EFFECT OF AUXIN COFACTORS ON ROOTING AND THE EFFECT OF GIBBERELLIC ACID ON SHOOT GROWTH OF LILAC SOFTWOOD CUTTINGS[1]

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Abstract. Lilac cuttings obtained from parental trees during flowering time root better than those cut later. Pyrogallol and indole increased the number of rooted cuttings per plot and showed synergistic effects on the number of roots and root length per cutting. Ascorbic, nicotinic, and boric acids used in talc with NAA increased additively, or synergistically, the total length and number of roots per cutting. H_3BO_3, $ZnSO_4$, and $MnSO_4$ sprays on the cuttings markedly stimulated rooting. Spraying the leaves of rooted cuttings with GA promoted their development.

Long term observations made in the Kornik Arboretum show that own-root lilacs grow more intensively, exhibit more viability and are more resistant to disease than grafted plants. They are also easier to maintain since root sprouts are the same cultivar and need not be removed. The use of auxin for rooting softwood lilac cuttings has been shown to be advantageous (4, 12, 20); however, some cultivars root poorly even with auxin. The purpose of the experiments described here was to test substances which increase the auxin effect and to check other substances that stimulate rooting and cause additive or synergistic effects with auxin. Rooting stimulators often cause excessive root growth and further development of the cuttings is inhibited due to root competition. An effort was made to overcome this condition by stimulating shoot growth with gibberellin.

MATERIALS AND METHODS

Experiments on rooting softwood cuttings of lilac have been conducted at the Institute of Dendrology, Kornik, Poland from 1971 to 1974. Two cuttings were taken from every stem of 1-year-old shoots of 10-year-old shrubs. All cuttings had one internode 5-8 cm long and one pair of leaves, reduced by half to reduce transpiration. The lower cut was made 2-3 mm below the lower node.

Auxin and other root-stimulating substances were supplied in talc. The microelements were applied twice to the cuttings as leaf sprays, immediately after sticking and 2 weeks later. The cuttings were stuck in a greenhouse bench in a 5 cm perlite layer placed over composted soil mixed with peat (2:1 v/v). During rooting the benches were covered with sash. The cuttings were watered by hand as needed depending on greenhouse temperature which varied from

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20 to 28°C. Every 2 weeks the cuttings were sprayed with 0.05% Benlate.

The experiment was replicated three times with 8 or 16 cuttings per plot. The results were recorded 4 and 8 weeks after planting. However, only the results obtained after 8 weeks are presented. The following data were collected: 1) number of rooted cuttings, 2) average number of roots per cutting and 3) total length of all the roots per cutting. In the following vegetative season the cuttings treated with the stimulating substances had very strong root systems but relatively small shoot system.

In order to stimulate shoot growth, gibberellic acid was used at 50 and 100 ppm. The spraying was performed four times according to two time schedules: *I schedule*: June 23, 29, July 3, 6; *II schedule*: July 27, 30, August 2, 8. The height of the plants was measured before spraying and in the fall after extension growth had terminated.

In order to perform statistical analysis of the number of rooted cuttings the proportions were converted to angular values by the Freeman-Tukey transformation. The remaining readings were subjected directly to analysis of variance and differences were compared by the new Duncan multiple range test at P = 0.01.

RESULTS

The time of collecting lilac cuttings from parental shrubs is of considerable significance for their rooting ability. The earlier the cuttings were collected the higher was the percentage of rooting; at the onset of blossoming, 85% rooted; after blossoming, 57% rooted. Earlier collected cuttings also formed stronger root systems (more and longer roots). NAA at 0.2% and 0.4% was equally effective in promoting rooting of the cuttings (Table 1). There was no effect of Benlate on the formation of adventitious roots.

Table 1. The influence of the date of taking cuttings and of the growth stimulator used on root production in *Syringa* 'Prof. Hoser'.

Date of taking cuttings	No. rooted (per 8)	No. roots per cutting	Total root length per cutting
May 17 (beginning of bloom)	6.1 cb*	4.4 b	40.7 b
May 22 (full bloom)	6.8 c	3.5 a	29.8 a
May 29 (end bloom)	5.2 ba	2.8 a	24.8 a
June 5 (after bloom)	4.6 a	2.8 a	23.2 a

Table 1. continued

Treatment			
Control	4.5 a	2.2 a	16.5 a
NAA 0.2%	5.8 b	3.9 b	39.6 c
NAA 0.2%+Benlate 0.5%	5.9 b	3.6 b	30.0 b
NAA 0. 4%	6.5 b	3.8 b	32.2 bc

*The numbers with the same letter do not differ significantly at P = 0.05

Indole and pyrogallol increased the number of rooted cuttings as effectively as auxin (by about 160% relative to the control). When given together with auxin the effect is similar to that of auxin alone. Indole at 0.2% and 0.4% as well as mixtures of indole and pyrogallol significantly increased the number of roots per cutting relative to the control. These substances, applied mixed with NAA, showed an additive or synergistic effect on the number of roots per cutting. The effect on total length of the roots per cutting was insignificant (Table 2). Vitamin C, nicotinic acid and boric acid had no effect on the number of rooted cuttings but they strongly affected the growth of the root system (Table 2). When used separately, only nicotinic acid at 0.02% increased the number and length of the roots on cuttings relative to the control. These substances, used together with auxin, caused an additive effect on the growth of the root system. A mixture of the two vitamins and NAA did not improve the number or length of roots in comparison to one of them mixed with the auxin. Boric acid had the greatest effect on the growth of the root system and appeared to act synergistically with auxin on both the number and length of roots.

Table 2. The influence of indole, pyrogallol and auxin on the rooting of cuttings of *Syringa* 'Katherine Havemayer' taken on May 17.

	No. rooted per plot*		No. roots per cutting*	
Treatment	without auxin	with auxin	without auxin	with auxin
Control	3.6 a		2.5 a	
NAA 0.2%		6.6 bc		5.8 c
Indole 0.2%	6.0 bc	6.3 bc	4.1 b	10.1 de
Indole 0.4%	5.6 b	7.0 bc	3.7 b	10.1 de
Indole 0.8%	5.6 b	7.0 bc	3.1 ab	9.1 d
Pyrogall. 0.05%	6.3 bc	7.3 c	3.4 ab	10.4 e
Pyrogall. 0.1%	6.6 bc	6.3 bc	3.4 ab	10.6 e
Pyrogall. 0.4%	6.6 bc	7.0 bc	2.4 a	9.9 de
Indole 0.4%+ +Pyrog. 0.1%	6.3 bc	7.0 bc	5.2 bc	10.5 e

*Numbers followed by the same letter do not differ significantly at P = 0.05.

Table 3. The influence of vitamins, boric acid and auxin on the rooting of cuttings of *Syringa* 'Felix' taken on May 26.

	No. rooted per plot*		No. roots per cutting*		Total root length per cutting*	
Treatment	without auxin	with auxin	without auxin	with auxin	without auxin	with auxin
Control	4.0 a		1.8 a		8.5 a	
NAA 0.2%		9.3 cde		2.8 bc		14.9 ab
Ascor. acid 0.01%	5.3 ab	9.4 de	1.9 a	3.3 cd	12.9 a	23.2 cde
Ascor. acid 0.02%	6.6 abcd	9.6 de	2.3 ab	3.8 de	16.7 abc	27.8 ef
Nicoti. acid 0.01%	6.0 abc	10.6 d	2.3 ab	2.9 bc	17.0 abc	25.9 def
Nicoti. acid 0.02%	7.6 abcde	10.3 de	2.9 bc	3.9 de	20.5 bcd	26.5 def
Nic. acid +Asc. 0.02%	5.0 a	9.6 de	2.3 ab	3.8 de	16.4 abc	30.4 ef
Boric acid 0.1%	5.3 ab	10.0 de	2.0 a	4.3 e	15.3 ab	32.1 f
Boric acid 0.2%	6.6 abcd	8.6 bcde	2.6 abc	4.1 e	19.9 abcd	31.2 f

*Numbers with the same letter do not differ significantly at P = 0.05.

Spraying NAA-treated plants with microelements such as zinc, manganese and boron increased the number of rooted cuttings relative to the NAA treatment alone (Table 4). Manganese and boron at 50 and 100 ppm increased the root system of the cuttings relative to the control and, when combined with the auxin treatment, their influence on the number and length of roots was additive. Also a synergistic effect of zinc at 100 ppm with the auxin was observed on the growth of the root system.

The rooted lilac cuttings reacted to gibberellic acid (GA_3) only when this was sprayed in the first time schedule (Fig. 1). At 100 ppm GA increased shoot extension growth by a factor of four relative to the control. Frost injury was not observed on GA-treated plants and laboratory studies indicated that they can stand temperatures of -35°C as well as the control plants.

Table 4. The effect of nutrient spraying and auxin on the rooting of cuttings of *Syringa* 'Ludwig Spaeth' taken June 7.

	No. rooted per plot*		No. roots per cutting*		Total root length per cutting*	
Treatment	without auxin	with auxin	without auxin	with auxin	without auxin	with auxin
Control	0.6 ab		0.6 ab		0.6 a	
NAA 0.2%		3.0 cd		2.5 def		24.8 de
$ZnSO_4$ 100 ppm	1.3 b	5.0 ef	1.1 abc	4.3 gh	2.7 a	34.7 fg
$ZnSO^4$ 200	0.3 a	4.6 de	0.3 a	2.8 ef	0.3 a	31.2 efg
$FeSO_4$ 100	1.3 b	3.0 cd	1.0 abc	3.6 fg	1.8 a	29.5 e
$FeSO_4$ 200	1.0 ab	4.0 de	1.3 abc	3.1 efg	3.6 ab	28.3 ef
$MnSO_4$ 50	1.0 ab	6.6 f	1.6 bcd	4.8 h	4.6 ab	32.6 efg
$MnSO_4$ 100	1.0 ab	5.0 ef	2.0 cde	4.5 h	10.3 bc	34.7 fg

Table 4. continued

Treatment	No. rooted per plot*		No. roots per cutting*		Total root length per cutting*	
	without auxin	with auxin	without auxin	with auxin	without auxin	with auxin
H_3BO_3 50	1.3 b	6.3 f	1.6 bcd	5.3 h	12.0 bc	38.8 gh
H_3BO_3 100	1.6 bc	6.3 f	2.3 cde	5.8 h	11.6 bc	44.2 h
$K_2SO_4$2500	1.6 bc	4.0 de	1.3 abc	2.4 de	7.3ab	25.4 e
$K_2SO_4$5000	1.6 bc	3.0 cd	1.6 bcd	3.0 efg	11.6 bc	26.9 e
$H_3PO_4$2500	1.0 ab	4.0 de	1.3 abc	3.0 efg	8.0 abc	16.9 cd
H_3PO_4 5000	1.0 ab	3.0 cd	1.3 abc	3.1 efg	10.0 bc	29.9 ef

*Numbers with the same letter do not differ significantly at $P = 0.05$.

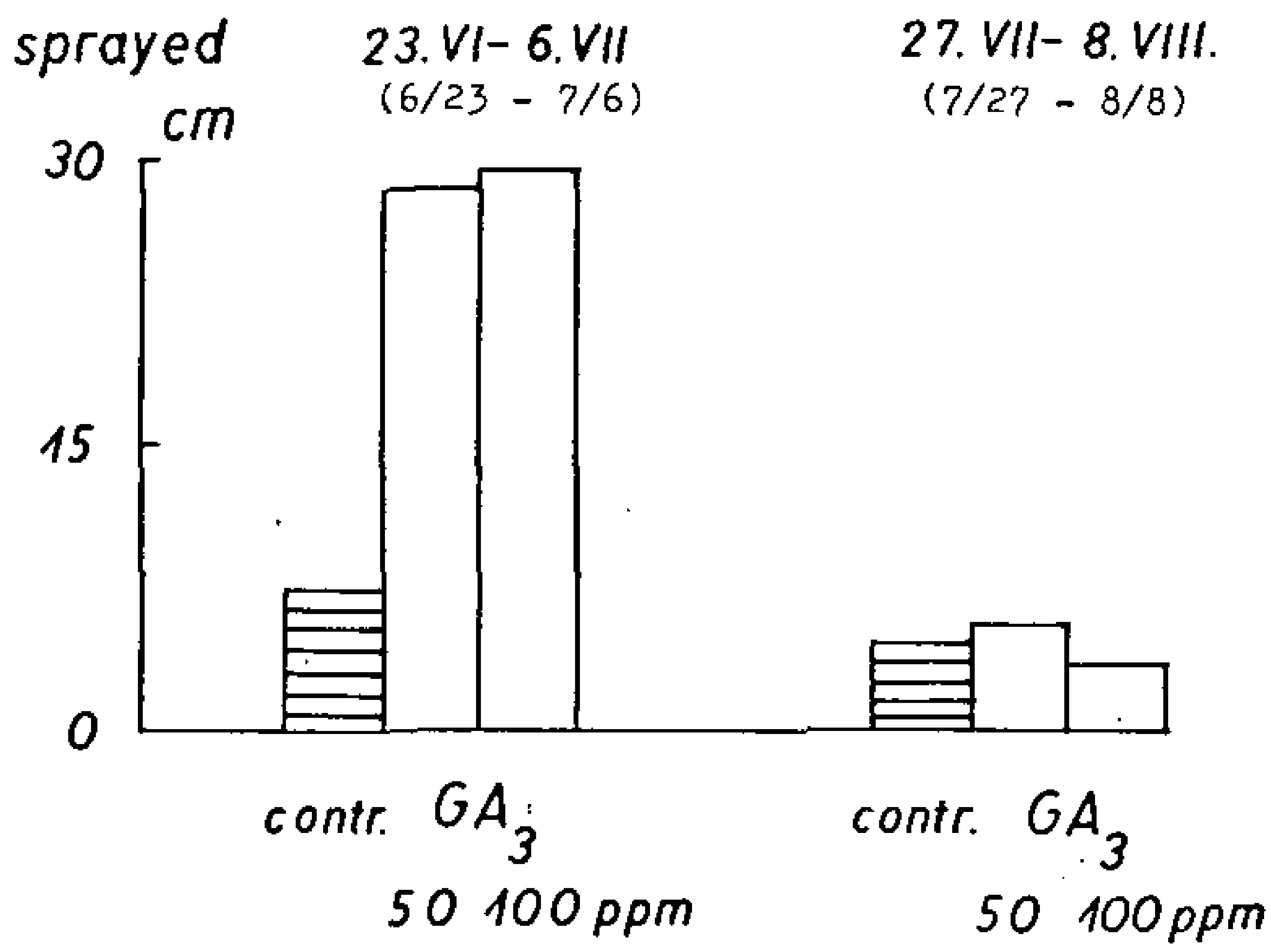

Figure 1. Differences in shoot growth as result of GA_3 spraying.

DISCUSSION

The natural ability of a cutting to root is dependent upon the time of collecting as has been indicated by several investigators (6, 17, 24). Komarow (13) reported the best time for rooting cuttings of a majority of lilac cultivars is the time between the peak and the end of flowering. Our observations show that the cuttings of many cultivars rooted best when collected at the onset of flowering. Those collected towards the end of flowering or after rooted less satisfactorily. Similar observations were made by Sonnenfeld (17). The periodic variation in the ability to root may be caused by fluctuation in the levels of endogenous auxin, rooting cofactors, or rooting inhibitors (23, 24). Since the period of optimal lilac rooting is very short (about 2 weeks) its extension would be important from a practical point of view. This was achieved with some lilac cultivars (4).

A synergistic effect between indole or phenols with auxin has been observed by Hess (11), Basu (2), Gorter (9). There were, however, only a few experiments reported on woody plants (12, 14). In our work, additive or synergistic effects of indole and pyrogallol with NAA was observed on their influence on the total root length and number of roots per cutting, but not on the number of cuttings rooted. The mechanism of action of these substances is not well known yet. They may slow down the action of some enzymes and protect natural auxin by inhibiting their oxidation (21) but this does not explain their synergism with synthetic auxin (16). They may interfere with auxin transport (3). Vitamins are known to act as root stimulators in some plants (1, 10). In the studies described here ascorbic and nicotinic acid, together with auxin, had additive effects on the growth of the root system but none on the number of cuttings rooted. This indicates that the vitamins do not stimulate root initiation but rather act on already formed root primordia, lowering the competition among them. Stimulating rooting by spraying mineral nutrients on the leaves of cuttings was reported earlier (5, 8, 15). Of the elements studied, boron, manganese and zinc have given the most spectacular effects (7, 15, 25). Some reports indicate that boron is not effective (16). Probably the effect of an applied microelement depends upon how much of it has been accumulated in the plant tissues before the cutting was collected.

Gibberellic acid is a strong growth stimulator for lilacs. In the work of Tamberg (19) lilacs seedlings treated with gibberellic acid were 10 times taller than the control. In our experiment gibberellin caused a strong promotion of shoot growth which reduced the disproportion between the partly inhibited shoot system and the overgrown root system. Possibly gibberellins may help in restoring proper balance between the above-ground part and the root system in cuttings of many other species.

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