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Rootstock effects on yield and mineral composition of rose cut flowers

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Abstract

Performance of three rose cultivars First Red, Versilia, and Virginia was evaluated when were grown on their own roots and when grafted onto three rootstocks *Rosa indica,* Major; *Rosa canina,* Inermis and *Rosa hybrida,* Natal Briar in a plastic house. Yield, dry weight and mineral composition were investigated for two successive years. Scion rose cultivars especially on the rootstock Natal Briar produced more flowers/plant which was greatly dependent on the rootstock. The Natal Briar rootstock was superior to that of *R. indica* and *R. canina* rootstocks. In addition, more yields were obtained from plant combinations than cultivars grown on their own roots. Scion/rootstock combinations were superior to those grown on their roots with respect to dry weight percentage and nutritional status. Higher and efficient macro and microelement contents were found in shoot and root portions of plant combinations than in the cutting plants. There was no relation between the yield and the elemental status of the root tissues except for phosphorus. Furthermore, shoot and root dry weights were highly correlated to the yield/plant. Shoot dry weight was highly correlated to manganese, magnesium and phosphorus, respectively. While root dry weight was mainly correlated to the manganese, zinc, and magnesium. We conclude that rose yields can be improved through more uniform mineral distribution within the plant tissue by selecting efficient rootstocks to grow scion cultivars on them.

Key words: Rose, cultivars, rootstocks, *Rosa indica, Rosa canina, Rosa hybrida,* yield, mineral composition

Introduction

Rose nursery plants for cut flower production are either cultivars grafted onto seedling rootstocks or cultivars grown on their own roots. For roses, the primary objectives of rootstocks are to influence scion vigor, achieve adaptation to various cultivation media and for their longevity and superior anchoring (De Vreis, 1993). Researches have demonstrated that rootstock play significant role for uniform growth of the combinations and precocity of production (Manners and Lakeland, 1996), increase flower yield (Zieslin *et al.*, 1973) and improve flower quality (Han *et al.*, 1994)

A survey of literature on roses indicated that, although rootstocks have been used for a long time, very few studies have been reported about their effects on the performance of rose scion cultivars. Most of the literature on mineral composition of roses is confined either to tissue analyses for diagnostic purposes (Post and Fischer, 1951) or studies conducted on the fertilizing bases (Tamimi *et al.,* 1999). However, The Agriculture Western Australia (1998b) proposed a list for the optimum leaf tissue element's levels in greenhouse roses. Trends of significant differences in elemental composition have been shown by different plant parts of 'Better Times' rose (Carlson and Bergman, 1965).

Due to the fact that none of the other workers used these particular combinations of cultivars (First Red, Versilia and Virginia) grafted onto *R. indica*, *R. canina,* and Natal Briar compared to the cuttings of each cultivar. The present study was conducted to evaluate the performance of three rose cultivars grown on their own roots and also grafted onto these rootstocks.

Materials and methods

This study was carried out for two consecutive years 1999 and 2000. Three cut flower rose cultivars First Red, Versilia, and Virginia were purchased from Olij Rozen, Holland. Each scion cultivar either grafted onto the three rootstocks: *Rosa canina, Rosa indica* and Natal Briar, or grown on their own roots. These were planted in a plastic house in mid-February 1999, Umel-Amad, 5 km east of Amman. Some of the soil chemical characteristics of the plastic house are shown in Table 1. Soil preparation included 40cm deep cultivation after spreading (200kg of manure, 4m^3 sand and 20kg phosphorus fertilizer, DAP) mixed with the soil. The soil was leveled to manually raised beds of 20cm height, 60cm wide and 150cm between bed centers. Plant combinations and the own rooted cuttings were arranged to a Split-Plot in a randomized complete block design with four replications. Each experimental unit consisted of 16 plants planted in two rows spaced 25 x 40cm. The plants were fertilized according to farmer recommendation by 8300 g nitrogen, 5900 g phosphorus as P_2O_5 and 5900 g potassium as K_2O ha^{-1} week^{-1}. These were applied with irrigation water as formulas of 28-14-14 during the first month after planting in the first season and after pruning in the second season and 20-20-20 throughout the rest of both seasons. In addition, 1500 g ha^{-1} week^{-1} of BMX complex fertilizer containing trace elements was applied throughout the two seasons.

The plants were subjected to pruning during February as

Table 1. Soil chemical characteristics

PH	EC ($dS.m^{-1}$)	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	$CaCo_3$ (%)	Organic matter (%)
7.3	2.0	0.011	127	542	2125	57	13.0	0.96

recommended by Hower (1995) and Faedo (1998). The plants were cut back to a good bud at 31 to 46 cm above the soil level (Faber and White, 1977). Harvesting of rose flowers was done according to the cultivar as outlined by Hasek (1980). Total yield was recorded on per plant basis.

One plant from each subplot was pulled out for mineral content determinations mid-October the first season, and mid-May the second season. These plants were separated at the union zone (at soil level for the own rooted plants), to the under and above-ground plant portions. Dry weights (oven dried at 55°C until a constant weight was obtained) were taken for each plant part as percentages. All samples were ground in a stainless steel Wiley Mill Model 4.

Macro and microelement contents were determined in each of the two plant portions. Nitrogen was determined by the Kjeldahl digestion method. The other elements were determined by the dry ash method by placing 1gm of ground plant material in a crucible. Ashed for 5 hours at temperature 550 °C in a muffle furnace. The cooled ash was dissolved in 5ml portion of 2N HCl on heating plate for 15-20 min. Allowed to stand for 15 min, filtered through Whatman No.2 filter paper discarding the first portions of the filtrates, then analysis the aliquots for phosphorus by (Spectronet 20 BAUSCH and LOMB Spectrophotometer), potassium (410 Corning No. 7292 flame photometer), calcium, magnesium, iron, manganese, zinc, and copper (Instrumentation aa/ae 357 No. 3810 atomic absorption spectroscopy). All as described by Ryan *et al.* (1996).

Results and discussion

Yield: Harvesting of flowering stems began in April of both seasons and flower production was recorded up to December. The scion and rootstock combinations in the year 1999 positively affected yield (Table 2). In general, the Natal Briar combined with different cultivars gave significantly higher yields. Versilia roses were significantly inferior compared to the First Red and Virginia (Table 2), while, in 2000, no significant differences were recorded. However, during both the seasons the cutting plants of the three cultivars showed the lowest yields.

Dry weight: Significant interactive scion rootstock effects on the shoot dry weight percentages were observed in the year 1999 (Table 3). The shoot dry weight percentage ranged from 35.62% for the First Red cuttings to 39.19 % for the Versilia / Natal Briar rose plants.

Cultivars did not differ significantly in dry weight percentages of shoots in 1999 (Table 3). On the other hand, regardless of cultivar, the rootstocks exerted a significant effect on percentage of shoot dry weight in the year 1999 but not the 2000 (Table 3). Shoot dry weight of the Natal Briar rootstock was the highest whereas the other two rootstocks were intermediate in this regard. Shoots on the cuttings of the three cultivars showed lowest dry weight percentages.

Scion and rootstock interaction significantly affected root dry weight percentages in the year 1999 (Table 3). Root dry weight percentages ranged from 32.73 % for the First Red cuttings to the heaviest 37.92 % for the same cultivar on *R. canina*. In the year 2000, no interactive effects were found in the percentage of root dry weight. Regardless of rootstock, cultivars did not differ significantly in root dry weight percentages (Table 3).

Table 2. Interactive effects of three rose cultivars and three rootstocks or own rooted cuttings (ORC) on total yield (number of harvested flowers/plant), season, 1999 and 2000

Cultivar	Rootstock	1999	2000
First Red	*R. indica*	41.4 de*	42.1
	R. canina	43.8 cd	43.3
	Natal Briar	50.6 ab	49.5
	ORC	31.3 f	20.9
Versilia	*R. indica*	38.6 e	39.2
	R. canina	40.9 de	41.2
	Natal Briar	51.5 ab	51.5
	ORC	18.1 g	14.6
Virginia	*R. indica*	47.6 bc	40.9
	R. canina	43.3 cde	41.6
	Natal Briar	53.9 a	51.9
	ORC	18.8 g	15.1
	LSD (*P*=0.05)	4.95	NS

(*): Mean separation within rows by LSD (*P*=0.05)
(NS): Not Significant in F test (*P*=0.05)

Table 3. Interactive effects of three rose cultivars and three rootstocks or own rooted cuttings (ORC) on percentages of dry weight of each plant portion for the two seasons 1999 and 2000

Cultivar	Rootstock	Shoot		Root	
		1999	2000	1999	2000
First Red	*R. indica*	39.05 a*	36.34	36.71 ab	36.11
	R. canina	38.03 abcd	35.84	37.92 a	34.03
	Natal Briar	38.98 ab	38.13	37.31 ab	36.26
	ORC	35.62 e	32.48	32.73 d	35.56
Versilia	*R. indica*	38.19 abc	36.95	36.39 abc	36.49
	R. canina	37.69 abcd	36.03	36.38 abc	33.89
	Natal Briar	39.19 a	38.07	36.78 ab	38.94
	ORC	37.47abcde	33.84	34.98 c	35.63
Virginia	*R. indica*	37.04 bcde	37.16	36.52 abc	36.48
	R. canina	36.86 cde	36.35	36.49 abc	36.93
	Natal Briar	36.18 de	37.63	36.51 abc	38.35
	ORC	38.61 abc	31.38	35.71 bc	32.20
LSD (*P*=0.05)		2.00	NS	1.64	NS

(*): Mean separation within rows by LSD (*P*=0.05)
(NS): Not Significant in F test (*P*=0.05)

Mineral composition

Macro elements: Regardless of rootstock type, no cultivar effect was observed on the concentration of all macro-elements in the shoot and root tissues in both the years. On the other hand, the three rootstocks showed significantly the highest nitrogen levels in the shoot and root plant portions in both the years when compared with the self rooted cuttings (Table 4).

Table 4. Main effect of rootstock and own rooted cuttings (ORC) on the levels of macro elements (percentages) in both shoot and root tissues

			R. indica	*R. canina*	Natal Briar	ORC	LSD
N	Shoot	1999	2.05 b*	2.55 a	2.47 a	1.14 c	0.17
		2000	2.17 c	2.63 a	2.40 b	1.48 d	0.16
	Root	1999	2.37 a	2.15 a	2.36a	1.23 b	0.24
		2000	2.37 a	2.42 a	2.14 a	1.48 b	0.41
P	Shoot	1999	0.31 b	0.28 b	0.38 a	0.17 c	0.05
		2000	0.32 b	0.30 b	0.38 a	0.18 c	0.03
	Root	1999	0.25 b	0.19 c	0.35 a	0.15 c	0.04
		2000	0.25 b	0.24 b	0.35 a	0.16 c	0.04
K	Shoot	1999	1.19 a	1.20 a	1.20 a	1.11 b	0.05
		2000	1.25 ab	1.24 b	1.29 a	1.16 c	0.04
	Root	1999	1.20	1.18	1.19	1.20	NS
		2000	1.25 b	1.25 b	1.29 a	1.15 c	0.03
Ca	Shoot	1999	2.42 ab	2.56 a	2.48 a	2.18 b	0.27
		2000	2.55 a	2.60 a	2.78 a	1.91 b	0.26
	Root	1999	1.80	1.75	1.71	1.90	NS
		2000	1.94 b	2.08 ab	2.21 a	1.62 c	0.25
Mg	Shoot	1999	0.44 b	0.44 b	0.51 a	0.29 c	0.04
		2000	0.44 b	0.45 b	0.50 a	0.24 c	0.03
	Root	1999	0.39 b	0.42 ab	0.44 a	0.33 c	0.05
		2000	0.37 b	0.42 b	0.47 a	0.28 c	0.05

(*): Mean separation within rows by LSD (P=0.05)
(NS): Not Significant in F test (P=0.05)

Table 5. Main effects of rose cultivar on levels of microelements (ppm) in both shoot and root tissues

			Cultivar			
			First Red	Versilia	Virginia	LSD*
Fe	Shoot	1999	125.2	133.8	126.8	NS
		2000	123.0	126.7	122.7	NS
	Root	1999	98.9	104.1	103.7	NS
		2000	101.5	102.2	103.3	NS
Mn	Shoot	1999	106.1	102.8	91.2	NS
		2000	108.0	105.7	100.4	NS
	Root	1999	96.5 a*	92.5 ab	83.2 b	9.54
		2000	97.8	96.6	90.8	NS
Zn	Shoot	1999	30.1	30.8	28.0	NS
		2000	31.3	32.7	29.1	NS
	Root	1999	29.2	26.4	25.5	NS
		2000	29.2	28.7	25.9	NS
Cu	Shoot	1999	17.3	12.1	11.9	NS
		2000	17.9	15.9	15.4	NS
	Root	1999	11.4	8.4	8.6	NS
		2000	12.9	11.1	10.9	NS

(*): Mean separation within rows by LSD (P=0.05)
(NS): Not Significant in F test (P=0.05)

Regardless of cultivar, significantly the least and highest phosphorus contents were recorded in the shoots of the cuttings and Natal Briar rootstock, respectively (Table. 4). However, the other two rootstocks were intermediate in this respect. Roots of the three graft combinations contained significantly higher levels of phosphorus than roots of the cuttings (Table 4). While, roots of the Natal Briar rootstock showed significantly the highest phosphorus levels compared to the roots of the other two rootstocks and the cuttings (Table 4).

Regardless of cultivar, rootstock exerted significant effect on shoot potassium contents during both the seasons (Table 4). Shoots of the three rootstocks have higher potassium levels compared to the shoots of the cutting plants. No rootstock effects was shown on the root tissue potassium contents in the year 1999 (Table 4). In the year 2000, root tissue of the Natal Briar rootstock gave the highest potassium levels compared to the other two rootstocks and that of the cutting plants (Table 4).

The three rootstocks showed significantly higher calcium levels in the shoot than that of the cutting plants in both the years (Table 4). No rootstock effect was noticed on the root calcium contents compared to the roots of the cutting plants in the year 1999 (Table 4). Irrespective of cultivar, generally, shoots and roots of the cutting plants showed significantly the least magnesium contents in both years (Table 4). Shoots of the Natal Briar rootstock showed the highest magnesium levels compared to *R. indica* and *R. canina* rootstocks during the two years (Table 4).

Microelements: Regardless of rootstock type, there were no significant differences in shoots and roots of the three cultivars in the iron levels in both years (Table 5). On the other hand, the Natal Briar rootstock exerted the highest iron levels in the shoots in 1999 (Table 6). However, in the year 2000, all three rootstocks were significantly superior in iron shoot contents as compared to the cuttings. Similar effect was recorded for iron root content in the two years (Table 6).

Irrespective of rootstock, no significant differences were found between the shoots of the three cultivars in the manganese level in both years (Table 5). On the other hand, shoots of the Natal Briar rootstock showed significantly the highest manganese levels in the year 1999 and the cuttings contained the least manganese content (Table 6). The other two rootstocks were intermediate in manganese content.

For the year 2000, the higher shoot tissue manganese levels were obtained from the First Red and Versilia roses with non-significant difference (Table 5). Furthermore the least manganese

Table 6. Main effect of rootstock and own rooted cuttings (ORC) on the levels of microelements (ppm) in both shoot and root tissues

			R. indica	*R. canina*	Natal Briar	ORC	LSD
Fe	Shoot	1999	131.4b*	130.4 b	143.5 a	109.1 c	12.00
		2000	129.4 a	133.1 a	140.3 a	93.6 b	12.38
	Root	1999	111.1 a	107.1 a	102.9 a	87.7 b	8.84
		2000	108.6 a	109.9 a	102.4 a	88.4 b	8.48
Mn	Shoot	1999	106.7 b	106.0 b	120.6 a	66.8 c	11.56
		2000	112.3 b	113.7 b	125.5 a	67.2 c	5.86
	Root	1999	98.1 a	99.8 a	104.3 a	60.8 b	9.93
		2000	102.6 a	104.2 a	108.4 a	65.3 b	7.90
Zn	Shoot	1999	30.8 a	31.3 a	32.8 a	23.7 b	3.50
		2000	31.7 b	32.7 b	36.8 a	22.9 c	2.93
	Root	1999	28.6 a	28.7 a	30.1 a	20.8 b	4.20
		2000	28.5 b	31.0 ab	33.2 a	19.1 c	3.64
Cu	Shoot	1999	13.3 bc	13.6 b	17.3 a	10.9 c	2.48
		2000	16.6 b	15.9 b	22.3 a	10.8 c	2.26
	Root	1999	9.5 ab	9.4 ab	10.1 a	9.0 b	NS
		2000	11.8 b	12.1 b	14.5 a	8.1 c	1.69

(*): Mean separation within rows by LSD test, (P=0.05)
(NS): Not Significant according to F test, (P=0.05)

Table 7. Coefficient of determination (R^2) between total yield, dry weight and individual nutrient elements of shoot and root plant portions

Independent Variable		Dependent Variable	
		Yield	Dry Weight
N %	Shoot	0.706**	0.260 **
	Root	0.495 (NS)	0.061 (NS)
P %	Shoot	0.530 *	0.290 **
	Root	0.430 **	0.122 (NS)
K %	Shoot	0.336 **	0.056 (NS)
	Root	0.150 (NS)	0.083 (NS)
Ca %	Shoot	0.212 (NS)	0.161 *
	Root	0.098 (NS)	0.115 *
Mg %	Shoot	0.724 (NS)	0.339 **
	Root	0.507 (NS)	0.224 **
Fe (ppm)	Shoot	0.300 (NS)	0.119 **
	Root	0.254 (NS)	0.118 *
Mn (ppm)	Shoot	0.714 (NS)	0.464 **
	Root	0.582 (NS)	0.331 **
Zn (ppm)	Shoot	0.459 (NS)	0.192 **
	Root	0.471 (NS)	0.308 **
Cu (ppm)	Shoot	0.262 (NS)	0.194 **
	Root	0.288 (NS)	0.144 (NS)
Dry Weight	Shoot	0.645 **	-
	Root	0.741 **	-

(*): Significant at *P*=0.05, (**): Significant at *P*=0.01, (NS): Not Significant.

shoot contents were recorded for the cutting plants compared to the three rootstocks. Shoots of the Natal Briar showed significantly higher manganese levels compared to the other rootstocks and the cuttings (Table 6). Roots of the First Red showed significantly the highest manganese levels in the year 1999 with no significant differences among the three cultivars noticed in the 2000 (Table 5). In addition, irrespective of cultivar, roots of the three rootstocks contained significantly higher manganese levels than the roots of the cuttings in both the years (Table 6).

Regardless of rootstock type, rose cultivars showed no significant effects on the zinc and copper contents in shoot and root tissues for the two years (Table 5). Significant positive rootstock effects were observed on zinc contents in shoots and roots in both the years (Table 6).

Shoots and roots of Natal Briar rootstock showed significantly the highest copper contents, while the least were recorded for the cuttings. Shoots and roots of *R. indica* and *R. canina* ranked second in copper levels in both years (Table 6).

The results revealed a positive rootstock effect on the number of harvested flowers per plant. These results are in full agreement with the data reported by Votruba (1981) and Ishtiaq (1994). They explained the differences in yield as a result of cultivar response to different rootstocks. Furthermore, other workers (Kool and Van De Pole, 1991; Yerkes, 1930 and Zieslin *et al.* 1973) reported that Madelon rose flower production was strongly dependent on the rootstock used, and they recommended the Natal Briar and *R. indica* Major as the best rootstocks.

Most of the macro and microelements concentrations determined for the two years were within the average ranges published by Carlson and Bergman (1965) for various above and below ground parts of Better Times rose cultivar, except for potassium and manganese.

The results clearly demonstrate higher positive significant influence of the three rootstocks on the mineral composition. Additionally, only the cutting plants became progressively worse, mostly producing deteriorates symptoms starting from about the end of the first season until the end of this research. These symptoms generally coincided with significantly lower contents of the nine elements determined in the shoot or root portion of the cutting plants.

Correlations were calculated for each of the nutrient in both plant portions with the total yield of flowers per plant and plant dry weight (Table 7), indicating that nitrogen, phosphorus and potassium contents in the shoots had the close relation with the yield 0.70, 0.53, 0.336, respectively (Table 7).

There was no significant relation between the yield and the elemental status of the root tissues except for phosphorus. Furthermore, shoot and root dry weights were highly correlated to the yield/plant (Table 7).

Shoot dry weight is mainly attributed to manganese, magnesium, and phosphorus. This is expressed by the determination coefficient of the relationships 0.464, 0.339, 0.290, respectively (Table 7). While root dry weight is mainly correlated to the manganese, zinc, and magnesium. This is supported by the coefficient for the relationships depicted in (Table 7).

Throughout both seasons total rose production was greatly dependent on rootstock used. The Natal Briar rootstock exceeded the other two *R. indica* and *R. canina* rootstocks. The lowest yields were for the own rooted cutting rose plants.

Grafted rose plants produced more dry weight with uniform and higher macro and microelement distribution than the own rooted cutting plants for the three cultivars in both shoot and root portions.

We conclude that Natal Briar is an outstanding rootstock based on its performance under prevailing conditions. Rose plants performed almost similarly on the other two rootstocks *R. indica* and *R. canina*. Furthermore, rose yields can be improved through more uniform mineral distribution within the plant tissue by selecting efficient rootstocks to grow scion cultivars on them.

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