

## THE INFLUENCE OF CULTIVATION TECHNOLOGY ON THE GROWTH AND PRODUCTIVITY OF SOME NEW APPLE VARIETIES

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### RESEARCH ARTICLE

#### Abstract

*The dominance of apple cultivation in Europe is explained by the creation of new varieties, as well as by the improvement of cultivation technology. In Western Europe, new varieties are grown that are resistant and have increased productivity, and with Romania's entry into the European Union, the introduction of such new varieties became necessary in order to maintain competition in terms of the quantity and quality of apples. By protecting the cultivation of these new varieties within the country, high-quality apples for consumption can be obtained. Romania's climatic conditions are favorable for achieving high-quantity and high-quality yields. It is evident that Romanian apple orchards must be modernized through the introduction of superior varieties and improvements in cultivation technology. Unfortunately, many outdated varieties are still grown, and these are more difficult to market on external markets. Examining the current situation of orchards in the country, it is found that when using the same technology, old varieties can be destined only for industrial purposes, while new varieties can be directed toward the consumer market.*

*From the above, it follows that in order to obtain superior quantitative and qualitative apple production, it is essential to consider superior varieties, modern technologies, appropriate treatments, and specialized expertise.*

**Keywords:** cultivation technology, productive yield, consumer market

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#### INTRODUCTION

In terms of the yield of the main fruit species produced worldwide, the apple ranks second after bananas. The changes in the mentioned production volumes depend on the favorable or unfavorable evolution of annual vegetation factors.

The new apple varieties meet the needs of the European market from all points of view and are suitable for modern cultivation technology. Nevertheless, in many cases, the new varieties are superior to the old ones in certain aspects such as storability, flesh firmness, transportability, the acid-sugar ratio, coloration, size, etc.

The importance of apples is demonstrated by the fact that there are over 200 processed products on the global food market. The best known of these are filtered and cloudy juices. Among fruit juices, besides orange juice, apple juice is among the most consumed.

The factors contributing to the modernization of apple production may include: modernization of rootstock and variety use, more intensive space utilization, increased consumption of fresh fruit, regaining former export markets, ecological cultivation

techniques, modern methods of protection against hail, frost during flowering, drought, and the use of modern post-harvest technologies where available.

The use of apple varieties differs across continents, as well as within them. It is enough to observe the apple variety usage in North America, China, New Zealand, Europe, Western and Eastern Europe. It can be noted that so-called main varieties have been established, and their number is periodically limited to 4–6 varieties out of the 50–100 known ones, such as *Gala*, *Golden Delicious*, *Red Delicious*, *Jonagold*, etc. It is noteworthy that more than 10,000 successfully cultivated varieties have appeared in different parts of the world. However, this diversity is rather a disadvantage on the global market: larger commodity bases can be managed more easily and simply, and for this reason, nowadays 4–5 major varieties represent about 50% of the total quantity.

The dynamic change in variety use has expanded the number of important varieties for global apple production. As a result, new varieties grown a few decades earlier—if they

are better than the basic variety—can spread rapidly over larger areas.

Rootstocks are used because by choosing the area to which production can best adapt, we are able to obtain successful economic yields (Bunea Aurel, 1999). Nowadays, intensive plantations use dwarf-type rootstocks, which have been selected for their beneficial cultivation properties. The effect of the rootstock can influence the vegetative and generative performance of the scion varieties, meaning their growth vigor, fertility, fruit formation, quality, and storage capacity.

#### MATERIAL AND METHOD

The research was carried out in an apple orchard that follows an integrated fruit production program. The plantation covers an area of 6.65 hectares



Figure 1. The plantation established in 2021

The observations focus on five apple varieties: “Braeburn Mariri Red,” “Braeburn Redfield,” “Golden Reinders,” “Granny Smith,” and “Red Jonaprince.

#### Braeburn „Mariri Red”

From the obtained data, it can be observed that no matter how good the variety is, its cultivation potential is not very successful due to its appearance. The ripening period of apples in our country’s climate makes them suitable for harvesting from mid-October, but their coloration tends to be more of a brick-red shade. This is not attractive for consumer markets, which demand bright, intense colors. If the surface color is not fully developed at harvest time, multiple harvest stages are required. This variety can be safely cultivated in most areas, but it requires a great deal of care and expertise. Practical experience shows that it is suitable for excellent storage only when accompanied by large amounts of calcium substitutes.



Figure 2. Braeburn „Mariri Red”

#### Braeburn „Red Field”

The more intensely colored version of the basic Braeburn variety has characteristics identical to those of the other variety presented above. The only difference lies in the surface coloration, which is not as intense. On the sunny side, the color is more moderate—about 40% brick-red—and can be considered more striped. The calcium requirement, as in the case of the basic variety, is also relevant for cultivation, which is confirmed here as well.



Figure 3. Braeburn „Redfield”

#### Golden Reinders

Its widespread cultivation is proven by its diverse favorable qualities. It is considered the classic mutation of the “Golden Delicious” apple. Compared to the basic variety, its surface is less moist, which makes its cultivation technology easier. It has excellent yield, good quality, and can be stored long-term. However, attention must be paid to its tendency to overcrop. Its fruits are medium-sized (140–180 g), more elongated than those of the original variety. The flesh is golden in color, juicy, with a pleasant sweet–slightly acidic flavor and a characteristic aroma. The skin is not thin, slightly waxy, and not at all or only minimally prone to sunburn, with a greenish-yellow color that turns yellow when fully ripe. The tree has medium-strong growth and increased fertility. It is usually prone to alternation. It can be stored until the end of June under proper conditions and with timely harvesting.



Figure 4. Golden Reinders

#### Granny Smith

It is a significant variety in the Southern Hemisphere, known for its green color and good storage capacity. In our country, the variety can be successfully cultivated only in warmer regions. The variety was discovered in Australia in 1868. The optimal harvest time is at the end of October or in the first days of November. Its fruits are medium or large (160–180 g),

symmetrical, round or truncated. The skin is waxy, green, with dark or white specks. In our country, due to sun exposure, a faint reddish shade may appear on the fruit's skin, which significantly reduces its market value. Its taste is slightly acidic, and its aroma is weak and not distinctive.

The tree develops a crown with medium branching, strong, well-structured, and dense. It is a latent carrier of various viruses and is also sensitive to calcium deficiency. The fruits appear fairly early, the yield is high, but the tree tends to alternate. It can be stored for at least 6 months, but is prone to bitter pit and browning of the skin and flesh. Harvesting can be done in a single pass at the end of September.



Figure 5. **Granny Smith**

### **Red Jonaprince**

It belongs to the "Jonagold" variety group and is of Dutch origin. The difference between the varieties lies in the fact that they are striped and have pale shades. It has a large, decorative fruit with a red covering color. It is characterized by crisp flesh and excellent taste. The fruit's productivity and storage capacity are also good. According to consumer preferences, the pale-colored variations are much more sought after than the striped ones, which is an excellent advantage for this variety. Its major advantage is that, unlike many other variants, it does not revert back to the basic variety, resulting in much greater uniformity in fruit quality compared to other clones. Furthermore, the tree's branching capacity is very good, being associated with a high fertility tendency.

All the fruits on the tree color very early (even during the less cool temperatures of the ripening period), first turning pale and then bright red. Due to the intense coloration, the fruits can be harvested in a single picking, but harvesting should not be tied to the coloration of the fruit (as the fruit may lack flavor), but rather to the storage parameters.



Figure 6. **Red Jonaprince**

The climate in this area is moderately dry, influenced by the continental character of the region, situated at the boundary between moderately cold and moderately warm zones. The number of sunshine hours averages 1,850 hours. Spring arrives relatively late, with temperatures around 10–12°C daily in mid-April, and spring frosts are common. The average annual temperature is 9.5°C, while the average temperature during the vegetation period is 16.8°C.

The average annual precipitation is 610 mm, with a minimum and maximum of 437 and 819 mm respectively. The rainiest months are May–June, while the driest months are February–March. The average groundwater depth is 2–4 m. The plantation is equipped with a cordon-type support system and drip irrigation.

In the orchard, soil and leaf samples are collected twice a year, and based on these analyses, the necessary nutrients are supplied in the form of fertilizers.

The purpose of the research is to determine, alongside cultivation technology, which variety is the most marketable and has the highest yield potential achievable through different phytotechnical and chemical methods.

- **Planting date:** spring of 2021
- **Applied crown shape:** vertical cordon
- **Rootstock used:** M9 in all cases
- **Spacing:** 4.0 m between rows × 0.6 m within rows (3,290 trees/ha)

For the research, we selected 3 variants of 5 trees each, with similar development, for every variety included in the study.

#### **Tree-specific observations:**

- trunk thickness as a basic index of vitality (cm<sup>2</sup>)
- number of branches and their age (pcs/tree; years)
- number of vegetative buds and flower buds (pcs)
- number of set fruits, as well as the number and quantity of fruits/final yield (pcs/tree; tons/ha)

**Measurement dates:** 26.04.2024, 25.05.2024, 04.08.2024, 07.09.2024.

## **RESULTS AND DISCUSSIONS**

### **Trunk thickness of the examined trees**

The cross-sectional area of the trunk is a complex indicator of the vegetative performance of the trees. Since the growth rate of the varieties differs, the trunk size is not the same within the examined plantation. For an objective comparison of the varieties, we

calculated an average value, which is presented in Figure 7.

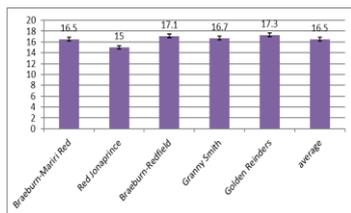


Figure 7. **Average cross-sectional area of the studied trees (cm²)**

It can be observed that there is a smaller or larger difference between the varieties, amounting to 2–2.3 cm² in total. In general, the trunk thickness of the generic varieties is smaller (*Red Jonaprince* and *Braeburn Mariri Red*). In contrast, despite being considered a vegetative type, *Golden Reinders* does not show a significantly larger size compared to the general thickness.

However, it should be emphasized that there is already a 15% difference between the smallest and the largest varieties in terms of trunk thickness by the fourth year. Due to the different fruit loads, this difference may increase even further in the future. This will also affect the varieties' response to environmental factors.

#### Number of branches and their age

The number of branches on the trees was determined by taking into account branches of different ages. We counted the 1-, 2-, and 3-year-old branches and calculated their average. This characteristic reflects the variety's branching capacity under the given technology and its level of development during the research period.

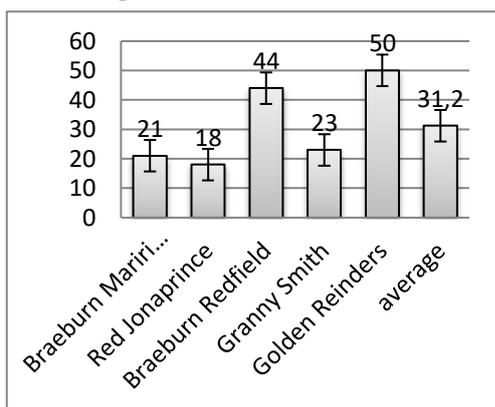


Figure 8. **Evolution of the average number of branches (pcs.)**

The graph shows the average number of branches of the examined trees, starting from the central axis. Among all varieties, three showed values lower than the average branching level: *Granny Smith* (26%), *Red Jonaprince* (42%), and *Braeburn Mariri Red*

(33%), while two varieties exceeded the average value: *Braeburn Redfield* (30%) and *Golden Reinders* (38%). For the varieties with lower values, the branching capacity within the crown is reduced. For the other two varieties, this phenomenon is not observed, suggesting greater adaptability, and therefore branching is not negatively affected.

#### Number of 3-year-old branches

In fruit cultivation terminology, these branches are called scaffolds. They determine the shape of the crown and the fruiting surface. The number of 3-year-old branches is illustrated in Figure 9.

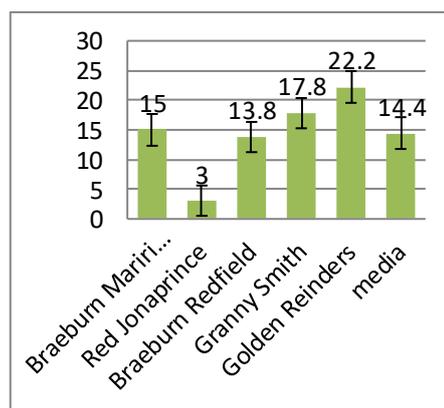


Figure 9. **Number of 3-year-old branches (pcs.)**

Regarding the number of branches, it can be observed that all varieties—except *Red Jonaprince*—are at the same developmental stage, with a similar number of branches. In the case of *Red Jonaprince*, this number is significantly lower, as the number of 3-year-old branches is 80% below the average. This may indicate, besides a weak branching capacity, that it is less adapted to the spatial and cultivation conditions.

The *Golden Reinders* variety is also above the average value (by 36%), which suggests a strong tendency to branch, combined with vigorous growth. The other varieties show similar abilities regarding 3-year-old branches, with only a small percentage difference.

#### Number of 2-year-old and 1-year-old branches

As with flower buds, the number of 1- and 2-year-old branches is also decisive in achieving high yields. Considering this, Figure 12 shows the proportion of 1- and 2-year-old branches.

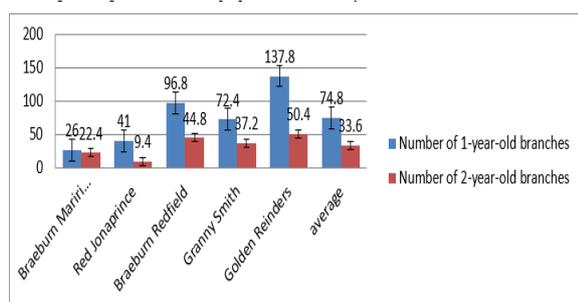


Figure 10. Number of 2-year-old and 1-year-old branches

After counting the productive branches, we used their average number for the varieties included in the study. Among these, *Braeburn Redfield* and *Golden Reinders* stand out, as the number of 1- and 2-year-old branches is well above the average. *Red Jonaprince* and *Braeburn Mariri Red* show a lower number of fruit-bearing branches compared to the average and to the other varieties. However, if we consider that the number of older branches (first-order branches) decreases from the bottom upwards, the number of younger fruit-bearing branches increases at the same time.

#### Average number of vegetative buds

We examined the average number of vegetative buds per variety on the branches on which the other tests were performed, since leaves play an important role in fruit formation, as illustrated in Figure 11.

The data show that the formation of vegetative buds was adequate, with *Braeburn Redfield* standing out (238 buds/tree). In this case, the formation of flower buds was also higher than in the other varieties, as shown in the next figure. The *Golden Reinders* variety likewise shows a higher-than-average number of buds (188 buds/tree). The other three varieties show values close to the average.

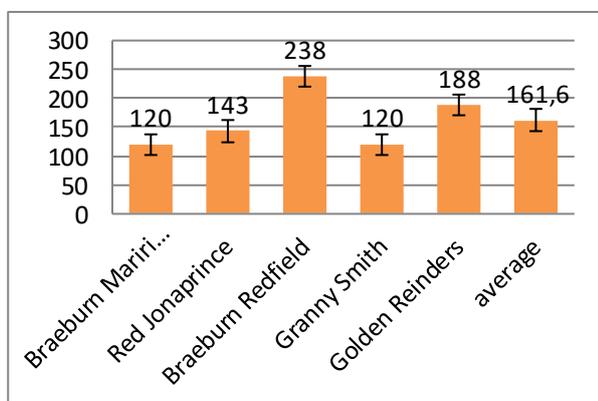


Figure 11. Number of vegetative buds

#### Average number of flower buds

The differentiation of flower buds occurs in three main stages and ends with the opening of the flowers. The data from April illustrate the

number of inflorescences on a tree, while the number of inflorescences counted in May shows the set inflorescences. In fruit crops, physiological fruit drop is a natural process, after which we can speak of the final fruit set.

Table 1

Generative and yield characteristics in the examined plantation (pcs/tree)

Growth Phenophase	Braeburn Mariri Red	Red Jonaprince	Braeburn Redfield	Granny Smith	Golden Reinders
27.04.2024 flowering	232	73	189	170	219
25.05.2024 first binding	115	55	152	145	189
25.06.2024 tied apple	65.6	46.4	114.4	93.4	109
harvested apple	58.5	40.4	108	88	95.8

The figure clearly shows the changes that occur between the flowering stage and the harvest stage. The number of inflorescences exceeds 200 in the varieties *Braeburn Mariri Red* and *Golden Reinders*. The smallest number of inflorescences was recorded for *Red Jonaprince* (73 inflorescences). Based on these data, we can see that there is a threefold difference already at the flowering stage. The high number of flowers can be considered natural in modern varieties, as varieties with high genetic potential tend to produce excessive flowering.

At the second counting in our study (May 25, 2024), we examined the number of primary set fruits. There were significant differences between varieties. In *Braeburn Mariri Red*, only 50% of the flowers set fruit (115 pcs). In *Golden Reinders*, we found the highest fruit set rate (86%). The other varieties had values between these extremes.

After natural fruit drop, we counted again the number of definitively set fruits. The lowest final set amplitude was recorded in the varieties *Golden Reinders* and *Braeburn Mariri Red* (about 57%). The highest fruit set percentage was found in *Red Jonaprince* (84.4%). Normally, this value does not change significantly until harvest.

The data on harvested fruit quantity confirm this only partially. Above all, *Braeburn Redfield* stood out, from which we harvested 94.4% of the total number of fruit that had initially set.

Despite the fact that the largest number of inflorescences was found in *Braeburn Mariri Red*, only 25% of them resulted in harvested fruit. A similar situation was observed in *Golden Reinders*: despite the high number of inflorescences, only 43.7% became marketable fruit. Values close to 50% were found in *Granny*

*Smith* (51.7%) and *Red Jonaprince* (55.3%). The highest value was measured in *Braeburn Redfield* with 57.1%.

In conclusion, it can be stated that a high number of flowers does not automatically lead to higher yields. This is confirmed by the fact that the variety with the highest number of flowers had the lowest fruit set percentage (*Braeburn Mariri Red*, 238 flowers, 58.8 fruits). In contrast, *Red Jonaprince*, with the lowest number of flowers, obtained fruit from about 55.3% of its flowers and developed them to harvest.

### Harvest quantity obtained

One of the main determining factors of the final yield is profitability. When this is combined with excellent quality, high income can be expected. The yield data are illustrated in Figure 12.

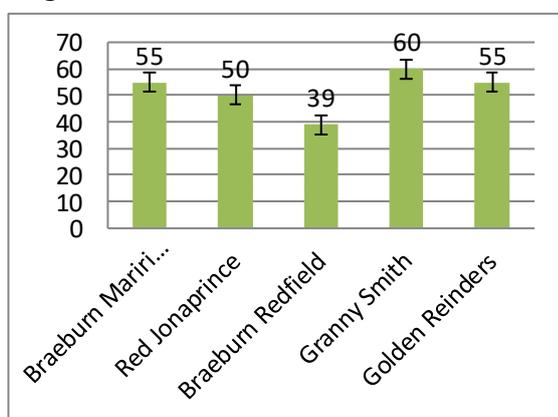


Figure 12. Fruit production (t/ha)

The analysis of the five studied apple varieties revealed significant differences in their vegetative and generative behavior, influenced by both genetic potential and their adaptation to local agroclimatic conditions and applied cultivation technology. *Golden Reinders* and *Braeburn Redfield* demonstrated superior branching capacity and a high number of vegetative and flower buds, indicating strong vigor and high fruiting potential. In contrast, *Red Jonaprince* showed fewer 3-year-old branches and weaker vegetative development, yet achieved above-average final fruit set, suggesting high generative efficiency. The results also show that a high number of inflorescences does not necessarily guarantee a higher final yield. This is evident in *Braeburn Mariri Red*, where excessive flowering resulted in a reduced fruit set. This confirms the need for appropriate phytotechnical interventions (such as pruning and thinning) to prevent overloading and to optimize fruit quantity and quality.

### CONCLUSIONS

The study demonstrated that the five examined apple varieties differ significantly in their vegetative development, generative capacity, and overall adaptability to the cultivation technology and environmental conditions of the plantation. *Golden Reinders* and *Braeburn Redfield* proved to be the most balanced varieties, combining vigorous growth, strong branching capacity, and a high number of productive buds, which together contribute to stable and high yield potential. In contrast, *Red Jonaprince* exhibited weaker vegetative growth but compensated through an efficient fruit set, resulting in a relatively high proportion of harvestable fruit. The results also confirmed that a large number of inflorescences does not necessarily translate into higher production, as observed in *Braeburn Mariri Red*, where excessive flowering led to reduced fruit retention. Overall, the findings highlight the importance of selecting varieties with both strong vegetative performance and reliable generative potential, as well as the necessity of applying modern cultivation technologies and appropriate phytotechnical measures to ensure high productivity and superior fruit quality in intensive apple orchards.

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