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Analysis of variation in progeny from *Rosa multiflora* crosses

Analyse af variationen i afkom fra Rosa multiflora *kryds*

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Summary

The effect of selection in *Rosa multiflora* seedling rootstocks has been analysed in these experiments. The results show that improvements can be achieved by selection of clones for a controlled seed production. Over the period 1979–81 10 clones were involved as parent clones and a total of 43 cross combinations were tested in the trials. Length and diameter of root necks were measured in both glasshouse and field grown seedlings and points were given for susceptibility to powdery mildew, growing strength, uniformity and leaf-spines. The results from 1980–81 showed that the influence of the female clones on the length of root neck and diameter of progeny was significant, whereas the effect of different pollinators on the progeny was weaker. Although progeny from 5 female clones were superior with respect to length of root neck, only 1 of the 5 female clones, no. 5679, produced progeny where the long root necks were found i combination with an acceptable resistance to powdery mildew, moderate growing strength and uniformity. Factors which must be considered in the choice of pollinator are resistance to mildew and properties of pollen.

By means of linear regression methods the root neck length of glasshouse grown seedlings, plant density and length of seedlings were related to length of hypocotyl, root neck length of field grown seedlings, root neck diameter and number of branches, respectively. The model showed a positive correlation between length of root neck and length of hypocotyl and length of seedling and root neck diameter, respectively. Plant density was negatively related to both root neck diameter and number of branches.

Key words: *Rosa multiflora,* rootstocks, selection, root neck, powdery mildew, uniformity, growing strength, leaf-spines.

Resumé

Formålet med undersøgelserne har været at analysere betydningen af selektion i danske *Rosa multiflora* grundstammer. Resultaterne viser, at forbedringer kan opnås ved at udvælge kloner til en kontrolleret frøavl. I perioden 1979–81 er 10 forældrekloner og i alt 43 krydskombinationer blevet afprøvet i forsøg. Rodhalslængde og -diameter er målt på frøplanter dyrket i væksthus og på friland, og frøplanterne er bedømt for følgende egenskaber: modtagelighed for meldug, vækstkraft, ensartethed og bladtorne. Resultaterne fra 1980–81 viste, at moderklonerne havde signifikant indflydelse på afkommets rodhalslængde og -diameter. Derimod kunne bestøvernes indflydelse på afkommet ikke påvises med statistisk sikkerhed. 5 moderkloner gav afkom med en signifikant længere rodhals, men kun afkom fra 1 af de 5 kloner, nr. 5679, havde samtidig de øvrige positive dyrkningsegenskaber såsom en acceptabel meldugresistens, moderat vækstkraft og god ensartethed. Flere faktorer må tages i betragtning ved valg af bestøverklon(er): meldugresistens, pollenkvalitet og -kvantitet.

Ved hjælp af lineær regression er rodhalslængden på frøplanter dyrket i væksthus, plantetæthed og længden af frøplanterne sammenlignet med henholdsvis længden af kimplanternes hypokotyl, rodhalslængden af frøplanter dyrket på friland, rodhalsdiameteren og antallet af grene. Modellen viser en positiv sammenhæng mellem henholdsvis rodhalslængden og hypokotyllængden og længden af frøplanten og rodhalsdiameteren. Plantetæthed var negativt korreleret med både rodhalsdiameter og antallet af grene.

Nøgleord: *Rosa multiflora,* grundstammer, selektion, rodhals, meldug, ensartethed, vækstkraft og bladtorne.

Introduction

Rosa multiflora Thunb. is the most popular rose rootstock in Scandinavia and is in addition exported to Austria, Switzerland, West Germany and England. In the period from July 1978 to June 1979 the entire export of rootstocks for roses from Denmark reached a total of 10.6 mill. seedlings (*Hansen & Eriksen,* 1980). The importance of rootstocks is stressed by the fact, that the income from Floribunda, Hybrid Tea and Climbing roses amounts to 20.3% of the total export income from Danish nurseries in the period mentioned. The winter hardiness of *R. multiflora* has for a long time favoured budding onthis rootstock, but market mechanisms and budding properties result in an increase in the production of *'Laxa'* rootstocks (*R. coriifolia* Fries var. *froebelii* Rehd.). Following are few of the advantages of using *R. multiflora:* Seeds easy to germinate, a growth period well adapted for areas with many precipitation days, winter hardiness, long budding period, almost thornless types, no suckering, a strong root system and good compatibility to scions (*Krüssmann,* 1978; *Leemans,* 1964; *Wennemuth,* 1969). In addition several types are considered resistant or hardly sensitive to powdery mildew (*Sphaerotheca pannosa*) (*Persiel,* 1979).

Unfortunately there are some disadvantages connected with *R. multiflora. Harkness* (1981) mentions their short and crooked root necks, and *Sønderhousen* (1974) estimates that only half of the germinated seedlings reach the budding process. The last fact is partly due to failure in the seedbeds and the sorting out plants during lifting and grading in the autumn and winter. This considerable reduction in the final outcome can be an economic burden for the producers of rootstocks, not only because of the loss of plants but even more because of the costs connected with the labourconsuming grading of plants.

The aim of the present work has been to analyse the possibilities of improving the *R. multiflora* seedling rootstocks, and through this minimize the production costs for the rootstock producers. The following demands were chosen as the first criteria for selection of material:

1. steady seed production and germination per cent (*Stougaard,* 1983)
2. long and straight root necks
3. uniformity
4. resistance to powdery mildew
5. moderate growing strength
6. no thorns and moderate leaf-spines.

Other criteria will be included in the future research on improvements: climatic tolerance, upright growth, resistance to rust (*Phragmidium mucronatum*) and blackspot (*Diplocarpon rosae*), root shape, compatibility to scions and influence on the flower quality of cultivars.

Material and methods

10 clones were included in the investigations in 1979. In 1980–81 the number of clones involved in cross pollination was reduced to 8. The clones used for these studies (fruiting shrubs) were selected both in a clone collection located at the Institute of Landscape Plants and within a seed production area kindly provided by a private nursery. The collected individuals or clones were numbered by the following clone numbers: 5547, 5548, 5678, 5679, 9246, 9247, 9248, 9249, 9254 and 9257.

The clones were thornless or with very few thorns. Pedicels, sepals and stipules were strongly glandular in clone no. 5679, while the other clones varied from less glandular to almost no glands (clone no. 9254). The flowers in the many-flowered corymbs were single and white except two clones which had whitepink (no. 5678) and pink (no. 5679) flowers. Clone no. 9246, 9247 and 9248 were considered resistant against mildew.

In 1979 progeny from 31 cross combinations were produced whereas the corresponding number of crosscombinations in 1980–81 was 32. Hand pollination and crossing barriers have been described earlier (*Stougaard,* 1983). The parental combinations obtained from all pollination trials are listed in Table 1.

Table 1. Progenies obtained in the pollination trials (1979, 80 and 81).

♀ \ ♂	5547	5548	5678	5679	9246	9247	9248	9249	9254	9257
5547				x						
5548			x	x						
5678	x	x		x	x	x				
5679		x	x		x	x				
9246			x	x		x	x	x	x	x
9247			x	x	x		x	x	x	x
9248					x	x		x	x	x
9249					x	x	x		x	x
9257			x	x	x	x	x	x	x	

Hips were harvested in October and the seeds were cleaned and sown in boxes immediately after (200 seeds per combination). The boxes were overwintered in a cold frame for natural stratification. In the spring the boxes were placed in a glasshouse where the seeds germinated.

The first measurements on the seedlings were carried out just at the time of unfolding of the cotyledons on the newly germinated plants. 40 seedlings per combination were randomly chosen and length of the hypocotyl (from the ground to the cotyledons) was measured.

The seedlings were transplanted after 4 weeks growth in a glasshouse. 80 seedlings from each combination were selected randomly from the sowing boxes and transplanted to 2 boxes, securing a uniform depth of planting because of later measurements of the root neck. Spraying with chemicals was omitted because of registering of disease resistance.

Points for various factors were given 12 weeks after germination. Resistance to powdery mildew, growing strength, uniformity and abundance of leaf-spines were determined on a 1–10 scale by an evaluation panel (4–6 persons from the institute). The factors were:

Powdery mildew
no attack: 10
total attack: 1

Uniformity
high uniformity: 10
low uniformity: 1

Growing strength
strong growth: 10
weak growth: 1

Leaf-spines
insignificant: 10
significant: 1

Length and diameter of root necks were measured immediately after giving points. 2 × 20 seedlings were randomly chosen from each combination. The length of root neck was measured from the top rootlets to the remains of the cotyledons.

Some of the seeds harvested in 1980 were sown in plots (1 × 1 m) in the field.

In October 1981 all the seedlings were lifted and length and diameter of root neck, length of seedling, number of branches and plant density were estimated.

The information was computerized and standard statistical procedures were employed by the

Biometric Section of The Danish Research Service for Plant and Soil Science. Statistical tests were based on 2 year averages and all linear measurements are averages of 40 seedlings. Correlation between traits were estimated by a simple linear regression model.

Results

Length and diameter of root neck

Analysis of variance in trials with length of root necks on progenies showed that the female parents contributed significant ($P < 0.001$) as a source of variation in the parental combinations (Table 2).

The female parents accounted only partly ($P < 0.01$) for the differences in root neck diameters as the contribution from replication was highly significant ($P < 0.001$) as a source of variation.

Table 2. Analysis of variance in trials with length and diameter of root necks measured at progeny (1980/81).

		F	
Source of variance	df.	length of root neck	diameter of root neck
Replication (year)	1	2.45	59.81***
Female clone	7	5.42***	4.35**
Pollinator	15	1.09	2.17*
Female clone × pollinator	23	0.55	1.50

Levels of significance (*:P < 0.05), (**:P < 0.01) and (***:P < 0.001)

Fig. 1 shows length of hypocotyls measured on seedlings just after unfolding of cotyledons (1980) and length of root necks from 12 week old seedling plants grown in a glasshouse (1980/81). Linear measurements are mean of 40 seedlings per combination from each year. With few exceptions the combinations were grouped according to their female parent. One exception was progenies with no. 9246 as female parent, where the male parent seemed to have an influence on the progeny. However F-test on averages from 1980/81 (Table 2) revealed neither significant differences between the combinations nor paternal effect. When comparing the reciprocal crosses obtained in the trials a relation between progeny and female parent can be observed.

The reciprocal crosses between clone no. 9246 and 9247 (both belonging to the same group in Table 2) produce progeny with root neck length of 1.61 versus 1.63 cm. On the contrary the reciprocal crosses between clone no. 5548 and 5679 (belonging to different groups in Table 3) produce progeny with a root neck length of 1.67 versus 1.94 cm, whereas the tendencies are weaker in the reciprocal crosses between 5678 and 5679.

In Table 3 progenies have been grouped according to their female parent. The mean from 1980/81 showed that progeny from 3 female clones were inferior with respect to length of root

Table 3. Length and diameter of root necks measured on glasshouse and field grown seedlings. The results are mean of progenies from 8 female clones.

		Length of root neck (cm)				Diameter of root neck (mm)			
Female clone no.	No. of combinations	field	glasshouse			field	glasshouse		
		80	80	81	80/81	80	80	81	80/81
5548	3	0.89	1.72	1.58	1.66[b] [1)]	6.63	2.91	3.29	3.08[b]
5678	5	0.99	1.79	1.70	1.76[a]	6.39	2.76	3.32	2.92[b]
5679	5	0.88	1.87	1.76	1.85[a]	6.28	2.72	3.24	2.80[b]
9246	8	1.05	1.67	1.74	1.70[b]	5.67	3.05	3.61	3.32[a]
9247	8	0.92	1.62	1.55	1.60[b]	5.74	3.01	3.56	3.26[a]
9248	3	1.05	1.82	1.94	1.88[a]	5.48	3.02	3.35	3.20[a]
9249	3	1.10	1.86	1.86	1.86[a]	5.15	2.98	3.45	3.18[a]
9257	5	1.02	1.82	1.77	1.80[a]	4.91	3.11	3.48	3.27[a]

[1)] Mean within the same trial and column, followed by the same letter are not significantly different at the 5% level using Fischer's LSD.

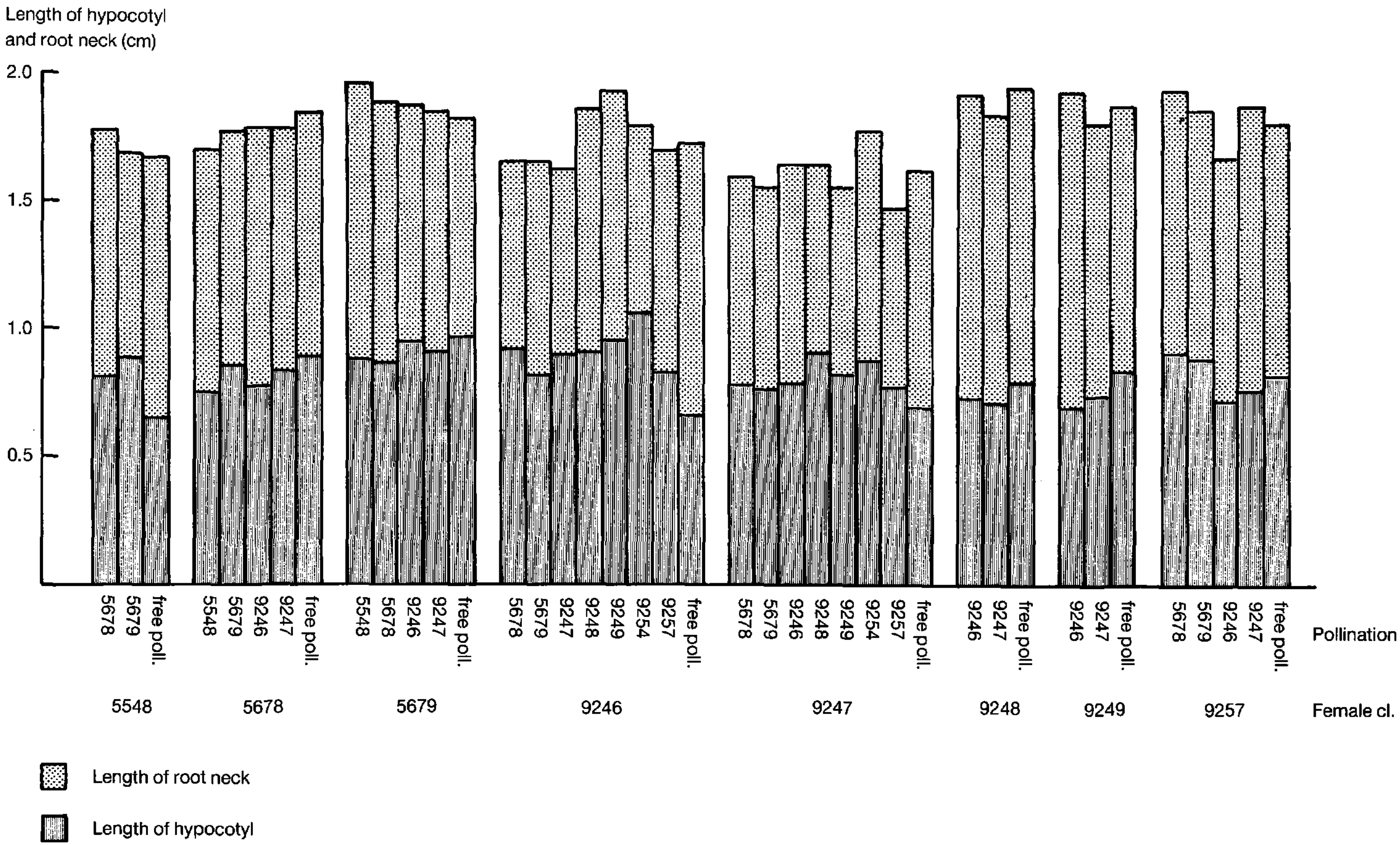

Fig. 1. Length of hypocotyl (after unfolding of cotyledons) and root neck of 12 week old seedling plants grown in a glassouse. The results are mean values of 40 plants per combination each year (1980/81).

Table 4. Coefficients of correlation, r, between different measurements of root necks, plant density, length of seedlings and number of branches based on results from 1980.

	Length of root neck (glasshouse)	Plant density	Length of seedling
Length of hypocotyl	0.332*		
Length of root neck (field)	−0.058	0.116	−0.085
Diameter of root neck		−0.582***	0.828***
No. of branches per plant		−0.584***	

Levels of significance (*:P < 0.05) and (***:P < 0.001)

necks (no. 5548, 9246 and 9247) wheras progeny from 5 female clones (no. 5678, 5679, 9248, 9249 and 9257) were superior – the length of root neck on 12 week old seedlings was between 1.76 and 1.88 cm. When comparing measurements in field versus glasshouse grown seedlings, no relation could be observed (Table 3 and 4). The mean (1980/81) of diameter of root necks should be taken with reservations due to the variation between measurements in 1980 and 1981. Table 3 shows a tendency of thicker root necks in 5 of the clones (no. 9246, 9247, 9248, 9249 and 9257).

The coefficient of correlation, r, shown in Table 4 indicates a relation between the length of hypocotyl and the length of root neck measured on 12 week old seedling plants. This relation indicates that in spite of disturbance by transplanting, hypocotyl characteristics will be present in the 12 week old seedling plants. Plant density had a pronounced effect on both diameter of root neck and number of branches as the hypothesis of correlation was highly significant. The diameter of root neck and length of seedling were closely correlated, whereas no correlation existed between length of root neck and length of seedling.

The bad correlation between the length of root neck measured on 12 week old seedling plants grown in a glasshouse and field grown seedlings is not surprising, as the outdoor grown seedlings were exposed to numerous external factors during the growth period.

Powdery mildew

The mean values for 1980/81 revealed no significant variation between the combinations whereas choice of female clone contributed significantly to the variation (Table 5). However, the most important source of variation in the trials was variation in infection grade in 1980 and 1981.

Points for powdery mildew on seedling plants are included in Table 6. Conditions for natural infection with mildew during 1980 and 1981 have been very unfavourable whereas the glasshouse trial in 1979 and field trial in 1980 gave a relatively higher infection rate. Progeny from clone no. 9247 and 9257 had a significantly higher susceptibility to mildew compared with progeny from the other female clones (mean 1980/81 in Table 6). The results from glasshouse trials in 1979 and field trials in 1980 indicated that combinations with clone no. 9248 and 9249 as female parents were also susceptible to mildew. The influence of pollinators on the progeny were unclear. Statistical tests (Table 5) gave no significant contribution from choice of pollinator on source of variation. However points from the two trials with the highest mildew infection grade (glasshouse trial 79 and field trial 80) showed a slight tendency in the direction of higher susceptibility to mildew in combinations with clone no. 9249 and 9257 as pollinators.

Table 5. Analysis of variance of points for powdery mildew (1980/81).

Source of variation	df.	F mildew
Replication (year)	1	39.17***
Female clone	7	2.52*
Pollinator	9	1.92
Female clone × pollinator	24	1.77

Levels of significance (*:P < 0.05) and (***:P < 0.001).

Table 6. Points (1–10) for powdery mildew on seedling plants grown in a glasshouse (1979, 80 and 81) and the field (1980).

Female clone	Pollinator	Glasshouse trials				Field trials
		79	80	81	80/81	80
5547	5679	9.3				
	free poll.	8.9				
	mean	9.1				
5548	5678		9.3		9.3	9.5
	5679		9.3	10.0	9.6	7.0
	free poll.	6.6	9.3	9.8	9.7	7.5
	mean	6.6	9.3	9.9	9.7[a 1)]	8.0
5678	5547	9.8				
	5548	9.3	9.4	9.8	9.6	
	5679	8.3	9.0	9.8	9.4	10.0
	9246		6.3	9.8	9.4	7.5
	9247		9.6	9.8	7.9	7.5
	free poll.	8.4		10.0	9.8	10.0
	mean	8.8	8.7	9.8	9.2[a]	8.8
5679	5548	9.0	8.5	9.8	9.1	
	5678	8.8	7.5	10.0	8.6	5.0
	9246		9.0	9.6	9.3	6.5
	9247		8.3	10.0	9.1	8.5
	free poll.	9.3	9.2	9.8	9.5	8.5
	mean	9.0	8.5	9.8	9.1[a]	7.1
9246	5678		9.8	9.9	9.9	9.0
	5679		9.2	9.9	9.6	10.0
	9247	9.0	10.0	9.8	9.9	10.0
	9248	9.0	9.2	9.9	9.6	10.0
	9249	7.0	8.5	9.3	9.0	6.0
	9254	9.5	9.3	9.6	9.5	8.0
	9257	9.8	6.3	9.6	8.4	10.0
	free poll.	9.8	8.4	9.8	9.0	8.5
	mean	9.0	8.8	9.7	9.3[a]	8.9
9247	5678		9.3	9.9	9.7	9.5
	5679		8.2	9.7	9.1	7.5
	9246	9.5	7.5	9.8	8.9	7.5
	9248	7.5	6.8	9.5	8.5	7.0
	9249	7.8	4.7	8.6	7.1	7.5
	9254	6.5	8.3	9.9	9.3	7.5
	9257	6.5	8.8	8.6	8.7	5.0
	free poll.	9.3	9.0	9.6	9.4	10.0
	mean	7.8	7.8	9.5	8.8[b]	7.7
9248	9246	6.0	9.2	9.8	9.6	5.0
	9247	7.5	9.0	8.6	8.8	4.0
	9249	7.0				
	9254	4.8				
	9257	4.8				
	free poll.	9.5	8.3	9.3	8.9	9.0
	mean	6.6	8.8	9.2	9.1[a]	6.0

Female clone	Pollinator	Glasshouse trials				Field trials
		79	80	81	80/81	80
9249	9246	7.8	8.7	9.2	9.0	3.5
	9247	6.5	8.3	8.9	8.7	1.5
	9248	7.7				
	9254	5.3				
	9257	2.5				
	free poll.	7.5	8.8	9.8	9.4	5.5
	mean	6.1	8.6	9.3	9.0[a]	3.5
9257	5678		7.3	8.4	7.8	
	5679		6.8	9.3	8.4	3.5
	9246	8.3	8.3	8.4	8.4	7.0
	9247	5.3	8.7	9.3	9.1	4.5
	9248	8.3				
	9249	5.0				
	9254	6.3				
	free poll.	6.3	7.5	9.6	8.8	2.5
	mean	6.5	7.7	9.0	8.5[b]	3.5

[1)] Means followed by the same letter are not significantly different at the 5% level, using Fischer's LSD.

Growing strength, uniformity and leaf-spines

The parental combinations with the strongest growth were found in progenies with clone no. 9246 as female parent (Table 7). One of the combinations, 9246 ♀ × 5679 ♂, achieved the maximum score (10) for growth strength and in addition, the maximum score (9.3) given for uniformity. There seemed to be a relationship between points given for growth strength and uniformity, i.e. there was identity between the female clones producing progeny with the poorest growing strength and the lowest level of uniformity (clone no. 5678, 9247, 9248 and 9249). However, the data revealed a very limited variation between progenies in factors as growth strength and uniformity. Leaf-spines were very prominent in combinations with no. 9246 and 9248 as female parents and least prominent in progenies with no. 5678 as female parent.

In the glasshouse trials in 1980 and 1981 etiolated seedlings could be observed at the time of unfolding of the cotyledons. This phenomenon was

Table 7. The influence of female and male parent on seedling plants grown in glasshouse (1980). Points (1–10) for growing strength, uniformity and leaf-spines.

Female clone	Pollinator	Growing strength	Uniformity	Leaf-spines
5548	5678	7.8	7.0	6.8
	5679	7.7	8.3	7.2
	free poll.	6.2	7.5	6.5
	mean of 3 comb.	7.6	7.6	6.8
	LSD[1)]	n.s.	n.s.	n.s.
5678	5548	7.9	6.6	7.4
	5679	7.0	5.8	8.2
	9246	7.5	5.8	6.7
	9247	6.3	5.7	6.8
	free poll.	8.0	7.4	7.6
	mean of 5 comb.	7.3	6.2	7.3
	LSD	1.0	1.5	n.s.
5679	5548	7.3	6.3	5.8
	5678	7.3	6.3	5.8
	9246	8.3	8.0	4.8
	9247	8.7	8.7	4.0
	free poll.	7.7	7.5	7.3
	mean of 5 comb.	7.9	7.4	5.7
	LSD	1.3	1.8	1.6

Female clone	Pollinator	Growing strength	Uni-formity	Leaf-spines
9246	5678	9.3	8.0	6.3
	5679	10.0	9.3	4.5
	9247	8.5	7.8	3.7
	9248	8.0	8.2	4.3
	9249	7.2	8.3	6.2
	9254	9.3	8.7	3.7
	9257	8.7	7.0	5.5
	free poll.	8.8	6.5	5.0
	mean of 8 comb.	8.7	8.0	4.9
	LSD	0.9	1.2	1.4
9247	5678	7.7	7.0	6.0
	5679	8.3	7.8	5.0
	9246	7.0	6.2	4.8
	9248	7.0	7.0	6.0
	9249	5.7	7.5	7.3
	9254	6.5	7.0	4.3
	9257	6.3	5.5	6.2
	free poll.	7.3	8.2	5.2
	mean of 8 comb.	7.0	7.0	5.6
	LSD	0.9	1.2	1.1
9248	9246	7.8	6.8	4.8
	9247	7.8	7.2	4.5
	free poll.	6.5	6.2	4.0
	mean of 3 comb.	7.4	6.7	4.4
	LSD	n.s.	n.s.	n.s.
9249	9246	6.3	7.3	6.2
	9247	7.2	6.2	5.5
	free poll.	7.2	7.2	6.2
	mean of 3 comb.	6.9	6.9	5.9
	LSD	n.s.	n.s.	n.s.
9257	5678	8.5	7.3	6.7
	5679	8.0	8.2	5.7
	9246	8.0	7.0	6.0
	9247	8.8	7.0	5.5
	free poll.	7.8	6.8	4.8
	mean of 5 comb.	8.2	7.3	5.7
	LSD	n.s.	n.s.	n.s.

[1] LSD at the 95% level.
n.s. = no significant differences.

due to a failure in the production of chlorophyll in combinations with clone no. 9247. The loss of seedlings could be significant in some of the combinations, as the percentage of etiolated seedlings was from 5.0 to 38.5% in the following combinations: 9248 ♀ × 9247 ♂, 9247 ♀ × 9248 ♂, 9254 ♀ × 9247 ♂ and 9247 ♀ × 9254 ♂.

Discussion

The aim of the work is to analyse the possibilities of improving *Rosa multiflora* seedling rootstocks by selection of parental clones. The natural mode of reproduction is cross pollination (*Stougaard,* 1983) and the meiotic division proceeds in the normal way (*Täckholm,* 1920, 1922). These facts exclude the possibility of selections with uniformity of seedling plants as in *R. canina,* where the progeny strongly resembles the female clones due to apomixis and heterogamy (*Kroon & Zeilinga,* 1974). However, the results of this study indicated that a considerable influence of the female parents could be seen in various traits in *R. multiflora,* whereas influence of the male parents could not be proved statistically. In fact, both length and diameter of root necks and susceptibility to powdery mildew revealed the same maternal tendency, although variation between years gave a significant contribution to the variation in some trials.

Direct comparison between the experimental results and length and diameters of root necks measured in the nurseries can not be made, as the test systems in glasshouse and the field does not resemble the nursery practice where seeds are sown in drills. However, the use of glasshouse gave the possibility of accelerating growth and providing a more controlled environment.

Grading of the rootstocks in the nurseries is based upon measurements of the root neck diameters, and the diameters of (1/0) *R. multiflora* rootstocks are sorted in the following classes: 8–12 mm, 6–8 mm, 5–8 mm, 4–6 mm, 3–5 mm, 3–4 mm and 2–3 mm. Table 3 indicates that no correlation exists between length and diameter of root neck – neither in the glasshouse nor in the field. However, field trials in 1980 showed a significant negative correlation between plant density and diameter of root necks. Contrary to expectations based on observations in nurseries, no correlation was found between plant density and length of root neck.

Registering of characteristics by points is very difficult to systematize. The conditions for evaluation of mildew susceptibility were extremely difficult in the years 1980 and 1981 due to the very weak mildew attack. To obtain more reliable results a controlled infection with mildew will be included in future tests. Despite the problems with mildew infection progeny from 2 clones, no. 9247 and 9257, showed a significantly higher susceptibility to mildew during 1980 and 1981 (Table 6). Although no statistical test supports the results from 1979 and the field trials in 1980, there is a tendency to stronger mildew attack in progeny from clone no. 9248 and 9249.

The variation in growing strength and uniformity was very limited, whereas points given for leaf-spines varied significantly between the combinations. As mentioned earlier, all the combinations were almost thornless. The absence of thorns could possibly be a consequence of earlier selections in the rootstock material used in these experiments.

The most important criteria for selection in *R. multiflora* is longer root necks, resistance to mildew, uniformity and a moderate growing strength. By grading these characteristics the final choice of female parent is clone no. 5679. Several factors must be considered in the choice of pollinator(s): e.g. the tendency of unwanted effects with respect to mildew susceptibility and effectiveness as pollen donator. Consequently, the male parent should be selected amog clone no. 5548, 5678 and 9246.

Further experiments should be included before introduction of plant material to the nurseries, e.g. trials with shape of roots (lifting-/transplanting properties), resistance to rust (*Phragmidium mucronatum*) and black spot (*Diplocarpon rosae*), compatibility with scion and influence on the flower quality of cultivars.

Persiel (1979) describes improvements of *R. multiflora* seedlings with respect to powdery mildew resistance by free pollination between resistant plants. Resistant and thornless plantsproduced from 0.0 to 32.6% resistant and thornless seedlings. The continuation of the breeding programme to the fourth generation resulted in an increase in resistant and thornless seedlings to 56.8%. The last fact indicates that further improvements could be obtained by extending the actual selection programme to breeding of *R. multiflora* seedlings.

Conclusion

In these experiments the effect of selection has been analysed, and the conclusion is, that improvements of *Rosa multiflora* rootstocks can be obtained by selection of parent clones for a controlled seed production. When used as the female parent, one of the clones, no. 5679, produced progeny with a high degree of resistance to powdery mildew and long root necks. The seedlings were uniform and the growing strength was moderate. Although the influence of different pollinators on length and diameter of root necks and powdery mildew resistance could not be proved with statistical tests, the tendency of unwanted effects on susceptibility to mildew will be considered in the choice of the male parent. Consequently the pollinator will be selected from clone no. 5548, 5678 and 9246.

Although the results showed significant differences between clones in various traits, the predominant impression was a limited variation in the *R. multiflora* population selected for these trials. Several possibilities exist for increasing the variation, and through this genetical diversity even better improvements in *R. multiflora* could be achieved. To obtain further increase in the variation, new experiments will include selection of material from botanical collections and foreign selections. However the research on improvement in *R. multiflora* ought not to be limited to selection, as a breeding programme, although time-consuming, could be even more beneficial. Such a breeding programme requires a basal knowledge of the plant material, a knowledge which has partly been obtained in this research work.

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