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THE EFFECT OF SHOOT BENDING AND ROOTSTOCK ON QUANTITY AND QUALITY OF CUT FLOWER OF ROSE CV. 'RED HOUSE' YIELD

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Abstract. In modern greenhouse cultivations using the shoot bending method, the architecture of rose shrub is obtained by bending of primary stem, forming and suitable cutting of flower shoots and simultaneously bending of low-valuable stems. The studies performed in 2010–2012 indicated that the bending of stems of rose cv. 'Red House' increase the sprouting of high quality flower shoots, and parameters of cut flower cultivated with both in traditional and shoot bending method were similar. The used rootstock has significant effect on quantity and quality of yield in unheated foil tunnel. The shrubs budded on *R. multiflora* are characterized by higher yielding in comparison to *R. canina* Schmid's Ideal.

Key words: *Rosa*, forming, tunnel foil cultivation

INTRODUCTION

The alternative for increasing competition and lowering the costs of cut flower production is improving a new methods of cultivation. One of such methods in climatic conditions of eastern Poland is cultivation in unheated foil tunnel. Roses cropped in tunnels are characterized by high quality, and covering with foil significantly accelerate the flowering. First flowering of roses in unheated foil tunnels occurs in a period of intensive demand for the cut flowers [Wiśniewska-Grzeszkiewicz 2001, 2003, Hetman and Szmagara 2013]. Also low costs of foundation and maintenance of plantation, and popularity of roses requires further increasing the efficiency and the optimization of technology of production by improving new methods of cutting and forming of shrubs, as well as the change of method of cutting of flower stems [Kim and Lieth 2004, Särkkä 2004, Hetman and Przegalińska-Matyko 2004a,b, 2005a,b, 2006, Hetman 2008, Ohkawa 2010].

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New methods of forming of rose shrubs rely on assuring the suitable foliage, and cutting of flower shoots should be lead in such way in order to not causing the loss of assimilation mass [Hetman and Szmagara 2013]. The date and way of forming of shrubs are the main factors decided about the success in cultivation of roses under the covers. The way of cultivation should be connected with such factors like climatic conditions, demand for flowers, yielding capacity of roses, strength of growth, healthiness of cultivar and the reaction of cultivar on the phase of bending stems [Fuchs 1986, Kool 1996, Kool and Lenssen, 1996, Lissa et al. 1999, Wiśniewska-Grzeszkiewicz 2001, Calatayud et al. 2008, Hetman and Szmagara 2013].

The correct connection rootstock-cultivar which affects on the quality of upstanding shrub and can decide in significant way on the yield of flower shoots during the cultivation under the covers. The plants in eastern Poland are exposed on unfavourable climatic conditions in late autumn and early spring, so the attention should be pay on the reaction of selected rootstocks on low temperature [Pudelska 2003]. The numerous observations confirmed that kind of rootstock significantly effects both on the resistant of plant on low temperature and also on the quality of obtained yield of flowers and on date and flowing of cropped cultivars [Włodarczyk and Bryzek 2008]. The choice of rootstock effects also on viability of budded shrubs and colouring of flowers. The footstock decisively effects on the length of flower stems, and short term of dormancy of some rootstock allow to obtain the high yield of flowers in cultivation under covers [Pudelska 2003, Hetman et al. 2007, Włodarczyk and Bryzek 2008].

In modern greenhouse cultivations using the shoot bending method, the defined architecture of rose shrub is obtained by forming and bending of primary stem, forming and suitable cutting of flower stems and simultaneously bending of low-valuable stems, i.e. thin and blind [Wiśniewska-Grzeszkiewicz 2001, Treder 2009, Ohkawa 2010]. These basal stems and lateral stems branch and give harvestable flowers. After the cutting primary stems, the next flower stems described as secondary stems develop on the shrub. In the first year of cultivation in greenhouse sometimes the pinching out the first appearing bud to plant can branch and produce leave as much as possible. Low-valuable and blind stems growing from further part of stem and auxiliary stems should be bending to increasing the assimilation area of leaves and the yield of flowers [Särkkä 2004, Treder 2009, Burema et al. 2010, Hetman and Szmagara 2013].

The aim of studies was the determination of effect of new forming methods, rootstocks and the development phase of bending stems on yielding and quality of roses cv. 'Red House' cultivated in unheated foil tunnel.

MATERIALS AND METHODS

The studies were performed in unheated foil tunnel in 2010–2012. The experimental material was roses cv. 'Red House' belonging to tea hybrid – *Rosa thea hybrida* (TH) from large-cultivar group. Cultivar was budded on three kinds of rootstocks: *Rosa canina* 'Schmid's Ideal', one-year's shrubs of *Rosa multiflora* (*Rosa multiflora* I) and two-year's shrubs (*Rosa multiflora* II).

Rose shrubs were lane planted in autumn. Shrubs in rows were planted in distance 25 cm, between the rows the distance was 40 cm, and between the lanes 1 m.

The experiment was established in blocks completely randomized, on field grown four shrubs, in five replications i.e. the combination consist of 20 shrubs. Totally 360 shrubs were planted. Directly after planting the shrubs covered to 30 cm to protect between frost damage. Shrubs were covered again after each vegetation period, in November, after removing the leaves. In early spring, depending on atmospheric conditions, after recovering the plants and levelling the ground in interrow the shrubs were trimmed. On every shrubs left, depending on stem thickness, 3–4 the strongest stems cut above 3rd bud. In the first and third year of cultivation six ways of shrubs forming were used, but in the second year only two ways, traditional (control) and the most favourable way selected after the first year of experiment.

Six ways of shrubs forming were used: 1) traditional (control); and five ways with bending of: 2) three shoots with headed buds and one leaf below, 3) three shoots with headed buds; 4) half of shoots with headed buds; 5) half of shoots with headed buds with one leaf below; 6) two shoots with buds in the hazelnut phase. In combinations of 2–5, shoots were headed in phase of breaking bud showing the colour.

According to the experimental scheme the bending of stems was performed in May, when stems reached suitable development rate. The flowers were collected when they reached the marketable value, i.e. when the sepals were tilted down, and petals starts opening, from 2nd–3rd decades of May to the end of October. During conducted studies the dates of harvest of flower shoot were noted. After the harvest biometric measurements, i.e.: length of shoot (cm), length of bud (cm), mass of shoot (g) and number of leaves on flower shoot (pcs) were performed. Obtained results were subjected to statistical analysis using the analysis of variation and Tukey's intervals, at the confidence level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The studies performed in 2010 showed that the bending of stems stimulates the sprouting of new stems (tab. 1). The bending effects on the increasing of assimilation area. This involve the production of carbohydrates and favour the strong basal shoots, which do not lessen during cultivation cycle, but still left with high quality [Champeroux et al. 1995, Nimura et al. 1997, Lissa et al. 1999, Ohkawa and Suematsu 1999, Wiśniewska-Grzeszkiewicz 2001, Kim and Lieth 2004, Särkkä 2004, Burema et al. 2010, Hetman and Szmagara 2013].

The tendency to increase of yield in first year of cultivation in unheated foil tunnel was proved also by Hetman and Przegalińska-Matyko [2004a, 2005a]. The most flower shoots of high quality from one shrub was obtained when three shoots in the phase of breaking bud were bending and bud was headed with leaf and when the half of all spring shoots in the phase of showing the colour, and the bud was headed were bending, e.g. at 5th and 4th way of shrub forming. The high yield of flower shoots was obtained also in rest combination, and the least number of flower shoots was produced from shrubs when two shoots with buds were bending in hazelnut phase and headed, e.g. formed with 6th way of forming (tab. 1). Obtained results confirmed earlier studies and was proved that heading of bending shoot and pinching of low-valuable shoots favors the sprouting of strong shoots at base of bending shoot. The heading of shoots interrupt the apical dominance and stimulate the plant to branching [Särkkä 2004, Hetman and Szmagara 2013].

Table 1. The effect of way of forming of rose cv.'Red House' shrub on field and its quality in the first year of cultivation (2010)

	Rootstock	Way of forming						Mean
		1	2	3	4	5	6	
Number of cut flower shoot (pcs plant^{-1})	*Rosa canina* Schmid's Ideal	10.6ab	10.5ab	9.6ab	10.8ab	11.2ab	8.9b	10.3b
	Rosa multiflora I	15.2ab	13.8ab	15.0ab	14.8ab	15.9ab	14.7ab	14.9a
	Rosa multiflora II	15.3ab	15.7ab	16.9a	16.9a	14.9ab	14.6ab	15.7a
	mean	13.8	13.3	13.8	14.1	14.0	12.7	13.6
Length of cut flower shoot (cm)	*Rosa canina* Schmid's Ideal	39.1	39.1	37.5	38.9	36.3	38.2	38.2
	Rosa multiflora I	40.3	43.0	36.6	39.6	41.2	37.8	39.7
	Rosa multiflora II	40.7	39.8	37.5	40.8	38.6	40.7	39.7
	mean	40.0	40.6	37.2	39.8	38.7	38.9	39.2
Mass of cut flower shoot (g)	*Rosa canina* Schmid's Ideal	15.3	15.7	14.2	14.4	12.6	13.5	14.3
	Rosa multiflora I	15.0	16.0	13.2	14.1	13.2	13.7	14.2
	Rosa multiflora II	15.7	13.9	12.7	15.2	13.9	15.1	14.4
	mean	15.3	15.1	13.4	14.5	13.2	14.1	14.3
Length of bud (cm)	*Rosa canina* Schmid's Ideal	3.3	3.3	3.2	3.4	3.0	2.9	3.2
	Rosa multiflora I	3.4	3.3	3.1	3.3	3.2	2.9	3.2
	Rosa multiflora II	3.2	3.2	3.2	3.2	3.1	3.4	3.2
	mean	3.3	3.3	3.2	3.3	3.1	3.1	3.2
Number of leaves on flower shoot (pcs)	*Rosa canina* Schmid's Ideal	6.5	6.7	6.4	6.7	5.9	6.0	6.4
	Rosa multiflora I	6.8	7.0	6.2	6.5	6.7	6.3	6.6
	Rosa multiflora II	7.0	6.3	6.3	6.9	6.6	7.0	6.7
	mean	6.8	6.7	6.3	6.7	6.4	6.4	6.5

Names of columns 1–6 are given according to the scheme of experiment in chapter "Materials and methods"
Values marked with the same letter do not differ significantly at $\alpha = 0.05$

Moreover, Kool and Lenssen [1996] observed that the buds situated higher on the stem strongly inhibited the sprouting of new shoots and should be removed, because they strongly competed for assimilates. The significant effect on obtained results has the bending and pinching of low-valuable shoots performed during whole experiment, which rejuvenated and increased the mass of assimilation, similar to studies other workers [Champeroux et al. 1995, Lissa et al. 1999, Särkkä 2004, Burema et al. 2010]. During analyzing the effect of rootstock on the number of flower shoots confirmed that the largest number of flowers were produced on shrubs which were budded on one- and two-year shrubs of *Rosa multiflora* (tab. 1), 14.9 and 15.7 pcs, respectively. These values differed significantly from number of flower shoots (10.3 pcs) obtained from shrubs cropped on *Rosa canina* Schmid's Ideal rootstock (tab. 1). The largest number of flower shoots with high quality per shrub (16.9 pcs) were gained at 3rd and 4th way of formation budded on two-year *R. multiflora* rootstock (tab. 1). Taking into account all ways of formation, shrubs budded on *Rosa canina* Schmid's Ideal yielded weaker, but the least number of flower shoots on this rootstock was obtained from control, and 6th and 3rd ways of formation, e.g. when two shoots were bended with buds in hazelnut phase and headed bud and when three shoots were bended in the phase of breaking bud and headed bud (tab. 1). The presented studies indicated that not only the way of formation but also the kind of rootstock significantly stimulated the growth and development of shrubs [De Vries and Dubois 1992, Pudelska 2003, Särkkä 2004, Ohkawa 2010].

Table. 2. The effect of way of forming of rose cv. 'Red House' shrub on field and its quality in the second year of cultivation (2011)

	Rootstock	Ways of forming		Mean
		1	2	
Number of cut flower shoot (pcs plant^{-1})	*Rosa canina* Schmid's Ideal	8.6c	12.1bc	10.3
	Rosa multiflora I	7.6c	17.0a	12.3
	Rosa multiflora II	9.0c	16.2ab	12.2
	mean	8.4b	15.1a	11.7
Length of cut flower shoot (cm)	*Rosa canina* Schmid's Ideal	49.5	43.1	46.3a
	Rosa multiflora I	44.3	39.5	41.9b
	Rosa multiflora II	47.6	41.2	44.4ab
	mean	47.1	41.3	44.2
Mass of cut flower shoot (g)	*Rosa canina* Schmid's Ideal	19.4	16.7	18.3
	Rosa multiflora I	15.4	14.7	15.1
	Rosa multiflora II	18.3	16.0	17.2
	mean	17.9	15.8	16.9
Length of bud (cm)	*Rosa canina* Schmid's Ideal	3.5	3.3	3.4
	Rosa multiflora I	3.2	3.1	3.2
	Rosa multiflora II	3.4	3.2	3.3
	mean	3.3	3.2	3.3
Number of leaves on flower shoot (pcs)	*Rosa canina* Schmid's Ideal	7.9	7.5	7.7
	Rosa multiflora I	7.7	6.8	7.3
	Rosamultiflora II	8.1	7.4	7.8
	mean	7.9	7.2	7.6

Names of columns 1–6 are given according to the scheme of experiment in chapter "Materials and methods"
Values marked with the same letter do not differ significantly at $\alpha = 0.05$

In the second year of studies significantly more flower shoots with high quality from one shrub were obtained in combination, in which the bending method of a part of spring shoots was used and three strong shoots in the phase of breaking bud showing the colour were bended, bud was headed and leaf was removed (15.1 pcs), in comparison to control way of formation (8.4 pcs) (tab. 2). The highest yield of flower shoots was gained from shrubs cultivated with shoot bending method and budded on one- and two-year rootstock *R. multiflora*, 17.0 and 16.2 pcs, respectively, and obtained results differed significantly from others. Weaker yielded shrubs cultivated in the same way but budded on *R. canina* Schmid's Ideal. The lowest yield of flower shoots was obtained on every rootstocks, when shrubs were cultivated in traditional way (tab. 2). Similar Pudelska [2003] in her studies noted the particularly favour effect of *R. multiflora* rootstock on quantity and quality of yield of cut flower. She indicated that crop cultivar budded on *R. multiflora* produced from 21 to 43% more flower shoots than budded on *R. canina* Schmid's Ideal rootstock. Some cultivar can generate even 40–50% more flower shoots on *R. multiflora* than on *R. canina* rootstock.

In the third year of rose cultivation the studies indicated that the way of formation with using the bending method had still significant favourable effect on the quantity of obtained yield of rose shoots (tab. 3). Mean the largest number of cut flower shoot was gained from shrubs cultivated with the 2nd way, when three shoots were bended, bud was headed in phase showing the colour and leaf below was removed (tab. 3). At the same high level was yield of flowers from another ways of formation, except the plants cultivated in control way, in which mean yield of flower was the lowest (tab. 3).

Results obtained in second and third year of cultivation confirmed that increasing of photosynthesized mass effects on the yield and quality of rose shoots cultivated in unheated foil tunnels. Similar results were obtained in greenhouses and heated foil tunnels [Mortensen and Gislerod 1994, Lissa et al. 1999, Särkkä and Rita 1999, Särkkä and Eriksson 2003, Kim and Lieth 2004, Särkkä 2004, Burema et al. 2010]. Analysing the effect of rootstock on the number of flower shoots was indicated that the highest mean yield of cut flowers was obtained from shrubs budded on two-year *R. multiflora* rootstock and differed significantly from number of shoots produced by shrubs budded on *R. canina* Schmid's Ideal, on which the yield was the weakest (tab. 3). The largest number of cut flower (17.7 pcs) was obtained from shrubs budded on two-year *R. multiflora* rootstock and formed by the 2nd way, when three shoots were bended, bud was headed in phase showing the colour and leaf below was removed (tab. 3). Control shrubs cultivated in traditional way yielded weaker, independently from rootstock, and the particularly low yield of flower (9.3 pcs) was noted on control shrubs budded on *R. canina* Schmid's Ideal (tab. 3).

Conducted studies showed that the length of flower stems, both in the new methods of formation, and in the traditional method, was comparable. It should underline the fact that the increasing number of flower shoots from shrubs cultivated with adapted methods on which the bending of a part of spring shoots is used did not caused the deterioration of the quality characteristics, just on the contrary, can effect positively [Kim and Lieth 2004, Särkkä 2004, Hetman and Szmagara 2013]. Särkkä [2004] in her studies obtained even longer flower shoots from shrubs cultivated with bending than from rose cultivated traditionally.

Table 3. The effect of way of forming of rose cv. ‘Red House’ shrub on field and its quality in the third year of cultivation (2012)

	Rootstock	Way of forming						Mean
		1	2	3	4	5	6	
Number of cut flower shoot (pcs plant^{-1})	*Rosa canina* Schmid’s Ideal	9.3e	11.7b–e	11.1de	10.7de	11.0dee	9.5e	10.5b
	Rosa multiflora I	11.6cde	15.0a–d	14.1a–e	12.1b–e	14.5a–d	13.2a–e	13.4a
	Rosa multiflora II	10.7de	17.7a	16.6ab	14.1a–e	16.2abc	13.5a–e	14.8a
	mean	10.9b	14.8a	13.9a	12.3b	13.9a	12.0b	12.9
Length of cut flower shoot (cm)	*Rosa canina* Schmid’s Ideal	40.5a	35.0bcd	34.5b–e	32.2de	31.9de	33.3de	34.6
	Rosa multiflora I	37.9ab	33.8cde	35.2bcd	33.3de	32.3de	34.9bcd	34.6
	Rosa multiflora II	37.5abc	33.6fcde	34.4b–e	30.8e	33.8cde	33.0de	33.9
	mean	38.6ab	34.1bc	34.7b	32.1c	32.7bc	33.7bc	34.3
Mass of cut flower shoot (g)	*Rosa canina* Schmid’s Ideal	12.2	10.5	10.4	11.2	10.6	12.5	11.2
	Rosa multiflora I	13.8	10.9	11.8	10.7	10.5	12.9	11.8
	Rosa multiflora II	13.8	11.8	12.0	9.7	11.5	11.6	11.7
	mean	13.2a	11.0bc	11.4bc	10.5c	10.8ef	12.3cde	11.66
Length of bud (cm)	*Rosa canina* Schmid’s Ideal	3.7	3.3	3.3	3.2	3.2	3.5	3.3
	Rosa multiflora I	3.4	3.2	3.2	3.3	3.2	3.4	3.3
	Rosa multiflora II	3.5	3.3	3.5	3.1	3.2	3.3	3.3
	mean	3.5a	3.3bc	3.3bc	3.2c	3.2c	3.4ab	3.3
Number of leaves on flower shoot (pcs)	*Rosa canina* Schmid’s Ideal	5.9bc	5.5cd	5.4d	5.7bcd	5.5cd	6.3abc	5.7b
	Rosa multiflora I	6.5ab	5.8bcd	6.2bcd	5.7bcd	5.7bcd	6.2bcd	6.0a
	Rosa multiflora II	7.1a	6.4ab	6.5ab	5.4d	6.1bcd	6.0bcd	6.3a
	mean	6.5a	5.9bcd	6.0bc	5.6d	5.8cd	6.2ab	6.0

Names of columns 1–6 are given according to the scheme of experiment in chapter “Materials and methods”
Values marked with the same letter do not differ significantly at $\alpha = 0.05$

Moreover, it was indicated that length of shoots cultivated on selected rootstock not differ significantly (tab. 1). In the second year of cultivation mean the longest flower shoots was obtained from shrubs budded on *R. canina* Schmid's Ideal and their length differed significantly only from the length of shoots produced by one-year of shrubs of *R. multiflora,* but did not differ from the length of shoots produced on two-year shrubs of this genus (tab. 2). In the last year of studies the longest flower shoots, among shrubs formed with shoot bending method were gained at the 2nd and the 3rd way of formation, e.g. when three shoots were bended in the phase of breaking bud and was headed with one leaf and when was headed without the leaf, but the values did not differed significantly from other combinations in which a part of spring shoots were bended and from the control (tab. 3).

The increased number of flower shoots from shrubs formed with bending of shoots did not affected significantly on decreasing of mass of cut flower shoots (tab. 1). The results concerning this parameter are comparable. Särkkä [2004] in her studies proved that proportion of blind shoots was lower in shrubs formed with bending than cultivated traditionally. Moreover, the analysis of variance did not indicated the significant effect neither the way of formation nor the rootstock on the mass of obtained flower shoots (tab. 1). In the second year of cultivation the mass of cut flower shoots, length of shoots and the number of leaves did not differ significant in shrub cultivated with shoot bending and traditional method, so the new method of formation did not affected negatively on the quality of obtained yield (tab. 2). In the third year of cultivation the mass of shoots with bending of the part of spring shoots differed significantly from mass of shoots from control shrubs. The mean mass of shoots obtained on individual rootstock did not differed significantly (tab. 3).

During the cultivation of roses in unheated foil tunnel the winter dormancy interrupt the production and 3–4 generations of cut flowers could be obtained in one cycle. It was confirmed that in such short cycle of cultivation the lessening of shoots in the following peaks of flowering did not occurred. The horizontal ending of stems between the rows did not caused the excessive plant thickening, just on the contrary, the light reached into the shrubs, what undoubtedly prevented the production of weak and blind shoots [Särkkä 2004, Hetman and Przegalińska-Matyko 2005a,b, Hetman and Szmagara 2013].

Performed statistical analysis showed that the length of bud and the number of leaves, independently from kind of rootstocks, was comparable among all ways of formation, so new methods of cultivation did not affected negatively on these quality characteristics. Moreover, the tendency of increase these characteristics on both, one-year and two-year, rootstocks *R. multiflora*, in comparison to *R. canina* Schmid's Ideal (tab. 1). Among the shrubs cultivated with adapted methods the largest number of leaves was found on stems of shrubs formed by the 6th way, when two shoots with buds in the hazelnut phase were bended, and obtained values did not differed significantly from these observed on control shrubs and on cultivated with 4th and 5th ways of formation (tab. 3).

The foliage of stems of cv. 'Red House' from shrubs budded on both *R. multiflora* rootstocks were significantly better than obtained from *R. canina* Schmid's Ideal (tab. 3). In the experiment was indicated that increased number of shoots from

shrubs cultivated with bending methods did not affected on the deterioration of the quality characteristics as mass and the number of leaves of flower shoots, and the length of bud, and the results concerning mentioned parameters are comparable with control, similar to other studies [Hetman and Przegalińska-Matyko 2005a,b, Hetman and Szmagara 2013].

CONCLUSIONS

1. The bending of a part of spring shoots positively affected on quantity and quality of yield of cut flower rose cv. 'Red House' cultivated in unheated foil tunnel and on increasing of its yielding during further years of cultivation.

2. The bending of shoots increasing the yielding, and the parameters of cut flower shoots obtained from shrubs cultivated with traditional and shoot bending methods are comparable.

3. The used rootstock has significant effect on quantity and quality of rose yield in unheated foil tunnel, and during three years of cultivation the shrubs budded on *Rosa multiflora*, especially on the two-year rootstock, characterized with higher yielding in comparison to shrubs budded on *Rosa canina* Schmid's Ideal.

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WPŁYW PRZYGINANIA PĘDÓW ORAZ PODKŁADKI NA WIELKOŚĆ I JAKOŚĆ PLONU KWIATÓW CIĘTYCH RÓŻ ODMIANY RED HOUSE

Streszczenie. W nowoczesnych uprawach pod osłonami przy zastosowaniu metody przyginania pędów, kształt krzewu różanego uzyskuje się przez przygięcie pędu pierwotnego, wyprowadzenie i odpowiednie ścinanie pędów kwiatowych oraz jednoczesne przyginanie pędów małowartościowych. Z przeprowadzonych w latach 2010–2012 badania wynika, że przyginanie pędów odmiany Red House zwiększa wybijanie z nich pędów kwiatowych wysokiej jakości, a parametry ciętych pędów kwiatowych z krzewów prowadzonych tradycyjnie i metodą z przyginaniem pędów są do siebie zbliżone. W nieogrzewanym tunelu foliowym istotny wpływ na wielkość i jakość plonu ma zastosowana podkładka. Krzewy okulizowane na *R. multiflora* charakteryzowały się wyższym plonowaniem w stosunku do *R. canina* Schmid's Ideal.

Słowa kluczowe: *Rosa*, formowanie, uprawa w tunelu foliowym

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