PROTECTION OF GENETIC RESOURCES OF POMOLOGICAL PLANTS AND SELECTION OF GENITORS WITH TRAITS VALUABLE FOR SUSTAINABLE FRUIT PRODUCTION

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EFFECTS OF ROOTSTOCK ON PHOTOSYNTHETIC ACTIVITY AND PRODUCTIVITY IN THE SWEET CHERRY CULTIVAR 'STELLA'

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ABSTRACT

From 1997 to 2003, a trial was conducted on the effect of ten different rootstocks on photosynthetic activity and productivity in the sweet cherry cultivar 'Stella'. The rootstocks evaluated were P1 (*Prunus mahaleb* seedling), GiSelA 5, GiSelA 4, GiSelA 195/20, GiSelA 497/8, Weiroot 10, Weiroot 13, Weiroot 53, Weiroot 72 and Weiroot 158. In December 1996, the trees were planted in a randomized plot design 6.0 x 4.5 meters apart. The trial was carried out near Plovdiv, Bulgaria. The trees were trained with a central leader and free-growing crowns by means of winter-pruning. Leaf gas exchange parameters were measured with a portable infrared gas analyzer (Model LCA-4, ADC Ltd., Hoddesdon, Great Britain).

The rootstock on which 'Stella' had the highest five-year average productivity was GiSelA 5, followed by Weiroot 72, GiSelA 4, Weiroot 53, Weiroot 10, GiSelA 195/20, P1, Weiroot 158, GiSelA 497/8 and Weiroot 13. In years after which irrigation was not regularly carried out, the trees grafted on GiSelA 5 were significantly less productive. Without adequate irrigation, the trees grafted on GiSelA 5 had worse leaf gas exchange parameters than the trees grafted on the other rootstocks. They also had fewer flower buds and blossoms, as well as a smaller fruit set.

Key words: sweet cherries, rootstocks, photosynthesis, productivity, GiSelA 5

INTRODUCTION

Sweet cherry rootstocks are studied mainly to determine how they affect growth and fruiting in the scion cultivar (Bujdoso and Hrotko, 2003; Franken-Bembenek, 1995; Grzyb et al., 1998; Lichev and Lankes, 2003; Lugli and Sansavini, 1997; Stehr and Ystaas, 1998).

There is little information how the rootstock affects the physiology of the scion (Perez et al., 1997). What little is know does not provide a significantly clear picture of the physiological state of the trees under study.

The goal of this study was to examine how ten rootstocks affected photosynthetic activity and productivity in the sweet cherry scion cultivar 'Stella'.

MATERIAL AND METHODS

From 1997 to 2003, ten rootstocks were examined in terms of their effect on photosynthetic activity and productivity in the scion cultivar 'Stella'. The rootstocks examined were P1, GiSelA 5, GiSelA 4, GiSelA 195/20, GiSelA 497/8, Weiroot 10, Weiroot 13, Weiroot 53, Weiroot 72 and Weiroot 158. P1 rootstock is a selected *Prunus mahaleb* seedling rootstock which is recognized as the standard in Bulgaria.

In December 1996, six or seven trees grafted on each rootstock were planted 4.5 x 6.0 meters apart in a randomized block design. Each tree was trained with a central leader and a free-growing crown by means of winter pruning. The strip along the rows was treated with herbicide, and the spaces between the rows was mechanically cultivated. Gravity irrigation was employed.

Physiological studies were carried out in 2001 and 2002 when the trees were in their phenological growth and flower formation phases. Physiological studies were carried out on leaves which were the same physiological age as the spurs. The leaves were located on two-year-old wood 1.8 to 2.0 meters above ground level. One leaf was selected on one skeleton branch of four trees per rootstock.

Leaf gas exchange parameters were measured with a portable infrared gas analyzer (Model LCA-4, ADC Ltd., Hoddesdon, Great Britain). During testing, the light level (PhAR) was 1200 µmol m^{-2} s^{-1}, the leaf temperature was 30 ± 2°C, the ambient CO_2 concentration was 350 µmol mol^{-1}, and the ambient relative humidity was between 60 and 65%.

RESULTS

Results for the effect of rootstock on leaf gas exchange parameters are presented in Table 1.

In the growth phase, leaf gas exchange was higher with all the GiSelA and Weiroot rootstocks than with the P1 rootstock. The net photosynthetic rate was 12 to 55% higher with the GiSelA and 'Weiroot' rootstocks than with the P1 rootstock. The transpiration rate was 12 to 75% higher. Stomatal conductance was also the same or higher with the GiSelA and Weiroot rootstocks than with the P1 rootstock, which probably contributes to the higher net photosynthetic rates.

T a b l e 1 . Effect of rootstock on leaf gas exchange parameters of the sweet cherry cultivar ‘Stella’ grafted on ten different rootstocks. Means for 2002 and 2003

Rootstock	Net photosynthetic rate [µmol CO_2 m^{-2} s^{-1}]		F/G[%]	Transpiration rate [mmol H_2O m^{-2} s^{-1}]		F/G[%]	Stomatal conductance [mol m^{-2} s^{-1}]	
	G*	F**		G	F		G	F
P1 (*Pr. mahaleb*)	7.3	6.1	83.6	0.8	1.0	125.0	0.02	0.02
GiSelA 5	10.7	7.1	66.4	1.3	1.2	92.3	0.04	0.03
GiSelA 4	10.9	8.0	73.4	1.0	2.0	200.0	0.03	0.02
GiSelA 195/20	10.5	7.3	69.5	1.1	1.6	145.4	0.04	0.02
GiSelA 497/8	9.9	8.2	82.8	0.9	1.4	155.6	0.02	0.05
Weiroot 10	8.2	6.2	75.6	1.0	2.1	210.0	0.03	0.02
Weiroot 13	8.5	5.8	68.2	1.0	1.8	180.0	0.05	0.02
Weiroot 53	10.6	8.5	80.2	1.3	1.6	123.1	0.04	0.04
Weiroot 72	11.3	9.4	83.2	1.4	1.5	107.1	0.04	0.02
Weiroot 158	9.9	8.7	87.9	1.0	2.0	200.0	0.03	0.02
GD 5%	0.7	0.6		0.1	0.2		0.02	0.02

*G = Growth phase **F = Flower formation phase

The net photosynthetic rate may be affected by both stomatal and mesophyllic factors. Our research confirms that mesophyllic factors affect the net photosynthetic rate (data not presented).

In the flower formation phase, leaf gas exchange was also higher with all the GiSelA and Weiroot rootstocks than with the P1 rootstock.

To compare the physiological state of the trees during the flower formation phase to the physiological state of the trees during the growth phase, we divided the results from the flower formation phase by the results from the growth phase. The net photosynthetic rate decreased with all rootstocks tested, especially GiSelA 5, GiSelA 195/20 and Weiroot 13. The transpiration rate increased with all rootstocks tested except GiSelA 5, which had a lower transpiration rate.

The physiological state of the trees grafted on GiSelA 5 was thus significantly worse during the flower formation phase than the physiological state of the trees grafted on the other rootstocks.

The next part of the study focused on examining how physiological state affected flower bud development and fruit set. In 2002 and 2003, we observed flower bud development and fruit set on two-year-old wood. The results are presented in Table 2.

T a b l e 2. Productivity parameters in the sweet cherry cultivar ‘Stella’ grafted on ten different rootstocks. Means for 2002 and 2003

Rootstock	Flower buds per spur	Flowers per flower bud	Flower buds per linear meter	Fruit set percentage
P1 (*Pr. mahaleb*)	3.08	2.81	110	60.0
GiSelA 5	2.92	2.40	110	47.0
GiSelA 4	3.39	2.99	152	52.7
GiSelA 195/20	3.59	2.55	156	56.8
GiSelA 497/8	3.81	2.57	140	60.3
Weiroot 10	3.20	2.95	125	64.0
Weiroot 13	3.05	3.01	131	62.7
Weiroot 53	3.77	2.98	153	60.6
Weiroot 72	3.11	3.17	137	68.2
Weiroot 158	3.16	3.17	124	64.4
GD 5%	0.62	0.46	39.48	10.69

The rootstock on which ‘Stella’ had the least flower buds per spur was GiSelA 5. Trees grafted on GiSelA 195/20, GiSelA 497/8 and Weiroot 53 had significantly more flowers buds per spur than trees grafted on GiSelA 5.

The rootstock on which 'Stella' had the the least flowers per flower bud was GiSelA 5. Trees grafted on Weiroot 72, Weiroot 158 and Weiroot 13 had significantly more flowers per flower bud than trees grafted on GiSelA 5.

The rootstocks on which 'Stella' had the least flower buds per linear meter were GiSelA 5 and P1. Trees grafted on GiSelA 4, GiSelA 195/20 and Weiroot 53 had significantly more flower buds per linear meter than trees grafted on GiSelA 5 and P1.

The rootstock on which 'Stella' had the lowest fruit set percentage was GiSelA 5. Trees grafted on Weiroot 72, Weiroot 158 and Weiroot 10 had significantly higher fruit set percentages than trees grafted on GiSelA 5.

The last part of the study focused on examining how physiological state affected productivity. The rootstock on which 'Stella' had the highest five-year average productivity coefficients was GiSelA 5. However, based on the two-year average for 2002 and 2003, trees grafted on GiSelA 5, GiSelA 195/20, GiSelA 497/8, Weiroot 13 and Weiroot 158 were relatively less productive (Tab. 3).

T a b l e 3. Coefficients of productivity for the sweet cherry cultivar 'Stella' grafted on ten different rootstocks

Rootstock	Total yield divided by trunk cross-sectional area		Total yield divided by crown area	
	1999-2003	2002-2003	1999-2003	2002-2003
P1 (*Pr. mahaleb*)	0.51	0.42	8.20	6.75
GiSelA 5	0.65	0.30	14.71	6.66
GiSelA 4	0.60	0.36	11.19	6.81
GiSelA 195/20	0.46	0.28	9.23	5.68
GiSelA 497/8	0.39	0.28	7.86	5.76
Weiroot 10	0.52	0.42	10.08	8.12
Weiroot 13	0.40	0.26	6.24	4.14
Weiroot 53	0.56	0.44	9.58	7.49
Weiroot 72	0.62	0.40	11.49	7.41
Weiroot 158	0.43	0.28	8.54	5.61
GD 5%	0.15	0.11	2.49	1.85

DISCUSSION

The reason for the relatively lower productivity of trees grafted on GiSelA 5 in 2002 and 2003 was that we did not have a water supply for irrigation in the second half of 2001 and 2002. This reduced flower bud formation in the summers of 2001 and 2002, which reduced flower bud development, fruit set percentage and productivity in 2002 and 2003.

Of all the rootstocks tested, GiSelA 5 was most sensitive to agrotechnical practices. Trees grafted on GiSelA 5 were very productive, but only when agrotechnical practices such as irrigation were carefully carried out. Trees grafted on GiSelA 5 have been reported to be very productive under optimal conditions (Baumann, 1997; Riesen and Ladner, 1998). Under less favorable conditions, such as those in our study, trees grafted on GiSelA 5 were not as productive as trees grafted on other rootstocks such as Weiroot 53, Weiroot 10 and Weiroot 72.

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WPŁYW PODKŁADKI NA AKTYWNOŚĆ FOTOSYNTETYCZNĄ I PLONOWANIE CZEREŚNI ODMIANY ‘STELLA’

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STRESZCZENIE

W latach 1997-2003 badano wpływ różnych podkładek: P1 (*Prunus mahaleb* siewka), GiSelA 5, GiSelA 4, GiSelA klon195/20 i 497/8, Weiroot 10, Weiroot 13, Weiroot 53, Weiroot 72, i Weiroot 158 na wzrost i owocowanie czereśni odmiany ‘Stella’. Sad założono w rejonie Plovdiv w grudniu 1996 roku w rozstawie 6 x 4,5 m. Korony prowadzono w formie naturalnej. Intensywność oddychania liści mierzono aparatem LCA-4 (ADC Ltd., Hoddesdon, produkcji angielskiej).

Stwierdzono, że w końcu siódmego roku życia najplenniejsze były drzewa czereśni ‘Stella’ szczepione na podkładce GiSelA 5, w następnej kolejności na Weiroot 72, GiSelA 4. Sad był sporadycznie nawadniany. W późniejszym okresie produktywność drzew na GiSelA 5 wyraźnie się obniżyła. W tych warunkach drzewa na podkładkach GiSelA 5 miały mniej korzystne warunki wymiany gazowej i niższą aktywność fotosyntezy niż drzewa rosnące na innych podkładkach. Na dwuletnich przyrostach miały one relatywnie mniejszą liczbę pęków kwiatowych i mniejszą od innych liczbę zawiązanych owoców niż we wcześniejszym okresie.

Słowa kluczowe: czereśnia, podkładki, fotosynteza, produktywność, GiSelA 5