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THE INFLUENCE OF THE THICKNESS OF ROOTSTOCK AND SCIONS ON THE GROWTH AND QUALITY OF THE OBTAINED SHRUBS OF TWO *Rosa* × *hybrida* CULTIVARS. PART II. THE QUALITY OF SHRUBS

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Abstract. In 1999–2001 years two *Rosa* × *hybrida* cultivars, 'Casanova' and 'Korlingo', were obtained by bud-grafting on a thornless multiflora rootstock (*Rosa multiflora* Thunb.). The first factor studied was the rootstock quality: class I (base diameter Ø = 4–6 mm); class II (base diameter Ø = 3–4 mm); class III (base diameter Ø = 2–3 mm). The second factor studied was the scion size: thick scions (Ø = 6–8 mm); medium scions (Ø = 4–6 mm); thin scions (Ø = 2–4 mm). The highest rate of rose shrubs was obtained with class I rootstocks, and lowest with class III rootstocks. The biggest number of I class shrubs was obtained on class I and class II rootstocks, and from thick scions, and the smallest number with class III rootstocks. The root system development was best with class I and class II rootstocks. The rate of successful grafts and the quality of the shrubs obtained were not affected by the scion size.

Key words. *Rosa* × *hybrida*, bud-grafting, quality, rootstock, *Rosa multiflora*

INRODUCTION

Rootstock quality is one of the main factors to determine whether the graft takes hold [Tonecki and Łukaszewska 1996]. The success rate of bud-grafting on the multiflora rootstock is high, and a large proportion of the bud-grafted plants is of high-quality [Wennemuth 1969 cited in Bärtels 1982, Kool and van de Pol 1991].

Fruit growers are aware of the effect of rootstock quality on product quality [Barrit 1990, Bielicki and Czynczyk 1992]. Similar issues occur in producing roses. The root-

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stocks used should be of uniform quality to facilitate planting and tending [Hetman 1987]. The success of bud-grafting depends on using healthy rootstocks with well-developed root systems and with root bases of the right thickness [Falińska-Król and Hetman 2001].

Successful bud-grafting depends on rootstock quality and scion size [Hetman and Monder 2003a i b]. With hybrid tea *Rosa* × *hybrida* and floribunda rose varieties, growth and quality are also affected by the developmental stage and topophysical origin of the scion [Hetman and Monder 2004a i b, Monder and Hetman 2006a i b].

The aim of this study was to measure growth and quality parameters in hybrid tea rose bushes produced by bud-grafting with rootstocks of different quality classes and scions of different size classes, with emphasis on the consequences of using low-quality rootstocks and scions.

MATERIAL AND METHODS

In 1999–2001 years two *Rosa* × *hybrida* cultivars, 'Casanova' and 'Korlingo', were obtained by bud-grafting on a thornless multiflora rootstock (*Rosa multiflora* Thunb.) in the test fields of Botanical Garden – Centre for Biological Diversity Conservation of the Polish Academy of Sciences in Warsaw.

At the end of March, the rootstocks were planted on plots of about 2.2 m^2. Twenty rootstocks were planted on each plot, with 3 different diameters of rootstock bases: class I (rootstock base Ø = 4–6 mm), class II (rootstock base Ø = 3–4 mm), and class III (rootstock base Ø = 2–3 mm). At the end of July the rootstocks were budded with buds from scions of three sizes: thick scions (Ø = 6–8 mm); medium scions (Ø = 4–6 mm); and thin scions (Ø = 2–4 mm).

The conditionals of cultivation, study, weather conditions are described in part I. The part II contain of results of the rate of successfully produced bushes; proportions of first-class, second-class and third-class bushes as defined by Polish Industrial Standard PN-87R-67020; stage of root system development. Root system development was recorded on a scale of 1 to 5 : 1 – root system weak and shallow with a few thin, unbranched lead roots; 2 – root system weak and shallow, with a few weakly branched lead roots; 3 – root system moderately well-developed and moderately deep, with several moderately branched lead roots; 4 – root system well developed and moderately deep, with numerous strong, well-branched lead roots bearing numerous secondary and tertiary roots; 5 – root system robust and deep, with abundant long, strong, highly-branched lead roots bearing abundant secondary and tertiary roots (fig. 1).

All data were statistically elaborated using one-way, two-way and three-way analysis of variance, followed by means separation using Tukey's t-test at $P < 0.05$.

RESULTS

The rate of successfully produced bushes was strongly affected by rootstock quality. The success rate was highest with class I rootstocks (60.3%), and lowest with class III

rootstocks (51.0%). For 'Casanova', the success rate in 2000 and 2002 was significantly higher with class I rootstocks than with class II rootstocks. For 'Korlingo', the success rate in 2000 was significantly higher with class I and II rootstocks than with class III rootstocks. For both cultivars combined, the success rate in 2002 was significantly higher with class I rootstocks (40.0%) than with class II rootstocks (32.6%). The success rate was not significantly affected by scion size (tab. 1).

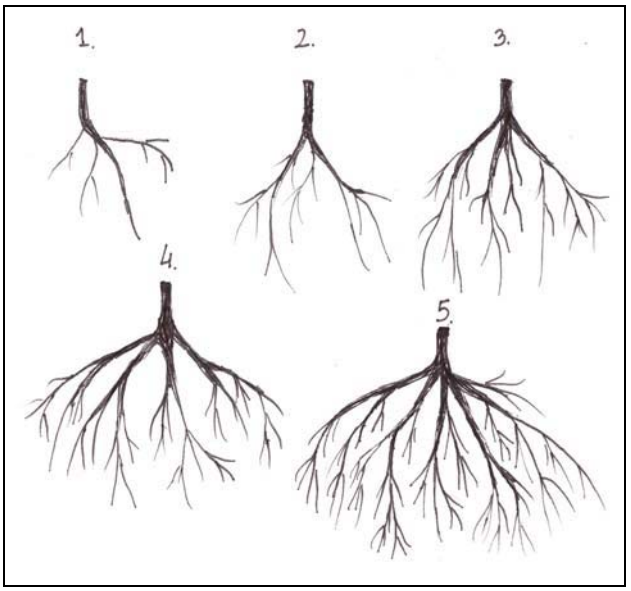

Fig. 1. The scale of root system development 1 to 5. 1 – root system weak and shallow with a few thin, unbranched lead roots; 2 – root system weak and shallow, with a few weakly branched lead roots; 3 – root system moderately well-developed and moderately deep, with several moderately branched lead roots; 4 – root system well developed and moderately deep, with numerous strong, well-branched lead roots bearing numerous secondary and tertiary roots; 5 – root system robust and deep, with abundant long, strong, highly-branched lead roots bearing abundant secondary and tertiary roots

Rys. 1. Skala rozwoju systemu korzeniowego. 1 – system korzeniowy bardzo słaby, płytki, główne korzenie cienkie i nieliczne, pojedyncze; 2 – system korzeniowy słaby, płytki, słabo rozgałęziony, główne korzenie nieliczne; 3 – system korzeniowy głębszy, średnio obfity, korzenie główne i boczne w większej liczbie; 4 – system korzeniowy głębszy, obfity, korzenie główne silne, rozgałęzione, liczne korzenie II i III rzędu; 5 – system korzeniowy głęboki, silny, korzenie główne liczne, długie, silne, obficie rozgałęzione, liczne korzenie II i III rzędu

In 2002, there was a significant interaction between graft size and scion size for success rate. For both of the cultivars tested, the success rate was highest with class I rootstocks and thin scions (44.5%), and lowest with class III rootstocks and thin scions (23.5%) (tab. 1).

The proportion of first-class bushes was highly dependent on rootstock quality. For both cultivars, the proportion of first-class bushes was highest with class II rootstocks (69.6%), and lowest with class III rootstocks (61.7%). In 2000 and 2002, the proportion of first-class bushes for both cultivars combined was higher with class I and class II rootstocks than with class III rootstocks. The differences were significant in 2002 (tab. 2).

The proportion of first-class bushes was not significantly affected by scion size. However, the proportion of first class bushes tended to be highest with thick scions (67.3%), and lowest with thin scions (64.2%) (tab. 2).

There was no significant interaction between rootstock quality and scion size with either of the cultivars tested. However, the proportion of first-class bushes was highest with class I and class II rootstocks and scions of all size classes. The proportion of first-class bushes tended to be lowest with class III rootstocks and thick scions for both of the cultivars tested (tab. 2).

Root system development was highly dependent on rootstock quality. For both of the cultivars tested, development was best with class I rootstocks (4.6), and worst with class III rootstocks (3.7). For both cultivars combined in 2001 and 2002, and for the three-year means for each cultivar, development was significantly better with class II rootstocks than with class III rootstocks (tab. 3).

Root system development was not significantly affected by scion size. There were no significant differences in development, except for 'Casanova' in 2000, when development was significantly better with medium scions than with thin scions. This tendency was not observed in the other years of the study (tab. 3).

There was a significant interaction between rootstock quality and scion size for both of the cultivars tested. In 2000, development was best with class I rootstocks and scions of all three size classes (4.3–4.5), and worst with class III rootstocks and thin scions (2.9) for both of the cultivars tested. In 2001, development was best with class I and class II rootstocks and thick (4.9 and 4.5) and thin (4.8 and 4.6) scions, and worst with class III rootstocks and thin scions (3.6). Development was also poor with class III rootstocks and thick (3.8) and medium (4.0) scions. The same pattern was observed in 2002 (tab. 3).

For 'Casanova', root system development in 2001 was best with class I rootstocks and thick (4.8) and thin (4.8) scions, and worst with class III rootstocks and thin scions (3.0). In 2002, development was best with class I rootstocks and scions of all size classes (4.8; 4.8; 5.0), and worst with class III rootstocks and thick scions (3.4) (tab. 3).

For 'Korlingo', root system development in 2001 was best with class I rootstocks and thick scions (5.0), and worst with class III rootstocks and thin scions (3.6). The same tendency was observed in 2000 and 2002 (tab. 3).

There were few significant differences between the cultivars in terms of the rate of successfully produced bushes and root system development. For both of the cultivars tested, the proportion of first-class bushes in 2000 was significantly higher for 'Korlingo' (68.1%) than for 'Casanova' (55.5%). In 2001 and 2002, there were no significant differences between the cultivars tested (tab. 3).

The quality of the bushes produced varied from year to year. The severe winter and drought in spring are unfavorable to roses too. For both of the cultivars tested, the rate

Table 1. The influence of the quality of rootstock and scions on percentage of shrub in relation to budded rootstocks
Tabela 1. Wpływ jakości podkładki i zrazów na procent uzyskanych krzewów w stosunku do zaokulizowanych podkładek

Year Lata	Cultivar C Odmiana C	'Casanova'			'Korlingo'			The average for both cultivars Średnia dla obu odmian			'Casa-nova'	'Korlingo'	Average Średnia
	thickness of scions B grubość zrazów B thickness of the rootstock A grubość podkładki A	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	average A średnia A	average A średnia A	average A średnia A
2000	class I (4–6 mm)	77.0	68.7	51.5	65.5	59.4	55.6	71.3	64.1	53.5	65.7 B*	60.2 B	63.0 B
	class II (3–4 mm)	59.6	58.6	57.6	69.1	58.0	59.4	64.4	58.3	58.5	58.6 A	62.2 B	60.4 AB
	class III (2–3 mm)	60.5	57.8	59.9	45.3	52.0	38.5	52.9	54.9	49.2	59.4 A	45.3 A	52.3 A
	average B – średnia B	65.7	61.7	56.3	60.0	56.5	51.2	62.9	59.1	53.8	61.2 B	55.9 B	58.6 B
2001	class I (4–6 mm)	63.2	78.2	78.6	86.1	92.4	76.0	74.6	82.1	77.3	73.3	84.8	78.0
	class II (3–4 mm)	79.7	71.8	70.9	76.7	72.4	85.8	78.2	70.9	78.4	74.1	78.3	75.8
	class III (2–3 mm)	65.4	69.4	87.3	58.8	83.3	77.5	62.1	76.3	82.4	74.0	73.2	73.6
	average B – średnia B	69.4	70.6	78.9	73.8	82.7	79.8	71.6	76.4	79.3	73.8 C	78.8 C	75.8 C
2002	class I (4–6 mm)	47.9 B	42.3AB	58.6 B	31.1	29.9	30.5	39.5AB	36.1AB	44.5 B	49.6 B	30.5	40.0 B
	class II (3–4 mm)	41.6AB	29.9AB	34.7AB	25.3	27.6	25.2	33.4AB	28.8AB	29.9AB	35.4 A	26.0	30.7 A
	class III (2–3 mm)	28.1ab	16.5a	24.5 A	28.5	42.6	22.5	28.3AB	29.5AB	23.5A	23.1 A	31.2	27.1 A
	average B – średnia B	39.2	29.6	39.3	28.3	33.3	26.0	33.7	31.5	32.6	36.0 A	29.2 A	32.6 A
Average A Średnia A	class I (4–6 mm)	62.7	61.0	62.9	60.9	60.6	54.0	61.8	60.8	58.4	62.2 B	58.5 B	60.3 B
	class II (3–4 mm)	60.3	52.6	54.4	57.0	52.7	56.8	58.7	52.6	55.6	55.8AB	55.5AB	55.6AB
	class III (2–3 mm)	51.3	47.9	57.2	44.2	59.3	46.2	47.8	53.6	51.7	52.2 A	49.9 A	51.0 A
	average B – średnia B	58.1	53.8	58.2	54.0	57.5	52.3	56.1	55.7	55.2	56.7	54.6	55.7

*Means followed by the same letter do not differ significantly at α = 0.05
*Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie α = 0,05

Table 2. The influence of the quality of rootstock and scions on percentage of the I quality of shrub in relation to number of all obtained shrub
Tabela 2. Wpływ jakości podkładek i zrazów na procent krzewów I wyboru w stosunku do całkowitej liczby uzyskanych krzewów

Year Lata	Cultivar C Odmiana C	'Casanova'			'Korlingo'			The average for both cultivars Średnia dla obu odmian			'Casa-nova'	'Korlingo'	Average Średnia
	thickness of scions B grubość zrazów B thickness of the rootstock A grubość podkładki A	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	average A średnia A	average A średnia A	average A średnia A
2000	class I (4–6 mm)	60.9	52.2	57.8	58.7	76.8	67.2	59.8	64.5	62.5	56.9	67.6	62.3
	class II (3–4 mm)	66.8	48.8	57.5	65.0	67.7	69.1	65.9	58.2	63.3	57.7	67.2	62.5
	class III (2–3 mm)	44.4	56.3	55.1	56.1	72.9	79.9	50.2	64.6	67.5	51.9	69.6	60.7
	average B – średnia B	57.4	52.4	56.8	59.9	72.4	72.1	58.6	62.4	64.4	55.5 A*	68.1	61.8
2001	class I (4–6 mm)	63.7	66.0	65.7	71.0	57.5	66.0	67.4	61.8	65.8	65.1	64.8	65.0
	class II (3–4 mm)	73.9	77.4	67.3	75.9	71.1	67.3	74.9	74.3	67.3	72.8	71.4	72.1
	class III (2–3 mm)	66.9	72.9	63.3	71.1	68.6	58.3	69.0	70.7	60.8	67.7	66.0	66.8
	average B – średnia B	68.2	72.1	65.4	72.7	65.7	63.9	70.4	68.9	64.6	68.6 B	67.4	68.0
2002	class I (4–6 mm)	72.6	69.5	73.4	82.3	86.2	46.4	77.4	77.9	59.9	71.8	71.6 AB	71.7 B
	class II (3–4 mm)	82.5	57.9	78.9	86.1	65.0	75.5	84.3	61.5	77.2	73.1	75.5 B	74.3 B
	class III (2–3 mm)	62.7	53.3	65.0	51.6	69.6	42.9	57.1	61.5	53.9	60.3	54.7 A	57.5 A
	average B – średnia B	72.6	60.3	72.4	73.3	73.6	54.9	73.0	66.9	63.7	68.4 B	67.3	67.9
Average A Średnia A	class I (4–6 mm)	65.7	62.6	65.6	70.7	73.5	59.9	68.2	68.0	62.8	64.6	68.0	66.3AB
	class II (3–4 mm)	74.4	61.4	67.9	75.7	67.9	70.6	75.0	64.7	69.3	67.9	71.4	69.6 B
	class III (2–3 mm)	58.0	60.8	61.1	59.6	70.4	60.3	58.8	65.6	60.7	60.0	63.4	61.7 A
	average B – średnia B	66.0	61.6	64.9	68.6	70.6	63.6	67.3	66.1	64.2	64.2	67.6	65.9

*Means followed by the same letter do not differ significantly at $\alpha = 0.05$
*Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$

Table 3. The influence of the quality of rootstock and scions on the shoot on roots system quality of shrub in five degree scale
Tabela 3. Wpływ jakości podkładek i zrazów na jakość systemu korzeniowego w pięciostopniowej skali

Year Lata	Cultivar C Odmiana C	'Casanova'			'Korlingo'			The average for both cultivars Średnia dla obu odmian			'Casa-nova'	'Korlingo'	Average Średnia
	thickness of scions B grubość zrazów B thickness of the rootstock A grubość podkładki A	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	thick (ø 6–8 mm) grube	medium (ø 4–6 mm) średnie	thin (ø < 4 mm) cienkie	average A średnia A	average A średnia A	average A średnia A
2000	class I (4–6 mm)	4.4	4.4	3.8	4.6	4.4	4.8	4.5 B*	4.4 B	4.3 B	4.2	4.6	4.4 B
	class II (3–4 mm)	3.8	4.4	3.3	3.2	3.8	3.0	3.5 AB	4.1 AB	3.2 AB	3.8	3.3	3.6 A
	class III (2–3 mm)	2.8	3.6	2.8	3.6	3.2	3.0	3.2 AB	3.4 AB	2.9 A	3.1	3.3	3.2 A
	average B – średnia B	3.7 AB	4.1 B	3.3 A	3.8	3.8	3.6	3.7	4.0	3.5	3.7 A	3.7 A	3.7 A
2001	class I (4–6 mm)	4.8 B	4.4 AB	4.8 B	5.0 B	4.4 AB	4.8 AB	4.9 D	4.4 BCD	4.8 CD	4.7 B	4.7 B	4.7 B
	class II (3–4 mm)	4.2 AB	4.2 AB	4.4 AB	4.8 AB	4.0 AB	4.8 AB	4.5 BCD	4.1ABCD	4.6 BCD	4.3 B	4.5 B	4.4 B
	class III (2–3 mm)	3.6 AB	3.8 AB	3.4 A	4.0 AB	4.2 AB	3.8 A	3.8 AB	4.0 ABC	3.6 A	3.6 A	4.0 A	3.8 A
	average B – średnia B	4.2	4.1	4.2	4.6	4.2	4.5	4.4	4.2	4.3	4.2 B	4.4 B	4.3 B
2002	class I (4–6 mm)	5.0 B	4.8 B	4.8 B	4.8	4.5	4.8	4.9	4.7	4.8	4.9 B	4.7 AB	4.8 B
	class II (3–4 mm)	4.4 AB	4.4 AB	4.6 AB	5.0	4.6	4.8	4.7	4.5	4.7	4.5 AB	4.8 B	4.6 B
	class III (2–3 mm)	3.4 A	4.3 AB	4.6 AB	4.6	4.2	4.0	4.0	4.2	4.3	4.1 A	4.3 A	4.2 A
	average B – średnia B	4.3	4.5	4.7	4.8	4.4	4.5	4.5	4.5	4.6	4.5 B	4.6 B	4.5 B
Average A Średnia A	class I (4–6 mm)	4.7	4.5	4.5	4.8	4.4	4.8	4.8	4.5	4.6	4.6 C	4.7 C	4.6 C
	class II (3–4 mm)	4.1	4.3	4.1	4.3	4.1	4.2	4.2	4.2	4.2	4.2 B	4.2 B	4.2 B
	class III (2–3 mm)	3.3	3.9	3.6	4.1	3.9	3.6	3.7	3.9	3.6	3.6 A	3.8 A	3.7 A
	average B – średnia B	4.0	4.3	4.1	4.4	4.1	4.2	4.2	4.2	4.1	4.1	4.2	4.2

*Means followed by the same letter do not differ significantly at $\alpha = 0.05$
*Średnie oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$

of successfully produced bushes was significantly higher in 2001 (75.8%) than in 2000 (58.6%) or 2002 (32.6%). For 'Casanova', the proportion of first-class bushes was significantly higher in 2001 (68.6%) and 2002 (68.4%) than in 2000 (55.5%). For 'Korlingo' and for both cultivars combined, however, there were no significant differences in the proportion of first-class bushes from year to year. For both cultivars, root system development was significantly better in 2001 (4.3) and 2002 (4.5) than in 2000 (3.7) (tab. 1–3).

DISCUSSION

In the study conducted, the rate of the obtained bud-grafts of *Rosa* × *hybrida* cultivars in relation to bud-grafted rootstocks was higher with I class rootstocks than II class rootstocks. With class III rootstocks, the success rate was particularly low when grafting with buds from shots from every scion size, but mostly thick scions and medium scions, probably because of anatomical incompatibility. However, rootstock quality did not significantly affect the average rate of the shrubs obtained.

In Kiczorowski's study [2003] on propagation of apple-trees, efficiency of bud-grafts in a nursery depended on the rootstock and its thickness. The best results were with thicker class rootstocks, and, for some weaker rootstocks, significantly higher efficiencies were in the medium size class. In other studies, the main cause of the low number of cherry-trees were thin rootstocks [Czynczyk and Grzyb 1987]. The results of the studies conducted by the authors indicate that rootstock quality has a deciding effect on the rate of the trees obtained, like in the present study.

For both cultivars, the rate of I class shrubs and the root system development were best with class I and class II rootstocks, and worst with class III rootstocks. Bielicki and Czynczyk [1992] obtained apple-trees of the highest plant quality with thick rootstocks. Samus and Gadzhiev [1997] and Kiczorowski [2003] obtained high-quality apple-trees also with medium rootstocks. In the study conducted by Kiczorowski [2003], the proportion of I class trees varied widely (from 13 to 88%), depending on the rootstock size. The proportion of I class trees was usually highest with thick rootstocks, and occasionally with medium rootstocks [Kiczorowski 2003].

In one study, four cultivars of plum were T-grafted onto 'Wangenheim' seedling rootstocks of different size classes. In other experiments, the same four plum cultivars were grafted on 'Wangenheim' seedling rootstocks and on standard *Prunus divaricata* rootstocks of the thinnest size class. On 'Wangenheimer' seedling rootstock, tree quality was highest with thick rootstocks, and lowest with thin rootstocks [Grzyb 1990].

CONCLUSIONS

1. Success with grafting *Rosa* × *hybrida* bushes is highest with class I rootstocks, and lowest with class III rootstocks.

2. The rate of successfully produced bushes and the quality of the bushes produced is generally not affected by scion size. However, scion size should be matched to rootstock size to ensure anatomical compatibility.

3. The proportion of first-class bushes is highest with thick scions and class I and class II rootstocks, and lowest with class III rootstocks.

4. Root system development is better with class I and class II rootstocks.

5. Weather conditions have a great affect on the rate of successfully produced bushes and on the quality of the bushes produced.

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WPŁYW JAKOŚCI PODKŁADEK I ZRAZÓW NA WZROST I JAKOŚĆ UZYSKANYCH KRZEWÓW DWÓCH ODMIAN RÓŻ Z GRUPY WIELKOKWIATOWYCH. CZĘŚĆ II. JAKOŚĆ KRZEWÓW

Streszczenie. Oczka dwóch odmian róż z grupy wielkokwiatowych ‘Casanova’ i ‘Korlingo’ pobierano ze zrazów o trzech różnych grubościach: (grube Ø = 6–8 mm; średnie Ø = 4–6 mm; cienkie Ø = 2–4 mm), okulizowano na podkładce *Rosa multiflora* Rhunb., typ bezkolcowy, wyboru I (szyjka korzeniowa Ø = 4–6 mm), II (szyjka korzeniowa Ø = 3–4 mm) i III (szyjka korzeniowa Ø = 2–3 mm. Najwięcej krzewów uzyskano przy okulizacji podkładek I wyboru, najmniej – III wyboru. Najwięcej krzewów wyboru I otrzymano przy okulizacji podkładek I i II wyboru oczkami ze zrazów grubych. Najmniej krzewów I wyboru uzyskano po okulizacji podkładek wyboru III. System korzeniowy najlepszej jakości miały krzewy pochodzące z okulizacji podkładek I i II wyboru. Jakość zrazów nie miała wpływu na jakość i liczbę uzyskanych krzewów.

Słowa kluczowe: *Rosa* × *hybrida*, okulizacja, jakość, podkładka, zraz, *Rosa multiflora*

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