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EARLY VEGETATIVE AND GENERATIVE DEVELOPMENT CHARACTERISTICS OF WILTON`S RED JONAPRINCE® SELECT ECO AND GOLDEN REINDERS® CULTIVARS ON B9 AND M9 DWARF ROOTSTOCKS IN IRRIGATED MOLIC EUTRICAMBOSOIL IN NORTHERN TRANSYLVANIA, ROMANIA

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Abstract

The research revealed some important initial vegetative and generative characteristics and tendencies in the early years of development of Wilton`s Red Jonaprince Select Eco ® /B9 (WRJSE) and Golden Reinders/M9 (GR) cultivar-rootstock combinations in a field trial located at FRDS Bistrita, Northern Transylvania in a high density drip irrigated orchard. The strongest vegetative growth was observed in Wilton`s Star Red Jonaprince Select ECO®/B9 in comparison with Golden Reinders/M9 but on the other hand being young trees at early stages of development the before mentioned cultivars gave similar results regarding trunk cross sectional area, tree height. The highest generative bud ratio was found at GR, highest crop load was found on GR while the highest number of fruit per tree was found in GR and the highest fruit diameter was found on WRJSE in comparison with GD. Being in the first years of development the obtained yield/tree had close values (1.99 kg/tree at WRJSE and 1.95 kg/tree at GD), thus yielding a total production of 2.44-2.49 to/ha at WRJSE and GD.

Key words*: apple, rootstocks, irrigation, yield, vegetative parameters, generative parameters.*

INTRODUCTION

Low vigour rootstocks present a series of advantages related to productivity and precocity but require very good soils and adequate fertilization-irrigation systems.

The rootstock M9-T337 (M9) (dwarf) is the standard for the apple industry and breeding programs and Bud-9 (B9) (dwarf) is one of the most dwarfing commercially available rootstocks.

B9 rootstock (sin Budagovsky 9, Bud.9) is a dwarfing rootstock resulting from a cross of M.8 x Red Standard (Krasnij Standard) from Russia. The leaves are a distinctive red. Regarding the height, B.9 is slightly more dwarfing than M9, about 25-35%, and has slightly higher yield efficiency than M9. B9 appears to be resistant to collar rot and is very cold-hardy. It has performed very well across a wide range of conditions (Gonda, 2003; Sharma et al., 2009). Trees needed to be supported.

The American strain was slightly less dwarfing and produced more burr knots than the European strain and yield efficiency was similar (Robinson et al., 2007; Russo et al., 2007). M9 (sin. Malling 9, Paradis Jaune de Metz) is the traditional and best-known dwarfing rootstock. It should be planted on a well-drained site. Trees on this rootstock always require leader support (Dayatilake and van Hooijdonk, 2015). The rootstock is susceptible to fire blight and can develop burr knots (Russo et al., 2007). Numerous clones of M9 are now being sold by nurseries such as Pajam 1 (Lancep) and Pajam 2 (Cepiland) which are French selections relatively new. They are 35 to 40 % more vigorous than M9 NAKB 337.

High-density systems rely mainly on the rootstock M9, a highly productive dwarfing rootstock, which is particularly susceptible to rootstock blight. In heavy fire blight years under natural conditions, tree losses greater than 50% are common for orchards planted on M9 rootstock (Ferree et al., 2002; Robinson et al., 2007). According to the Regulation of the Commission of the European Communities No 85/2004 of 15 January 2004, which lays down the marketing

standard for apples (European Union, 2011), Jonagold/Jonagored is classified with its mutants, including Crowngold, Decosta, Jonabel, Jonagold 2000, Jonagored Supra, King Jonagold, and Red Jonaprince. The production of Red Jonaprince in the European Union is rapidly increasing, and even the United States Department of Agriculture, while presenting apple production in European Union, indicates this specific mutant with Jonagold/Jonagored as a group of Jonagold/Jonagored/Red Jonaprince (Podbielska et al., 2017).

The cultivar Golden Delicious especially his mutant Golden Delicious Reinders which is free from russeting is one of the more promising cultivars, whose production in commercial orchards is increasing each year (Kruczyńska, 2008; Czynczyk and Bielicki, 2012).

In the experiment of Czynczyk and Bielicki (2006), Golden Delicious Reinders come into biennial bearing quite early. It is known from the foreign literature (Crassweller et al., 2001; Bonany et al. 2002), that all growers of Golden Delicious Reinders, in order to obtain good size and regularly yielding trees, have to thin fruitlets very heavily using bioregulators, which is often corrected by hand, so this involves hand work. To obtain good results, a lot of attention has to be paid to pruning and thinning of fruitlets (Czynczyk and Bielicki, 2012).

In this context, the paper presents an analysis of the vegetative and generative parameters in the North East region of Romania of Wilton`S Red Jonaprince® Select Eco grafted on B9 and Golden Delicious Reinders® grafted on M9 rootstocks, in order to put into evidence the comparison of the shoot growth, tree height, and trunk cross-sectional area. Regarding generative parameters, the bud ration, crop load, number of fruits, and their diameter were studied.

MATERIALS AND METHODS

The experiment was conducted in an apple orchard at Fruit Research and Development Station Bistrita (FRDS). FRDS Bistrita is located at 47°10' North latitude and 24°30' East longitude, at 358 m altitude with an average annual temperature of around 10°C and a multiannual average of 758.80 mm of rainfall, according to the data recorded by the meteorological station at FRDS Bistrita, in the last 30 years. The climate is temperate-continental, with relatively hot summers, and less dry cold winters. The orchard was established in 2020, with Wilton`s Red Jonaprince Select Eco®/B9 (WRJSE) and Golden Reinders®/M9 (GR) apple trees in a high-density slender spindle training system with drip irrigation. The experiment had a bifactorial design using for Factor A the scion cultivars WRJSE and GR respectively for Factor B the rootstocks M9 and B9 as graduations. In our study during 2021-2022, we focused on three vegetative growing parameters (trunk cross-sectional area, tree height, shoot length) and six generative parameters (yield per tree, fruit number per tree, crop load, fruit diameter, fruit surface colour, brix degree content of soluble solids). Fruit surface colour was determined with application Image Analysis Toolset - IAT by Google, and it's method is colorimeter RGB. Statistical comparisons of the mean values were performed using ANOVA analysis of variance, followed by pairwise correlations with Duncan`s multiple range test with $P<0.0001$ aimed by XLSTAT (Addinsoft, France) statistical software package using MS Excel platform.

RESULTS AND DISCUSSIONS

Early results showed that the planted young trees with preformed crown produce vegetative and generative organs well balanced in the first years of growing with a good premise for yield (Figure 1).

Figure 1. Aspects from the high-density orchard Wilton`S Red Jonaprince® Select Eco/B9

From the first years of development, the trees produced fruits and the soil substrate until now

seemed acceptable for M9 and B9 rootstocks in molic eutricambosoil (Figure 2), the root system explored well the upper surface of the soil.

Figure 2. Aspects from the high-density orchard with Golden Delicious Reinders®/M9

Regarding the meteorological conditions of the Bistrita area, the temperatures recorded in the last three years fluctuated, influenced by the complex factors of global climate changes. Annual average temperatures were between 10.5°C (2019)-11.2°C (2022), with absolute maximum temperatures between 34.6°C (2019) ranging 35.6°C (2022). Regarding rainfall, the total was 538.9 mm in 2019, 678.8 mm in 2020, 784.5 mm in 2021 and 759.3 mm in 2022 (Table 1). The average value of annual rainfall in the Bistrita region is 758.8 mm, but the years 1999 and 2000 were very dry compared with 2021-2022. A general observation during the last years is that the rainfall distribution is uneven during the year, which can cause an imbalance of growth and fructification processes for apple trees in non-irrigated plots. We concluded that the lack of necessary water amount was especially in the summer months June-August where drip irrigation is compulsory. In the drip irrigated research field, the trees became the required necessary water calculated by FAOSTAT ETP Calculator aimed by Pennmann-Monteth ETr formula for the development and bearing processes.

Table 1. Climate indicators 2019-2022

Climate indicators	2019	2020	2021	2022
Average annual temp. (°C)	10.5	10.1	9.5	11.2
Absolute maximum temp.(°C)	34.6	33.7	33.6	35.6
Rainfall (mm)	538.9	678.9	784.5	759.3

The strongest **vegetative growth** (Figure 3) was observed in Wilton`s Star Red Jonaprince Select ECO®/B9 (36.27 cm shoot lenght) in comparison with Golden Reinders®/M9 (26.36 cm shoot length), but on the other hand being very young trees the before mentioned cultivars gave quite similar results regarding trunk cross sectional area (Figure 4), 5.79 cm^2 in WRJSE and 5.61 cm^2 in GR in our preliminary research.

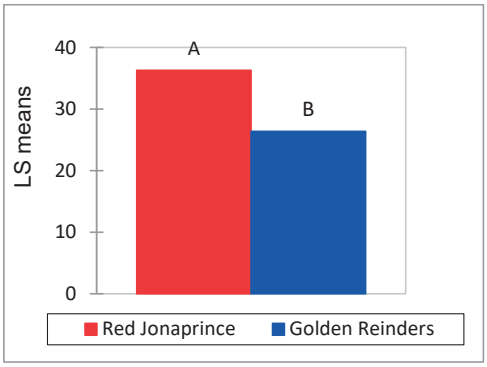

Figure 3. Comparison of shoots length (left-Red Jonaprince/B9, right-Golden Reinders/M9)

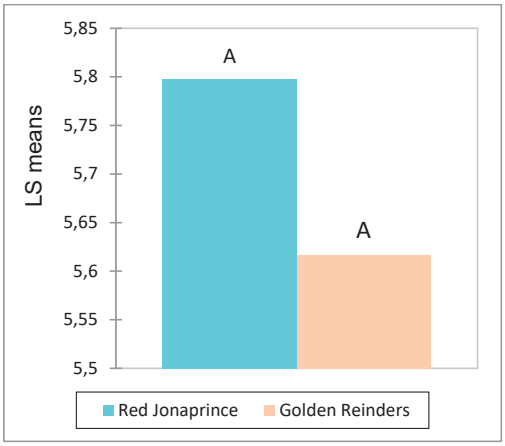

Figure 4. Comparison of TCSA (left-Red Jonaprince/B9, right-Golden Reinders/M9)

Regarding tree height (Figure 5) we can conclude that the studied cultivars gave slight similar growth habit in the first years, 1.46 m was registered at Golden Reinders ®/M9 and 1.43 m at Wilton`s Star Red Jonaprince Select ECO®/B9.

The numerical differences between the variants were multifactorial, mainly due to rootstock and scion influence.

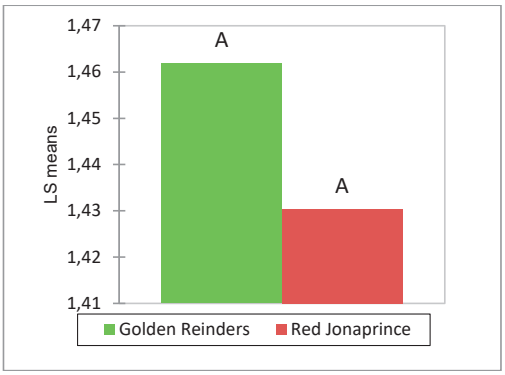

Figure 5 Comparison of tree height (left-Golden Reinders/M9, right-Red Jonaprince/B9)

The highest **generative** bud ratio (Figure 6) was found at GR (31% from total) versus WRJSE (21% from total), highest crop load (Table 2) was found on GR (3.53 fruit/cm^2) in comparison with WRJSE (1.67 fruit/cm^2), while the highest number of fruit per tree (Figure 7) was found in GR (16 in GR and 8 in WRJSE).

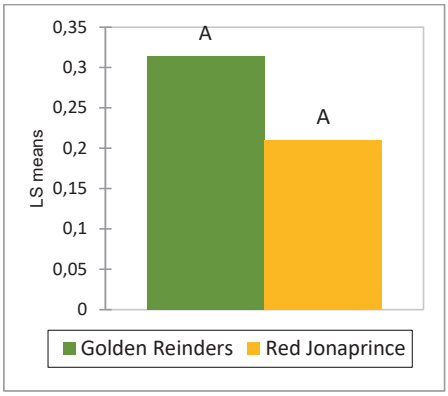

Figure 6. Comparison of generative buds (left-Golden Reinders/M9, right Red Jonaprince/B9)

Table 2. Crop load in treatment cultivars

Cultivars	Crop load (no fruit/cm^2)
Golden Reinders/M9	3.532 a
Red Jonaprince/B9	1.669 b

The results regarding the biometric measurements showed that the size and diameter of fruits (Table 3) was specific to the varieties, with the largest fruit in for Wilton`s Star Red Jonaprince Select ECO®/B9 cultivar with 69.76 mm, followed by Golden Reinders ®/M9 with 62.05 mm.

Table 3. Average fruit diameter of treament cultivars

Cultivars	Fruit Diameter (mm)
Red Jonaprince	69.757 a
Golden Reinders	62.054 b

The indicator number of fruits per tree (Figure 7) showed that at Golden Reinders/M9 there were registered an average of 15 fruits/tree and 7 fruits per tree at Wilton`s Star Red Jonaprince Select ECO®/B9. Golden Reinders/M9 in our researches reached double the value obtained by WSRJ showing the extraordinary bearing capacity of this scion-rootstock combination, but the size of fruits was different.

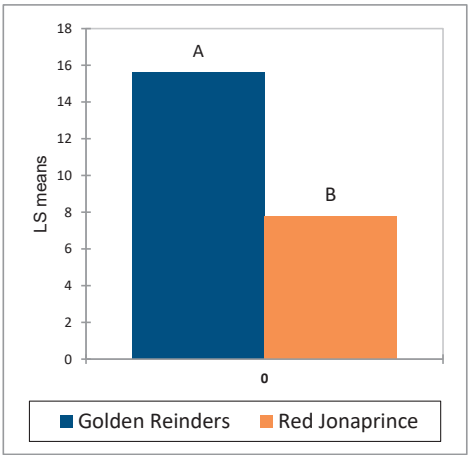

Figure 7. Comparison of number of fruits per tree (left-Golden Reinders/M9, right-Red Jonaprince/B9)

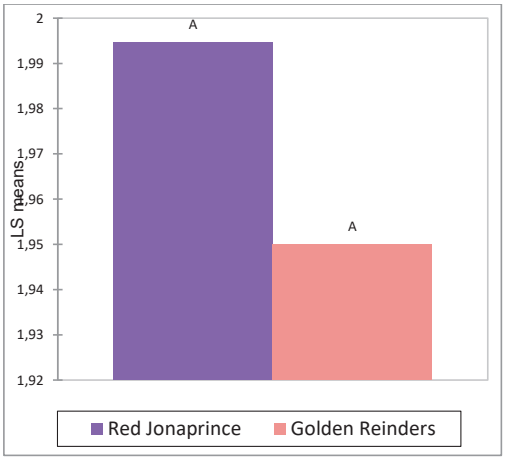

Figure 8. Comparison of the yield kg/per tree (left-Red Jonaprince/B9, right - Golden Reinders/M9)

Results regarding yield (kg/tree) (Figure 8) showed quite similar results in the first years of development, showing 1.99 kg/tree in Wilton`s Star Red Jonaprince Select ECO®/B9 and 1.95 kg/tree in Golden Reinders®/M9.

Brix degree of soluble solids content were ranging between 21-26.4 for WRJSE cultivar and between 12-15.8 for GR cultivar.

The studied cultivars reached very good fruit surface color (80.23-99.9%), especially at Wilton`s Red Jonaprince Select Eco ®/B9.

Csihon et al. (2015; 2022) determinated the fruit surface color and color intensity of the surface for WRJSE fruits, for two consecutive years and the fruit surface color varied from 79 to 83, thus our results are in agreement with our collegues results.

Acording to Racsko et al. (2006), fruit no/tree in GR/M9 varied between 38.2-44.7 fruits/tree showing no extreme differences between on and off alternating bearing years. The smallest number of fruit per tree was 14.8, our results having close values (15.63). Similar results were observed at crop load indicator in GR (6.4 fruit/cm^2) with the lowest values of 1.1 fruit/cm^2, in our results being 3.53 fruit/cm^2.

Average fruit diameter in our results (62.05 mm) had close values to those obtained by Racsko et al.(2006) with values of 79.9- 84.9 mm.

Yield data showed that the trees registered 3.5-4.5 kg/tree in the experiments of Racsko et al. (2006) in the off year, with quite greater results than ours, due to the 4th year of age of trees.

Regarding TCSA, our results (5.61 cm^2) were similar to Csihon et al. (2015) results, which conclude that for WRJSE/M9 the trunk cross-sectional area was 8.2 cm^2. Our scion/rootstock combination WRJSE/B9 registered a weaker growth because the vigor of B9 was slightly weaker than M9, thus the slightly weaker growing habit influences the weaker growth in TCSA.

CONCLUSIONS

Results showed that the planted trees obtained by Knipp technology produced fruits from the first years after establishment, thus the bearing capacity of both cultivars in drip irrigation conditions was relatively good. The fruits obtained at Wilton`s Star Red Jonaprince Select ECO®/B9 rootstock combination achieved a good diameter for marketing and at Golden Reinders®/M9 the bearing capacity is extraordinary with many fruits per tree which showed the necessity of thinning. Further research will be made in order to study the proper adaptation of the studied scion-rootstock combinations in molic eutricambosoils in Northern Transylvania climate region.

Our study provided useful information regarding the expectancy of vegetative and generative development characteristics of the studied cultivars in the first years after establishment, for fruit growing specialists and farmers for establishment of new plantations in molic eutricambosoils.

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