The influence of inorganic salts, sucrose and CEPA on rooting of willow cuttings

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Abstract

Hardwood or leafless softwood cuttings of *Salix viminalis gallica* (hort.) or *S. daphnoides acutifolia* Will. were soaked in water or separately in IAA, IBA, NaCl, KCl, NaNO_3 , KNO_3 and sucrose solution or in sequence with one of the auxins, or CEPA. The inorganic salt treatments (KCl , KNO_3 , NaNO_3) stimulated rooting of cuttings to the same degree as auxin, while sucrose and NaCl with IAA resulted in high stimulation of rooting, but with IBA no synergistic effect was observed in the other willow species. CEPA induced the largest increase of root number per cutting, stimulated significantly subsequent root growth and also reduced significantly the rooting period.

INTRODUCTION

Growth substance requirements for root formation have been studied by many workers. Nutritional compounds are also known as important factors in rooting. Sucrose as a carbohydrate source is recognized to be essential for root production. Inorganic salts given into the rooting medium (Wille 1974) or in nutrient mist (Wott et al. 1967) were found to affect rooting of cuttings. Some plants rooted easier in response to ethylene treatment (Zimmerman and Hitchcock 1933; Kawase 1971; Abeles 1973). However, in some studies the effect of ethylene was inhibitory to cell division in the vascular cambium (Radin and Loomis 1969), and in pea root and shoot apices (Apelbaum and Burg 1972). On the other hand, ethylene promoted the induction of apogamous buds in *Pteridium* (Elmore and Whittier 1973). The purpose of the present investigation was to test the effects of inorganic salts, CEPA and sucrose in rooting of willow cuttings.

MATERIAL AND METHODS

Hardwood or leaf-less softwood cuttings 20 cm long, of *Salix viminalis gallica* (hort.) or *Salix daphnoides acutifolia* Will. were carefully selected, according to their diameter and their location on the twig. After

washing with tap-water they were immersed in the solution of inorganic salts or sucrose at 2/3 of their length. When the cuttings were soaked in 2 substances, they were treated with each of them in succession, for 24 h. CEPA in the preparation Ethrel (Amchen 68-250 formulation) was applied as ethylene source. The hardwood cuttings were regarded as rooted when at least one root longer than 5 mm has emerged, and as softwood when a root longer than 2 mm appeared. Sixteen cuttings per treatment were used. The data were analyzed statistically by the variance method and the LSD at 95 or 99 per cent probability level were given.

RESULTS

The number roots per cutting was similar in controls and in the cuttings treated with NaCl only and with sucrose only (Fig. 1). IAA alone promoted the rooting. IAA alone promoted less outgrowth of roots than

Fig. 1. Effect of NaCl, sucrose and IAA on the rooting of *S. daphnoides* hardwood cuttings. The cuttings rooted during 25 days (planted on November 25) at 20°C.

LSD_{0.01} = 2.6

in the combined treatment of IAA with NaCl or sucrose. These combined treatments caused synergistic effects. For *S. viminalis* hardwood cuttings the inorganic salts of concentration 0.062 M proved similar effect on the number of roots per cutting, as IBA alone (Table 1). The

Table 1

Effect of salts, sucrose, CEPA and IBA on the rooting of *S. viminalis* hardwood cuttings. Rooting was examined after 26 days (planting October 23 at 20°C

Treatment	Roots	
	No. per cutting	total length (mm) per cutting
Check — water	4.8	168
IBA 50 mg/l	11.2	202
NaCl 0.062 M	7.3	204
KCl 0.062 M	10.5	305
NaNO ₃ 0.062 M	10.4	322
KNO ₃ 0.062 M	12.9	402
Sucrose 0.125 M	3.6	122
NaCl + IBA	6.9	124
Sucrose + IBA	10.3	206
CEPA 230 mg/l	25.9	466
CEPA + IBA	20.5	472
CEPA + NaCl	25.6	716
LSD _{0.01}	5.2	124
LSD _{0.05}	3.8	92

effectiveness of this treatments depended on the ion used. Since KCl was better than NaCl concerning the effect on total root length per cutting and, NaNO₃ was better than NaCl⁻, it was supposed, that K⁺ ion is more promoting than Na⁺, and NO₃⁻ more than Cl⁻. According to this supposition KNO₃ should be most promotive ion combination, what is supported by data presented in Table 1. KNO₃ salt developed higher root number per cutting than NaCl and higher total root length per cutting than KCl or NaCl.

Treatment with CEPA caused the formation of twice as much roots per cutting and twice as much total root length than IBA treatment. NaCl addition to CEPA treatment caused further significant increase of total root length per cutting. There was no synergism between CEPA and IBA treatment, and the number of roots per cutting was lower than in treatment with CEPA only. The rooting effects of different NaCl concentrations and of sucrose were compared with those of control treat-

Fig. 2. Effect of NaCl and sucrose concentration on the rooting of *S. viminalis* leaf-less softwood cuttings. The cuttings rooted 11 days (planted on August 3) at 21°C. $LSD_{0.01}=0.35$ for concentrations. There was no significant difference between NaCl and sucrose. IBA — 50 ppm concentration

ment (water), or with IBA 50 ppm (Fig. 2). The NaCl concentrations ranged from 0.0 to 0.5 M and of sucrose from 0.0 to 0.1 M, respectively. The optimal concentrations were about 0.06 M of NaCl and 0.13 M of sucrose. They produced the same promotion as IBA 50 ppm. Therefore, it seems, that the observed effects are rather related to the osmotic concentration (O.C.) than to the molar concentration (M.C.) of used solutions.

Besides the presented effects of various substances on the root number per cutting and on the mean total length of roots, the time-course of rooting was investigated. The process of root formation in control cuttings was very slow, about 70 per cent of cuttings rooted during 25 days (Fig. 3). IBA accelerated markedly the process of root-formation

Fig. 3. Time-course of the rooting of *S. viminalis* hardwood cuttings. The same treatments were applied as described in Table 1

and caused rooting of 100 per cent cuttings during 20 days. CEPA caused extremely fast rooting of all cuttings—in 7 days. The combined treatment with CEPA and IBA as well as CEPA and NaCl caused also very fast rooting. Among the other treatments, which did not contain CEPA, only sucrose and IBA accelerated rooting significantly. Application of sucrose alone affected the rate of rooting similarly as IBA. Remaining treatments: NaCl, KCl, NaNO_3 , NaCl + IBA, did not prove marked difference with controls concerning the effect on the rooting rate.

DISCUSSION

The data presented in this paper proved that CEPA promoted most effectively the rooting of willow cuttings. The compound CEPA applied alone gave twice as much roots per cutting and of total root length as IBA. Promotive effects of CEPA on adventitious root formation were reported for several species of plants (Morgan 1972; Abeles 1973). Mullins (1970) working on *Phaseolus* has found that CEPA promoted the outgrowth of preformed root primordia, but inhibited the formation of new root primordia. According to Hartmann and Kester (1959), *Salix* is known as having numerous preformed root primordia. Therefore, marked promotion of root production in willow cuttings caused by CEPA may be due to stimulation outgrowth of such primordia.

Distinct acceleration caused by CEPA should be stressed. All treatments containing CEPA proved such effect, but CEPA alone was most effective. Such strong rooting acceleration was not reported by other authors. Mineral salts were used by several authors as nutrient spray on leaves of rooted cuttings (Wott et al. 1967). Stimulatory effects of soaking the cuttings (24 h) in diluted solutions of different salts were unexpected by the authors. The results presented in Figure 2 suggest, that sucrose affected in twice as high concentration as NaCl and, that the effects were of osmotic nature. However, Lovell et al. (1972) and Moore et al. (1972) suggested that such mechanism is not involved in rooting. Nanda and Rattacharya (1973) stressed that sugar is needed for rooting as a source of energy.

The synergistic effect of auxin (IAA) and NaCl in the rooting of *S. daphnoides* cuttings was found (Fig. 1). However, no such synergism occurred in *S. viminalis* (Table 1). This difference may be due to physiological differences among these two species or to another auxin used.

It may be pointed, out, that treatment with KNO_3 proved better effect on rooting than IBA, concerning total root length per cutting. The root's number per cutting and the rate of root production was not worse than that of IBA (Table 1, Fig. 3).

Promotive effect of sucrose on rooting in *Raphanus* and *Sinapis* cotyledons were found by Lovell et al. (1972). In our experiments sucrose alone was slightly promotive with *S. daphnoides*. Its effect on *S. viminalis* was visible only in acceleration of rooting process. Synergistic effect of sugar and auxin treatment was observed by Nanda and Rhattacharya (1973). In our experiments such synergism occurred in both investigated species. However, in *S. daphnoides* it was observed as the increase of the number of roots per cutting, and in *S. viminalis* as significantly marked acceleration of rooting.

In leaf-less softwood cuttings of *S. viminalis*, sucrose in concentration 0.125 M, stimulated rooting similarly like IBA. It seems therefore, that in this particular case, sucrose induced root promotion was due to its osmotic concentration, since NaCl in similar O.C. gave the same root promotion.

Its is important — from the practical point of view — that willow cuttings formed haevy root-system with CEPA in the time only half as long as with IBA. It seems also important, that similar acceleration may also be obtained at the treatment with sucrose and IBA.

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Wpływ soli nieorganicznych, sacharozy i CEPA na ukorzenianie sadzonek wierzby

Streszczenie

Sadzonki wierzby, *Salix viminalis gallica* (hort.) lub *S. daphnoides acutifolia* Will., moczone w wodzie, w roztworach samego IAA, względnie IBA lub NaCl, KCl, NaNO_3 , KNO_3 , CEPA (Ethrel) albo sacharozy. Poza tym stosowano traktowanie NaCl lub sacharozą, a następnie jedną z auksyn albo CEPA.

Ukorzenianie sadzonek najintensywniej stymulował CEPA w stężeniu 230 ppm, co uwidoczniło się w liczbie i ogólnej długości korzeni oraz w bardzo silnym przyspieszeniu ukorzeniania. KCl, NaNO_3 , KNO_3 w stężeniu 0,062 M stymulowały ukorzenianie w tym samym stopniu co auksyna, a sacharoza w stężeniu 0,125 M i NaCl 0,062 M działały podobnie, jak woda.

Zastosowanie sacharozy lub NaCl z IAA powodowało synergistyczny efekt ukorzeniania sadzonek *S. daphnoides*, czego nie stwierdzono przy użyciu IBA dla sadzonek *S. viminalis*.