristics of various fruit tree varieties has been ongoing in the Gvara-Khutsubani demonstration nursery of fruit crops based on a memorandum signed between N(N)LE Agroservice Center and the Batumi Shota Rustaveli State University. The study is investigating the respiration intensity of the crops, which is a key factor in their cold storage potential.

Materials and Methods

The aim of this study is to assess the morpho-biological characteristics of various fruit tree varieties in the Gvara-Khutsubani demonstration nursery of fruit crops, located in the humid regions of the Black Sea coast in Western Georgia. In addition to evaluating their agricultural suitability, the research will also examine the refrigeration potential of these crops.

The research object: The fruit tree nursery value chain and the measurement of fruit respiration intensity. Initially, the test plants belonging to various apple, pear, and subtropical persimmon varieties were selected, with 5 plants of each type being tagged and recorded in the registration log.

We carried phenological observations and biometric measurements on test plants, which included 9 apple, 3 pear, and 3 subtropical persimmon varieties. Based on these data, we calculated the average arithmetic indicators. We also assessed the yield.

As for the fruit's technical characteristics and physicochemical indicators, they were evaluated by the Food Safety Department at the Agricultural and Membrane Technologies Institute of the BSU, using samples provided by us.

The table illustrates the progression of phenological phases across 9 apple and 3 pear varieties,

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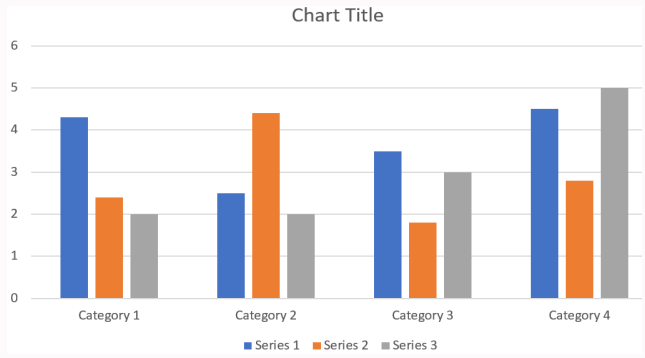

Figure 1: Biometric indicators and yield of apple and pear species.

highlighting notable differences among them. For instance, Champagne Rennet exhibits the earliest bud swelling and vegetation onset (24-26.03), while Gold Rush experiences these stages later (30.03-1.04), with a 6-day gap between the two. In other species (3-4) in terms of flowering and fruit ripening, the earliest is Champagne Rennet (10-12.04; 3-8.10), and the latest is Gold Rush (16-18.04; 20-25.10). Topaz, Ariva, Forlaid, and Fuji Kiku all have fruits ripening almost simultaneously, from October 7th to October 15th. Finally, Rubinola fruits ripen relatively late, from 15 to 20.10.

Thus, the ripening of the mentioned apple varieties starts between October 3rd to 8th and ends between November 20th to 25th. Ariva (3-8.10) and Fuji Kiku (5-8.10) complete vegetation earlier, while Gold Rush (2-7.11) and Summerland (22-27.10) finish later.

Gold Rush has the latest leaf fall (15-20.12), while other trees from November 15th to 20th to November 25th to 30th. Among pear varieties, Conference begins vegetation earlier (12-14.03), while Carmen starts later (19-21.03). Abbot Vettel has an intermediate starting time (14-16.03). The flowering starts and ends early for Conference (1-3.04; 9-11.04), late for Carmen (4-6.04; 12-14.04), and Abbot Vettel is transitional in this regard (2-4.04; 10-12.04).

Regarding the ripening period of pear fruits, Carmen ripens the earliest (22-27.08), followed by Abbot Vettel (7-12.09) and Conference (15-21.09). Carmen also finishes its vegetation first (1-5.09), followed by Abbot Vettel (10-13.09), and Conference finishes last (12-17.09).

The period of leaf fall in pear varieties starts from November 07th to 10th and ends from November 12th to 15th. Carmen completes its leaf fall earliest (7-12.11), and Conference completes it later (10-15.11) (Figure 1).

Table 1 presents the biometric indicators and yield of apple and pear varieties. During determination of the biometric indicators, we measured: Tree height, trunk diameter, length and diameter of annual shoots, leaf blade length and width, leaf stem length, and fruit height and diameter. In addition, the average fruit weight and yield were determined both per plant and per hectare.

Table 2 displays the variation in height among the apple varieties, with a range of 2.3 m to 3.2 m. Rubinola stands out as the tallest (3.2 m), while Fuji-Kiku is the shortest (2.4 m). Champagne Rennet has the thickest trunk (5.9 cm), followed by rubinola (5.8 cm) and topaz (5.6 cm). Conversely, the thinnest trunk is found in Sipani at 4.7 cm. The trunk diameter of the other varieties falls between 4.8 cm to 5.6 cm.

Rubinola (55 cm; 1.9 cm) and Ariva (51 cm; 1.8 cm) stand out with the length and diameter of one-year shoots. In contrast, Sinap and Forlaid have the shortest one-year growths (38 cm and 39 cm respectively), and correspondingly smaller diameter of (1.3 cm; 1.5 cm).

Champagne Rennet and Fuji-Kiku plants are distinguished by the size of the leaf blade, with dimensions of 10.3 cm to 6.2 cm and 10.2 cm to 6.1 cm. Meanwhile, Topaz (7.2 cm to 4.7 cm) and Gold Rush (7.6 cm to 4.7 cm) produce the smallest leaves. The length of the stem differs among the different varieties, ranging from 2.1 cm to 4.5 cm.

In terms of the dimensions and average weight of the fruit, Champagne Rennet takes the lead with a height of 6.6 cm, a diameter of 7.8 cm, and an average weight of 162 g. Gold Rush comes in second place (157 g). The smallest fruits are produced by Forlaid (115 g) and Ariva (120 g).

The varieties with the highest yield are Gold Rush and Forlaid, producing 8.0 kg and 7.5 kg per plant, respectively, and 6.4 t and 6.0 t per hectare. The remaining varieties have a yield range of 1.8 kg to 6.2 kg per plant and 1.4 tons to 5.0 tons per hectare.

Abbot Vettel is the tallest pear variety that grows to a height of 2.1 m and stands out by a trunk diameter (4.5 cm), one-year shoots length (48 cm) and diameter (1.5 cm), size of the leaf blade (7.6 cm to 4.8 cm) and its fruit measures (13.8 cm to 7.9 cm) and a weight (255 g). It is also distinguished by its yield, which is on average 2.8 kg per tree, equivalent to 2.2 tons per hectare.

While in storage, products release heat and moisture, which can potentially disrupt the storage environment. Only live products such as fruits emit heat, whereas any cells containing water are responsible for moisture release. Use of low temperature during the storage of fruits and vegetables serves for 2 purposes: a) rapid cooling and b) long-term preservation in a chilled or frozen state. Fruits are still subject to respiration even after they have been harvested from the tree, which involves the continuous release of energy through both aerobic and anaerobic respiration in living tissues.

$$C_6H_{12}O_6 + O_6 \rightarrow 6CO_2 + 6H_2O + 672\ Kcal$$

Anaerobic respiration takes place during a lack of oxygen (less than 2%).

$$C_6H_{12}O_6 \rightarrow C_2H_5OH + 2CO_2 + 24\ Kcal$$

Fruits and vegetables undergo a breakdown process during respiration, beginning with monosaccharides, followed by disaccharides, starch, fats, organic acids, and other substances. The plant organism's respiration process is complex and depends on the fruit type, enzyme system, and environmental temperature as well. The gaseous composition of the air also impacts the intensity of respiration. When the oxygen level is reduced to 5% to 6%, the intensity of respiration in fruit and vegetables is halved. This does not affect the respiration quality due to a respiration coefficient of 1. The respiration coefficient is a ratio that expresses the volume of carbon dioxide released during respiration to the volume of inhaled air. According to observations, a pathological disturbance in respiratory secretion occurs during a significant reduction of oxygen, resulting in the accumulation of ethyl alcohol in the cell. A respiratory coefficient of 1 indicates that only carbohydrates are utilized in the respiration process, which continues until the formation of final products. When acids are used in respiration, the respiration rate exceeds 1. Based on

Table 1: Phenological phase of apple and pear.

#	Name of species	Swelling of buds, start of vegetation	Opening of buds	Showing of leaves	Showing of flower buds	Start of flowering	End of flowering	Ovary development	10-12 mm fruit development	Ripening maturity	End of vegetation	Start of leaf fall	End of leaf fall
1	Rubinola	26-28.03	10-13.04	20-22.04	16-18.04	12-14.04	23-25.04	19-16.05	5-10.06	15-20.10	18-22.10	18-23.11	25-30.11
2	Gold Rush	30.03-1.04	14-16.04	23-25.04	20-22.04	16-18.04	28-30.04	16-19.05	8-13.06	20-25.10	2-7.11	8-13.12	15-20.12
3	Champagne Reinette	24-26.03	2-5.04	10-12.04	8-13.04	10-12.04	21-23.04	7-10.05	1-5.06	3-8.10	8-13.10	12-17.11	20-25.11
4	Fuji Kiku	28-30.03	8-10.04	16-18.04	13-15.04	11-13.04	23-25.04	11-14.05	3-8.06	10-15.10	5-8.10	10-13.11	17-20.11
5	Forlaid	1-3.04	2-5.04	10-13.04	7-9.04	18-20.04	27-29.04	8-11.05	1-5.06	8-10.10	7-12.10	11-16.11	18-23.11
6	Ariva	2-4.04	3-5.04	11-14.04	8-10.04	20-22.04	1-3.05	9-12.05	2-6.06	8-13.10	3-8.10	6-11.11	15-20.11
7	Sinapi	4-6.04	4-7.04	12-15.04	10-12.04	21-23.04	2-4.05	10-13.05	3-8.06	10-15.10	7-12.10	7-12.11	17-22.11
8	Topaz	28-30.03	9-11.04	15-17.04	13-15.04	13-15.04	24-26.04	14-17.05	7-12.06	7-12.10	9-14.10	13-18.11	22-27.11
9	Summerland	29-31.03	12-14.04	20-22.04	16-18.04	16-18.04	26-28.04	17-20.05	10-15.06	8-13.10	22-27.10	23-28.11	25-30.11
10	Conference	12-14.03	23-25.03	31.03-2.04	26-28.03	1-3.04	9-11.04	18-21.04	1-5.05	15-21.09	12-17.09	6-10.11	10-15.11
11	Abbot Vettel	14-16.03	26-28.03	3-5.04	1-2.04	2-4.04	10-12.04	23-26.04	5-10.05	7-12.09	10-13.09	4-9.11	9-13.11
12	Carmen	18-20-03	28-30.03	5-7.04	1-3.04	4-6.04	12-14.04	25-28.04	10-15.05	22-27.08	1-5.09	2-7.11	7-12.11

Table 2: 2014-2016 Average Indicators.

#	Name of species	Tree height, m	Trunk diameter, cm	Annual shoots length, cm	Annual shoots diameter, cm	Length of leaf blade, cm	Width of leaf blade, cm	Length of leaf stem, cm	Height of fruit, cm	Diameter of fruit, cm	Average weight of fruit, g	Yield on 1 seedling, kg	Yield on 1 Ha, T
1	Rubinola	3.2	5.8	55	1.9	8.4	4.9	3	6.3	7.6	150	3.1	2.5
2	Gold Rush	2.6	4.9	42	1.8	7.6	4.7	2.5	5.4	6.8	157	8	6.4
3	Champagne Reinette	2.9	5.9	45	1.6	10.3	6.2	3.4	6.6	7.8	162	6.2	5
4	Fuji Kiku	2.4	5.1	43	1.7	10.2	6.1	3.6	5.8	6.7	135	5.3	4.2
5	Forlaid	3	4.8	39	1.5	8.9	6.1	4.5	6	6.3	115	7.5	6
6	Ariva	3.1	5.4	51	1.8	10.1	5.9	3.3	5.9	6.5	120	3.3	2.6
7	Sinapi	2.9	4.7	38	1.3	9.5	5.5	3.2	6.5	6.2	123	1.8	1.4
8	Topaz	2.7	5.6	49	1.5	7.2	4.7	2.1	5.4	7.1	130	2.7	2.2
9	Summerland	2.8	5.2	50	1.6	9.2	6.2	3.1	6.1	7.5	144	4.8	3.8
10	Conference	1.9	4.3	44	1.3	7.2	4.3	3	13.1	7.1	238	2.4	1.9
11	Abbot Vettel	2.1	4.5	48	1.5	7.6	4.8	2.3	13.8	7.9	255	2.8	2.2
12	Carmen	2	4.4	46	1.4	7.4	4.6	3.9	11.3	4.6	216	1.5	1.2

the observations, the same happens during the oxygen defiance.

Analysis and method

The methods used to determine the respiration rate of fruits and vegetables are based on the absorption of carbon dioxide gas in an alkaline area of a specific concentration. The volume of CO_2 absorbed by the alkaline is determined through titration. To perform the test, a certain quantity of fruits and vegetables is placed on the grate exsiccator. A petri dish containing 0.5 kg to 1 kg of fruits and vegetables is placed on the bottom of the exsiccator, while a separate petri dish containing 20% potassium or sodium alkaline is also placed.

Carbon dioxide released during the respiration process of fruits, is absorbed by the alkaline. The reaction is expressed by the following equation:

$$2KOH + CO_2 = K_2CO_2 + H_2O$$

Once the test is completed, a small amount of salt and alkaline that did not participate in the reaction will be present in the petri dish. This mixture is then subjected to titration a) by HCl and (K_2CO_3). HCI reacts in 2 stages.

Before titration, HCl solution (K_2CO_3) is added by 4 to 5 drops of phenolphthalein, resulting in a crimson color. As $KHCO_3$ is formed during titration, the solution becomes colorless, and then methyl orange indicator is added. The solution changes to orange, and as further acid titration converts all $KHCO_3$ to free H_2CO_3, the solution changes to a pinkish-reddish color. Phenolphthalein is used to titrate excess KOH, which did not react with CO_2, and with half of K_2CO_3, while methyl orange is used to titrate the other half. The formula used to determine respiration intensity is as follows:

$$I = \frac{(a-b).k.22}{T_1 - T_2}$$

Where a, is 1n HCl total volume in milliliters.

22 is 1N HCl in milliliters used for titration of 20 ml of 1N KON with phenolphthalein.

a-b is an amount of 1N HCl in milliliters, used for titration of K_2CO_3.

k is an HCl correction coefficient, 22 is equivalent to CO_2.

T_1-T_2 start and ending time of the test.

G the mass of research sample (kg)

The use of low temperature for preserving fruits and vegetables serves for 2 purposes:

1. Rapid cooling, 2. Long-term storage.

First, the fruits are placed in plastic boxes and cooled at -5 and +5. This allows for accumulating about 3,600 kg of cooled fruits in the refrigerator, this is then packed in polyethylene bags using a packing machine. The packages are placed in plastic boxes and stored in a refrigerator at a temperature between - 18 to - 25 until they are sold.

Conclusion

1. We studied the morphological and agricultural characteristics of fruit trees; apple and pear, their biometric indicators, technical characteristics and yield in the Gvara-Khutsubani territory.

2. We studied phenological phases of apple and pear.

3. We studied a respiration intensity and refrigeration potential of apple and pear species.

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