ACTA AGROBOTANICA
Vol. XXVIII, z. 1, 1975

Influence of phenolic substances on rooting of softwood cuttings of *Populus alba* L. and *P. canescens* Sm.

T. BOJARCZUK and L. S. JANKIEWICZ

Research Institute of Dendrology, Kórnik by Poznań,
Research Institute of Pomology, Skierniewice, Poland

(Received: March 22, 1974)

Abstract

Pyrogallol and salicylic acid used alone or in combination with auxin increased markedly the number of rooted cuttings, the number of roots per cutting and the total length of roots per cutting. The effect of phenolic substances was most visible when treatment was done in late summer, i.e. when natural ability to form roots was very low.

INTRODUCTION

The root-promoting property of phenolic substances was discovered several years ago (Hess 1962; Tomaszewski 1964), but was as yet little investigated (Basu 1969; Lee and Tuckey 1971; Hackett 1970; Jankiewicz et al. 1973). It seemed therefore interesting to examine if these substances may improve rooting of cuttings of poplars (section *Leuce*). Poplars of this section are important in forestry of many countries but their propagation is difficult. Especially the propagation with softwood cuttings gives little success with several clones. With other clones which may be easier propagated with cuttings there is a problem of hastening the rooting to obtain more rotations of cuttings per frame in one season.

MATERIALS AND METHODS

Cuttings were made of current year shoots taken from one-year-old mother trees of *Populus canescens* 'Rogalinensis' and of *P. alba* 'Tryńcza 3' or 'Gniewczyna 2'. One or two cuttings were made of one shoot. The apical part was always rejected since it was found in the preliminary experiment to be very susceptible to diseases. The cuttings contained 3

nodes. The largest leaves were cut by 1/3, the lowest leaf was removed. The cutings were treated with diluted solutions of phenolic substances for 24 hours and then their lower ends were dipped in talc powder containing 0.2% or 0.4% naphtaleneacetic acid (NAA) with or without fungicide. In one experiment the quick-dip method was also used (see Table 5). The cuttings were planted in a greenhouse in 5 cm layer of washed sand placed on a mixture of sterilized compost soil. The benches with cuttings were cover with windows to avoid too much evaporation. Watering was done 2-3 times a day by hand. Once a week the cuttings were sprayed with 0.3% Captan.

The results were estimated by counting the number of rooted cuttings per plot with 16 cuttings (in one case 8), and also by counting the number of roots per cutting and by measuring the total root length per cutting. The experiment was set up in 3-4 randomized blocks. The results were worked up statistically with the method of analysis of variance using Duncan's multiple range test for significance at $P=0.05$.

RESULTS

Populus alba 'Tryńcza 3' cuttings rooted generally better than *P. canescens* 'Rogalinensis' (Table 1) and *P. a.* 'Gniewczyna 2' (Table 2). The control cuttings of all 3 clones rooted in low number or not at all.

Phenolic substances: pyrogallol and salicylic acid applied alone increased sometimes the number of rooted cuttings of *P. c.* 'Rogalinensis' and of *P. a.* 'Tryńcza 3' (Table 1), but not of *P. a.* 'Gniewczyna 2' (Table 2). The effect of these substances on the number of roots per cutting and on the root length was none or weak (although in some cases significant).

NAA alone, in talc stimulated rooting in all 3 clones. The joint treatment with phenolic substance (diluted solutions method) and with auxin (in talc) increased the number of rooted cuttings of *P. a.* 'Tryńcza 3' in 1972 and of *P. a.* 'Gniewczyna 2' over the number obtained with NAA alone. This difference was insignificant for *P. a.* 'Tryńcza 3' in one of the experiments (Table 3). The joint treatment with phenolic substance and with auxin showed, however, always marked synergistic effect on the number of roots per cutting and on the total root length in the cuttings of all 3 clones. The optimal concentration of a phenolic substance in a joint treatment with auxin was in most cases 0.5-5 or even 20 mg/l (Tables 1-4).

The fungicide Captan added to the talc preparate with NAA, in a combined treatment with salicylic acid increased the number of rooted cuttings of *P. a.* 'Tryńcza 3' but diminished the root length (Table 1). With other clones its effect was insignificant (Tables 1, 2 and 4).

Salicylic acid, a monophenol promoted rooting of *P. a.* 'Tryńcza 3'

Table 1

The influence of salicylic acid on rooting of *P. alba* 'Tryńcza 3' cuttings (1) and of pyrogallol on rooting of *P. canescens* 'Rogalinensis' cuttings (2)
Planted on August 5, results checked on August 26, 1972

Treatment (Concentrations of phenolic substances in ppm)	Average number of rooted cuttings per plot of 16 cuttings		Average number of roots per cutting		Average total length of roots per cutting	
	1	2	1	2	1	2
control	3.0 a	0.0 a	1.5 a	0.0 a	9.3 a	0.0 a
phenolic substance						
0.5	10.0 c	2.3 b	7.8 ab	2.2 b	33.6 bcd	4.1 ab
1.0	11.7 cdef	—	9.0 ab	—	36.3 cd	—
2.0	12.3 defg	2.0 b	8.3 ab	1.3 b	33.6 bcd	2.9 ab
5.0	13.0 efg	2.0 b	7.7 ab	1.3 b	29.9 bcd	1.9 ab
10.0	12.7 defg	—	8.3 ab	—	29.1 bcd	—
20.0	10.0 c	2.7 b	6.3 a	2.2 b	22.0 b	3.8 ab
50.0	11.0 cd	3.3 b	7.6 ab	2.3 b	23.5 b	5.7 b
NAA 0.2% (=n)	5.0 b	7.0 c	11.8 c	4.5 c	39.7 d	17.7 c
phenolic substance						
0.5+n	11.0 cd	10.7 d	24.1 e	10.6 e	88.1 g	42.4 d
1.0+n	10.7 cd	—	23.9 e	—	85.1 g	—
2.0+n	13.3 fg	9.2 cd	23.5 e	10.3 e	83.8 g	42.6 d
5.0+n	11.4 cde	8.3 cd	23.9 e	10.7 e	86.3 g	41.6 d
10.0+n	11.3 cde	—	18.4 d	—	59.7 ef	—
20.0+n	10.7 cd	8.7 cd	19.1 d	9.3 e	61.4 ef	39.5 d
50.0+n	12.3 defg	8.0 c	18.0 d	7.2 d	60.1 ef	21.7 c
5.0+n+captan	13.7 g	9.0 cd	21.3 e	10.0 e	64.0 ef	40.5 d

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

cuttings similarly or even better than pyrogallol — a polyphenol (Table 1 and 3). In one separate experiment, however, salicylic acid showed only weak and in most cases insignificant effect on the number of roots per cutting in *P. c.* 'Rogalinensis' (Table 4), its effect with NAA on total length of roots per cutting was, however, marked and synergistic even in this case.

Since the method of application of growth regulators in concentrated solutions (quick-dip method) is more convenient in practice than diluted solutions method, we applied salicylic acid with this method for the cuttings of *P. a.* 'Tryńcza 3' (Table 5). It was found that all concentrations, which were used, of this compound alone, increased markedly the number of rooted cuttings and the number of roots per cutting, but not the total lenght of roots per cutting. The auxin used separately showed also marked effect on adventitious roots production. Joint treatment with

Table 3

The influence of pyrogallol on rooting of *P. alba* 'Gniewczyna 2' cuttings (Planted on August 4, results checked on August 26) (Other details as in Table 1)

Treatment	Average number of rooted cuttings per plot of 16 cuttings	Average number no of roots per cutting	Average total length or roots per cutting
Control	2.0 a	2.1 a	4.1 a
Pyrogallol 0.5 ppm	2.0 a	3.5 a	3.9 a
2.0	2.0 a	2.0 a	3.5 a
5.0	3.3 a	1.6 a	4.2 a
20.0	3.0 a	3.0 a	4.0 a
50.0	3.0 a	2.0 a	4.3 a
NAA 0.2% (=n)	9.3 b	10.6 b	16.3 b
Pyrogallol 0.5+n	13.3 c	13.3 cd	51.3 e
2.0+n	13.0 c	13.7 d	55.3 f
5.0+n	13.7 c	13.4 cd	44.9 d
20.0+n	10.3 b	12.1 bcd	40.6 c
50.0+n	9.7 b	11.7 bc	40.7 c
5.0+n+captan	14.0 c	12.2 bcd	47.2 d

Table 3

The influence of salicylic acid, pyrogallol and NAA on the rooting of *P. alba* 'Tryńcza 3' cuttings (Planted on August 4, results checked on August 25) (Other details as in Table 1)

Treatment	Average number of rooted cuttings per plot of 8 cuttings	Average number of roots per cutting	Average total length of roots per cutting
Control	6.7	4.1 a	10.4 a
Salicylic acid 1.0 ppm	6.7	5.2 a	17.0 a
Salicylic acid 5.0 ppm	7.7	5.0 a	18.5 a
Pyrogallol 1.0 ppm	7.7	5.0 a	19.0 a
Pyrogallol 5.0 ppm	7.7	7.1 a	18.5 a
NAA 0.2% (=n)	7.7	13.5 bc	50.8 b
Salicylic acid 1.0+n	7.7	19.5 ef	68.5 c
Salicylic acid 5.0+n	8.0	21.2 f	65.0 c
Pyrogallol 1.0+n	7.3	18.0 de	69.4 c
Pyrogallol 5.0+n	7.7	16.0 cd	63.4 c

both substances increased only slightly the number of rooted cuttings over the number obtained with salicylic acid alone (significant difference only for some concentrations), but showed marked additive effect on the number of roots per cutting and on the total length of roots per cutting.

Thus salicylic acid can be used with a convenient quick-dip method instead of diluted solutions method. The concentrations 1000 mg/l — 5000 mg/l in a joint treatment with auxin seem to be optimal.

Table 4

The influence of salicylic acid on rooting of *P. canescens* 'Rogalinensis' cuttings (Planted on August 4, results checked on August 26)

Treatment	Average number of rooted cutings per plot of 16 cuttings	Average number of roots per cutting	Average total length of roots per cutting
Control	0.0 a	0.0 a	0.0 a
Salicylic acid 0.5 ppm	2.3 a	1.5 ab	3.0 bc
1.0	2.3 a	1.0 ab	2.0 b
2.0	3.0 a	1.9 ab	2.1 b
5.0	2.3 a	1.2 ab	1.3 b
10.0	3.7 ab	1.9 ab	5.3 d
20.0	2.0 a	1.2 ab	2.0 b
50.0	2.3 a	1.7 ab	4.5 cd
NAA 0.2% (=n)	7.3 bc	4.0 ab	18.1 f
Salicylic acid 0.5+n	10.0 c	4.3 ab	23.1 h
1.0+n	10.0 c	4.9 b	27.3 i
2.0+n	10.0 c	4.3 ab	20.4 g
5.0+n	8.7 c	4.7 b	19.9 fg
10.0+n	10.0 c	4.5 b	19.7 fg
20.0+n	10.0 c	5.0 b	14.3 e
50.0+n	10.0 c	3.4 ab	12.4 e
5.0+captan	11.3 c	4.4 b	19.6 fg

A separate experiment was set up to investigate if the date of taking cuttings influences their response to growth regulators. The results presented in Table 6 show that the numbers of rooted cuttings were the highest at the first date irrespective of the treatment. The combined treatment with an auxin and phenolic substance evoked the best rooting effect in all dates. The interaction "date"×"treatment" was insignificant in this case. This interaction was, however, significant for the traits "average number of roots per cutting" and "total length of roots per cutting". Presented results show that the mixture of auxin and phenolic substance shows most marked effects on these traits in latest date of treatment, exceeding markedly the effects obtained with auxin alone. At the first two dates of treatment the auxin was alone as effective or even more effective, concerning root number per cutting and total root length, than the above mixture.

Table 5

The influence of salicylic acid, NAA, and the fungicide Captan in the quick — dip method * on the rooting of *P. alba* 'Tryńcza 3' cuttings

(Planted on August 3, results checked on August 25)

Treatment	Average number of rooted cuttings per plot of 16 cuttings	Average number of roots per cutting	Average total length of roots per cutting
Control	3.3 a	1.5 a	8.3 a
scalicylic acid			
500 ppm	8.7 bcd	6.6 bc	15.8 ab
1000	9.7 bcde	5.5 b	16.7 abc
1500	8.7 bcd	3.1 b	9.7 a
1500+captan (=c)	11.8 def	5.4 b	15.0 ab
5000	10.0 bcde	4.7 b	8.4 a
NAA 0.2% (=n)	7.0 b	11.7 d	32.8 cd
n+c	7.7 bc	10.7 cd	27.7 bc
salicylic acid			
500+n	11.3 def	18.3 e	43.7 d
1000+n	10.7 cdef	17.5 e	68.0 e
1500+n	12.3 ef	17.5 e	66.8 e
1500+n+c	13.3 f	19.7 e	67.5 e
5000+n	11.0 cdef	17.1 e	63.8 e

* The cuttings were dipped for 5 seconds in 50% ethanolic solution of salicylic acid. Other details as in Table 1.

DISCUSSION

There are very scanty data on the use of phenolic substances to promote adventitious root formation in cuttings of woody plants (Lee and Tuckey 1971; Piątkowski et al. 1973; Jankiewicz et al. 1973). The authors have not found as yet any data concerning their use for poplars. Our results, these and unpublished, show that phenolic substances improve rooting of several clones of *Populus alba* and *P. canescens*, particularly when given together with auxin.

Phenolic substances: salicylic acid and pyrogallol applied by diluted solutions method promoted most root production in very low concentrations 0.5-20 mg/l. In Basu et al. (1969) experiments with *Eranthemum* cuttings salicylic acid given with auxin was also most effective in low concentrations 1-100 mg/l. Another phenolic substance — rutin showed marked root-promotive activity in as low concentration as 10^{-7} M (Lee and Tuckey 1971). Pyrogallol was used in rather too high concentrations: 100 mg/l or more, by Basu (1972) and Piątkowski et al. (1973) with no sucess in root promotion. Lee and Tuckey (1971)

Table 6

The effect of treatment and date of experiment on the rooting of cv. *P. alba* 'Tryńcza 3' cuttings

(Averages joined by the same letter are not significantly different)
Other details as in Table 1

Treatment	Average number of rooted per plot of 8 cuttings			
	7-28 VI	7-28 VII	5-26 VIII	Mean
Control	6.7	2.3	2.3	3.4 a
NAA 0.2% (=n)	7.3	5.3	4.0	5.5 b
NAA 0.4%	6.7	3.3	4.7	4.9 b
Salicylic acid 1.0 ppm+n	8.0	6.0	6.8	6.9 c
Mean	7.2 b	4.2 a	4.4 a	
Treatment	**Average number of roots per cutting**			
Control	7.2 b	2.0 a	2.3 a	
NAA 0.2%	26.0 f	21.0 def	11.4 bc	
NAA 0.4%	22.3 def	18.5 de	16.7 cd	
Salicylic acid 1.0 ppm+n	18.5 de	22.0 def	24.3 ef	
Treatment	**Average total length of roots per cutting**			
Control	13.7 ab	7.5 a	15.2 ab	
NAA 0.2%	84.1 de	80.2 de	42.0 c	
NAA 0.4%	75.8 de	80.3 de	32.7 bc	
Salicylic acid 1.0 ppm+n	68.7 d	91.5 e	94.1 e	

have shown for rutin that too high concentrations of phenolic substance do not stimulate rooting.

Salicylic acid applied by quick-dip method (followed by auxin treatment) was most effective in concentrations 1000-5000 mg/l. In the experiments of Lee and Tuckey (1971) and of Jankiewicz et al. (1973) the other phenolic substanes rutin and pyrogallol were effective in quick-dip method in similar concentrations.

The monophenol salicylic acid and a polyphenol pyrogallol showed similar root promoting activity, when combined with an auxin. Also in Basu (1969, 1970) experiments a number of monophenols and polyphenols showed root-promotion of *Phaseolus* and *Eranthemum* cuttings. This does not support the suggestion that polyphenols increase synergistically the auxin effect on rooting by inhibiting IAA-oxidase system. Basu (1971a) have found no direct relation between the activity of a given

phenolic substance in rooting tests and its ability to stimulate or inhibit IAA-oxidase system. There was found (Basu 1972), however, a correlation between the ability of some phenolic substances to stimulate the acropetal translocation of an auxin and their property to antagonize auxin-induced root promotion.

When salicylic acid was applied with auxin on different dates, their joint effect concerning root number per cutting and root length was most prominent in plant material taken on August 5. Although the effect on the number of rooted cuttings per plot was significant on all dates. Lee and Tuckey (1971) have shown that the synergism between the phenolic substance and auxin could be easily detected only in mature cuttings but not in immature ones.

The result of the presented paper may have practical meaning in poplar propagation. A combined treatment with a phenolic substance and auxin may markedly increase the number of rooted cuttings per frame, may prolongate the time of rooting the cuttings and may shorten the period needed to root them. This enables the nurseryman to have more rotations of cuttings per frame in a single season which is an important economic factor in vegetative propagation of poplars.

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Wpływ substancji fenolowych na zakorzenianie się sadzonek zielnych topoli *Populus alba* L. i *P. canescens* Sm.

Streszczenie

Potraktowanie sadzonek kwasem salicylowym lub pirogallolem, w połączeniu z traktowaniem auksyną — NAA zwiększało znacznie liczbę zakorzenionych sadzonek, liczbę korzeni na sadzonkę i sumę długości korzeni na sadzonkę ponad wartości otrzymane przy traktowaniu samą auksyną lub samą substancją fenolową. Synergizm między auksyną a związkami fenolowymi występował, jeśli chodzi o liczbę zakorzenionych sadzonek na poletko, przez cały sezon wegetacyjny, a jeśli chodzi o liczbę korzeni na sadzonkę i sumę długości korzeni na sadzonkę, przede wszystkim w drugiej połowie lata. Optymalnymi stężeniami związków fenolowych w metodzie roztworów rozcieńczonych były 0,5-20 mg/l, a w metodzie roztworów stężonych 1000-5000 mg/l.