# EVALUATION OF THE EFFECT OF P 14 ROOTSTOCK PROPAGATED *IN VITRO* AND IN STOOLBEDS ON THE GROWTH AND YIELDING OF THREE APPLE CULTIVARS

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A B S T R A C T

The aim of the experiment was to evaluate the field performance of 'Jonagored', 'Gala Must' and 'Elstar' apple trees grafted on the new Polish rootstock P 14, which had been propagated in three different ways: traditionally in stoolbeds (control), in stoolbeds established from *in vitro* propagated plants, or directly by micro-propagation. Tree growth vigour of the three cultivars grafted on the rootstocks propagated in the three different ways was similar during 9 consecutive years of the experiment. Over the period of 8 years of fruiting, the cumulative yields of the three cultivars on *in vitro* propagated rootstocks were similar to these of the trees grown on the traditionally propagated rootstocks. The cumulative yields, expressed in kg per $cm^2$ of trunk cross-sectional area, were also similar for all the trees grown on the rootstocks obtained by the different methods of propagation. Fruit size and weight for the three cultivars were good and similar, regardless of the rootstock propagation method. The results of the nine-year experiment fully justify the use apple trees grafted on the *in vitro* propagated P 14 rootstock for setting up commercial orchards.

**Key words**: apple, rootstock, stoolbeds, *in vitro*, tree vigour, yielding

## INTRODUCTION

For predominantly light soils in Poland, semi-dwarfing rootstocks, such as M.26, P 14 and P 60, are recommended for establishing commercial orchards (Mika, 1994; Czynczyk et al., 2002; Czynczyk and Bielicki, 2007). However, when the traditional methods of stooling or layering are used for propagation, it is necessary to wait many years to

obtain large quantity of newly-bred rootstocks. One of the alternative methods for fast production of a large number of new clones and cultivars is to propagate them *in vitro* (Orlikowska and Czynczyk, 1988; Webster and Jones, 1991). Studies carried out in Poland (Czynczyk and Piskor, 2000; Czynczyk et al., 2007) have proven the high suitability of trees on P 22 and P 14 rootstocks obtained from *in vitro* cultures for growing fruit. Also, trials conducted in the Netherlands (Van Oosten, 1986; Wertheim, 1988; Webster and Jones, 1991) have revealed the high suitability of the M.9 rootstock propagated in tissue culture for growing fruit trees. The increasing use of the semi-dwarfing rootstock P 14 in fruit tree production in Poland (up to 8% in 2006) justifies the research aimed on determining whether trees grafted on the P 14 rootstock propagated *in vitro* are as suitable for fruit growing as trees grafted on this clonal rootstock obtained by the traditional methods of stooling or layering.

## MATERIAL AND METHODS

To establish the experiment, one year-old maidens with a few lateral shoots of three apple cultivars were used (Tab. 1). The trees were budded at a height of about 10 cm above the ground on rootstocks obtained in three different ways: directly from *in vitro* cultures, from stoolbeds established with *in vitro* propagated mother plants, and from vertical layers propagated traditionally in stoolbeds (control). The experimental orchard was set up in the autumn of 1998 on a podsolic soil overlaying boulder clay in the Experimental Orchard in Dąbrowice, which belongs to the Research Institute of Pomology and Floriculture in Skierniewice. The experiment was set up in a random block design, in four replications, with 3 trees spaced at 4.0 x 1.85 m per a plot. Before winter, the soil around each tree was piled up to a height of about 25 cm. The trees were trained as spindles. Soil cultivation, fertilization and plant protection were carried out according to the recommendations for commercial orchards. During the growth period the following observations and measurements were recorded: health status of the trees, trunk circumferences a height of 30 cm above ground in a permanently marked place on each tree, yield and fruit quality. For evaluating fruit quality, all fruits were taken from one representative tree in each plot (replication). Fruit weight and size were assessed using the electronic sorting machine manufactured by Greef. The results were statistically analyzed using the variance analysis method. The significance of the differences between means was determined by Duncan's test at $p = 0.05$.

## RESULTS AND DISCUSSION

### Tree health

After the first severe winter of 1998/1999, symptoms of frost injuries to the bark were found on the trunks of almost all the trees of the

three cultivars, up to a height of about 50 cm above the ground. This severe damage to the tree trunks made necessary to cut down the trees at about eight centimeters above the budding area and to promote the strongest shoots of the new outgrows. Thanks to this course of action, regular and well-developed maiden trees with a few lateral shoots were obtained in the autumn of 1999. During the subsequent nine-year period of growth no trees had been lost as a result of damage either to the root system of the rootstock or injuries to the cultivar caused by frost or diseases.

**Tree size**

The obtained results indicate that the trees on the differently propagated rootstocks were similar in size in the subsequent years of growth. After nine years of growing, the trees grafted on the rootstocks obtained directly from in vitro cultures and those on the rootstocks from stoolbeds established with *in vitro* propagated parent plants were almost of the same size as the trees growing on the traditionally propagated rootstocks (control) (Tab. 1). Only the trees of the cultivar 'Elstar' grafted on the rootstocks obtained from stoolbeds established with *in vitro* propagated parent plants were significantly larger in comparison with the trees grown on the rootstocks obtained directly from *in vitro* culture. The finding that the nine-year-old trees growing on the rootstocks from *in vitro* cultures were similar in size to those on the rootstocks from stoolbeds is consistent with earlier data presented by Van Oosten (1986), Zimmerman and Miller (1991), Czynczyk and Piskor (2000) and Czynczyk et al. (2007).

**Yielding**

All the trees of the three apple cultivars began fruiting in the second year after planting. The yielding in the first five years was presented in earlier reports (Czynczyk et al., 2003; 2007). The cumulative yields for the three cultivars over the subsequent four-year period of fruiting (2004-2007) were similar for the trees growing on rootstocks propagated by different methods (Tab. 1). Also, the cumulative yields for the three cultivars tested over the period of eight years of fruiting were similar for all the trees growing on the differently propagated rootstocks. Any differences in yield were insignificant, regardless of the rootstock propagation method, which confirms earlier results presented by Wertheim (1988), Van Oosten (1996), Czynczyk and Piskor (2000) and Czynczyk et al. (2007). The values of the cropping efficiency coefficient (CEC) were also similar for nearly all of the trees despite the three different methods of rootstock propagation (Tab. 1). The lack of any significant differences between the yield efficiencies of the trees on the differently propagated rootstocks indicates that the trees growing on the *in vitro* propagated rootstocks and on those propagated traditionally by stooling (control) have the same suitability for fruit growing.

Table 1. Tree size and fruit yield of three apple cultivars growing on P 14 rootstock propagated in three different ways

| Cultivar | Method of rootstock propagation ** | TCA in 2007 ($cm^2$) | Yielding (kg/tree) | | | CEC [$kg/cm^2$ TCA] | Weight of 100 fruits [kg] | % of fruits with diameter > 7.0 cm *** |
|---|---|---|---|---|---|---|---|---|
| | | | 2000 -2003 | 2004 -2007 | 2000-2007 | | | |
| Jonagored | 1 | 81.35 a* | 102.1 a | 69.1 a | 171.3 a | 2.18 a | 22.5 a | 89.1 a |
| | 2 | 80.58 a | 103.9 a | 68.0 a | 171.9 a | 2.15 a | 22.4 a | 84.5 a |
| | 3 | 85.97 a | 105.9 a | 69.8 a | 175.8 a | 2.09 a | 22.7 a | 88.1 a |
| Gala Must | 1 | 71.21 a | 98.2 a | 102.2 a | 200.5 a | 2.84 a | 18.7 a | 74.8 a |
| | 2 | 67.05 a | 90.4 a | 94.8 a | 185.2 a | 2.82 a | 19.1 a | 78.0 a |
| | 3 | 68.17 a | 93.8 a | 91.8 a | 185.5 a | 2.75 a | 18.5 a | 78.9 a |
| Elstar | 1 | 99.07 ab | 63.4 a | 67.2 a | 130.6 a | 1.34 ab | 19.4 a | 74.9 a |
| | 2 | 93.00 a | 64.2 a | 76.0 a | 140.2 a | 1.53 b | 19.6 a | 75.3 a |
| | 3 | 106.57 b | 66.4 a | 60.7 a | 127.1 a | 1.22 a | 19.5 a | 75.3 a |

*Means within columns followed by a different letter are significantly different at p = 0.05
**1 – P 14 rootstock propagated traditionally in stoolbeds, vertical layers (control)
2 – P 14 rootstock obtained from in vitro cultures
3 – P 14 rootstock from stoolbeds with in vitro propagated parent plants
***for 'Jonagored' fruit diameter was > 7.5 cm

Fruit size and weight for the three cultivars growing on the differently propagated rootstocks were also much the same (Tab. 1), which is consistent with earlier results obtained by Czynczyk and Piskor for trees grow-ing on P 22 (2000) and Czynczyk et al. (2007) for trees growing on P 14 rootstocks propagated in different ways.

## CONCLUSIONS

The results of the nine-year experiment allow the following conclusions:

1. Trees of three apple tree cultivars; 'Jonagored', 'Gala Must' and 'Elstar' growing on rootstocks obtained from *in vitro* cultures and on rootstocks propagated traditionally in stoolbeds (control) had similar growth vigour during the successive years of the experiment.
2. The size of nine-year-old trees, expressed in terms of their trunk cross-sectional area in $cm^2$, growing on rootstocks obtained directly from in vitro cultures and on rootstocks from mother plants propagated in the traditional way by stooling (control) was very similar.
3. All the trees of the three cultivars began fruiting in the second year after planting. The cumulative yields for the first eight years of fruiting were similar regardless of the rootstock propagation method. The cumulative yields in kg per $cm^2$ of trunk cross-sectional area were also similar for the different methods of rootstock propagation. The fruits of the three apple cultivars

growing on differently propagated rootstocks were also very similar in size and weight.

4. The results of the nine-year experiment fully justify the use apple trees grafted on *in vitro* propagated P 14 rootstocks for setting up commercial orchards.

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# WPŁYW PODKŁADKI P 14 ROZMNAŻANEJ W KULTURACH *IN VITRO* I PRZEZ KOPCZYKOWANIE NA WZROST I OWOCOWANIE TRZECH ODMIAN JABŁONI

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S T R E S Z C Z E N I E

Celem doświadczenia była ocena odmian jabłoni: 'Jonagored', 'Gala Must' i 'Elstar' na podkładce P 14 rozmnażanej trzema metodami: tradycyjnie przez kopczykowanie (kontrola), tradycyjnie przez kopczykowanie roślin matecznych otrzymanych z kultur *in vitro* i podkładek otrzymanych bezpośrednio z mikrorozmnażania. Drzewa trzech odmian rosnące na podkładkach rozmnażanych różnymi metodami były zbliżonej wielkości w kolejnych 9 latach doświadczenia. W okresie 8 lat owocowania sumaryczne plony trzech odmian rosnących na podkładkach rozmnażanych w kulturach *in vitro* były zbliżone do plonów otrzymanych z drzew szczepionych na podkładkach rozmnażanych metodą tradycyjną (kontrola). Sumaryczne plony przypadające w kg na 1 $cm^2$ powierzchni poprzecznego przekroju pnia były również zbliżone wielkością do plonów otrzymanych z drzew rosnących na podkładkach rozmnażanych różnymi metodami. Jakość owoców trzech odmian była dobra niezależnie od różnych metod rozmnażania podkładek. Dziewięcioletnie wyniki doświadczenia potwierdzają wysoką przydatność drzewek jabłoni szczepionych na podkładce P 14 otrzymanej z kultur *in vitro* do zakładania sadów towarowych.

**Słowa kluczowe**: jabłoń, podkładka, kopczykowanie, rozmnażanie *in vitro*, wzrost drzew, owocowanie