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Use of auxin, fungicides and rooting cofactors to induce adventitious root formation in softwood cuttings of apple, gooseberry and some ornamental plants

M. G. PIĄTKOWSKI[1], L. S. JANKIEWICZ[1], S. KASPRZYK[2]

[1] Research Institute of Pomology, Skierniewice, Poland
[2] Institute of Dendrology, Kórnik near Poznań, Poland

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Abstract

Cuttings of apple rootstocks MM 106, Alnarp 2, M VII and M 26, of the ornamental plants *Pyracantha coccinea* Roem., *Syringa Meyeri* Schneid., and *Weigela* cv. Vanhouttei formed a larger numbers of adventitious roots with a mixture of naphthaleneacetic acid and the fungicide Captan than with auxin alone. Boric acid, vitamin B_1 as well as pyrogallol and vanilic acid in rather high concentrations showed no effect on rooting when used separately or in a mixture with an auxin. Intermittent mist and bottom heat were used.

INTRODUCTION

Several new methods of promoting root production in cuttings have been developed recently. It seemed worthwhile to try them on economically important fruit and ornamental plants.

Root formation in apple rootstocks softwood cuttings was investigated recently under the conditions of intermittent mist and bottom heat by Monin (1968). He has found that cuttings prepared from the apical part of a shoot rooted to a lower per cent than those from the lower part. July seemed to be the best period to take cuttings. In the experiments of Czynczyk and Grzyb (1971) auxin treatment markedly stimulated the root production of softwood apple cuttings. For instance the cuttings of MM 106 rootstock rooted to 74% with auxin and only to 17% without them. Similar results have been obtained by Schmadlak (1969) with M IX and M XI rootstocks. Auxins also promote the rooting of many ornamental plants (Thimann and Behnke-Rogers 1950; Białobok and Jankiewicz 1953).The Root-inducing effect of auxins in gooseberry cuttings is less certain (Czynczyk 1968), although some authors have successfully used auxins to promote rooting in this species (Tarasenko 1958; MacNeil 1969; Fernqvist 1970). Treating the cutting with auxins is often not sufficient to obtain a high percent of rooting. In some poorly rooting apple and pear cultivars the auxins, instead of inducing root formation, cause an increase in growth inhibitor content Chailakhian and Sarkisova 1970).

The effect of auxin treatment may be heightened by adding fungicides to the auxin solution or auxin talc preparate (van Doesburg 1964; Fiorino et al. 1970; van Elk 1969). Sometimes, however, a detrimental effect of fungicides was also noted, for instance with Captan (Guerriero and Loretti 1968).

Several phenolic compounds were found to stimulate adventitious root formation (Hess 1962; Tomaszewski 1964; Hackett 1970). This may be partly explained by the inhibiting effect of polyphenols on IAA-oxidase (Tomaszewski 1964). A list of phenolic compounds which act synergisticly with auxin in promoting the rooting of *Phaseolus vulgaris* cuttings is given by Poapst and Durkee (1967).

Gibberellins present in the tissues may inhibit the rooting of cuttings. Therefore lowering their level by treatment with (2-chloroethyl) trimethylammonium chloride (Urban and Libbert 1967), with abscisic acid (Basu et al. 1970) or with SADH (succinamic acid 2,2-dimethydrazide) (Read and Hoysler 1969), improved root production in the cuttings of several plant species.

Several other rooting cofactors such as vitamins or microelements were used to promote rooting (Thimann and Behnke-Rogers 1950; Turetskaya 1961; Falaschi and Vittagliano 1970).

MATERIAL AND METHODS

The apple and gooseberry cuttings were cut in the nursery of the Pomological Experiment Station near Skierniewice and transported overnight to Kórnik Arboretum near Poznań. The cuttings of ornamental plants were cut in Kórnik Arboretum. The apple and goseberry cuttings were cut 10 - 12 cm long from the apical part of the shoots including the apex. The cuttings of ornamental plants were taken from the apical and medium parts of the shoot. The cuttings were dipped in talc preparates of growth regulators (Białobok and Jankiewicz 1953) with or without the fungicide Captan. In some cases this treatment was preceeded by soaking the basal ends of cuttings in diluted solutions of rooting cofactors (pyrogallol, vanilic acid, boric acid, usually for 12 h. Phenolic substances were dissolved in 0.025 M $NaHCO_3$ (Poapst and Durkee 1967). The rooting medium consisted of washed sand and sterilized hotbed soil (1:1) covered with a layer of sand. The cuttings were planted in a greenhouse with intermittant mist and with bottom heat at +25°C.

Several weeks after the date of treatment the number of healthy, rooted cuttings were examined. The cuttings were assigned to the following classes depending on the number of roots:

Class I — 1 root per cutting
Class II — 2 roots
Class III — 3 to 4 roots
Class IV — 5 to 8 roots
Class V — more than 8 roots

The results were presented as per cent of rooted cuttings and as rooting coefficient calculated as follows: the number of a class was multiplied by the number of cuttings assigned to this class. The resulting products were summed and divided by the total number of cuttings in a given plot. Exemple:

A) No. of the class	I	II	III	IV	V	0 (unrooted)	Total
B) Cuttings per class	2	4	5	1	0	3	15
C) Products A×B	2	8	15	4	0	0	29

Rooting coefficient = 29:15 = 1.93

The experiment was set up in 3 or 4 randomized blocks. There were 15 - 20 equally treated plants per plot. The results expressed as rooting coefficients were analyzed statistically with the method of analysis of variance using Duncan's test for the significance of differences.

RESULTS

Apple rootstocks. The ability of MM 106 cuttings to produce adventitious roots depended very much on the date of treatment. The control cuttings and those treated with growth regulators rooted better when planted in June than in late July or September (Fig. 1, Tab. 1). Also Alnarp 2 cuttings rooted better when planted in June than in late July (Fig. 2, Tab. 1).

Control cuttings of all apple cultivars investigated rooted rather poorly. The fungicide Captan used separately did not improve rooting, with the single exception of Alnarp 2 cuttings taken in June. Naphthaleneacetic acid (NAA) in most cases significantly increased the production of roots (Fig. 1 - 3, Tab. 1). Joint treatment with Captan and NAA caused usually better root production than with NAA alone. A mixture of NAA with the fungicide Ceresan was less effective than Captan +

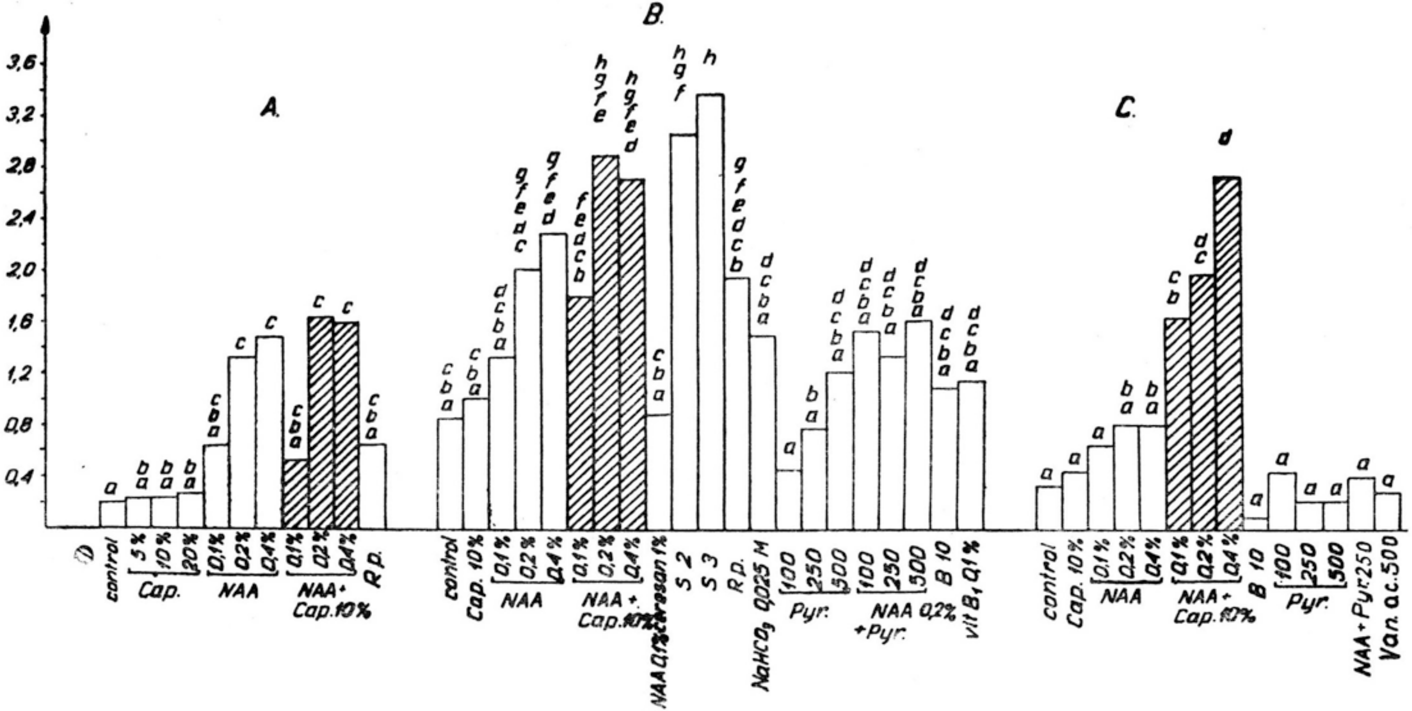


Fig. 1. Influence of auxin, fungicides and rooting cofactors on the rooting of cuttings expressed as rooting coefficients (see "Material and Methods")

Apple cv. MM 106 cuttings taken on September 5 (*A*), June 16 (*B*), July 31 (*C*). Boric acid (*B*), pyrogallol (*Pyr*) and vanilic acid (*van ac.*) were used as 12 h presoaks before auxin and Captan treatments or as a separate treatment. Their concentrations are in mg/l. Vitamin B_1 was mixed with talc. In most cases NAA 0.2% and Captan 10% were used in mixtures, with cofactors. S 2 and S 3 — Seradix 2 and 3. Rp — Rooting powder. Columns marked with the same letters represent the values which do not differ significantly at P = 0.05 for a given date.

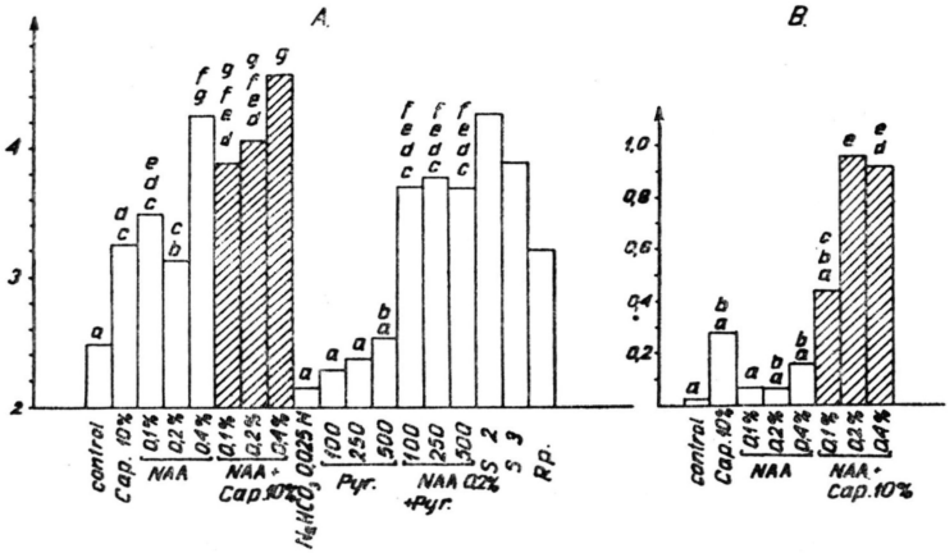
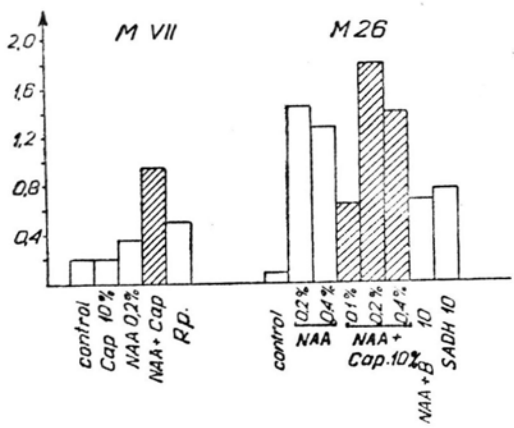


Fig. 2. Rooting coefficients for cuttings of apple cultivar Alnarp 2 taken on June 17 (*A*) and July 31 (*B*)

Other details as in Fig. 1 and Tab. 1



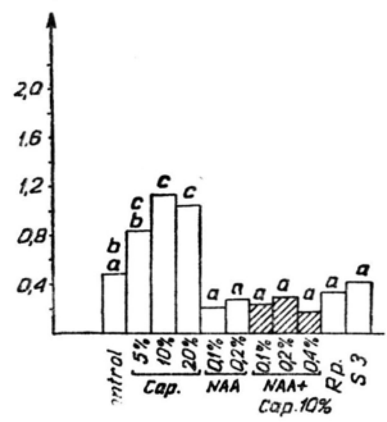


Fig. 3. Rooting coefficients for cuttings of apple cv. M VII and M 26. The data were not worked out statistically

For other details see Fig. 1 and Table 1

Fig. 4. Cuttings of goosebery cv. Resistenta taken on June 16

For other details see Fig. 1 and Tab. 1

Table 1

Percentages of rooting of cuttings depending on treatments

Species Cultivar	Date of planting	Date of checking	Hotbed (H) Green-house (G)	Treatments												
				Con-trol	Captan			NAA			Captan 10%+NAA			Seradix no. 2	Seradix no. 3	Roting powder
					5%	10%	20%	0.1%	0.2%	0.4%	0.1%	0.2%	0.4%			
Apple																
MM 106	16 VI	31 VII	G	37	45	53	47	55	67	71	55	75	78	87	87	84
MM 106	31 VII	24 IX	G	13	—	15	—	20	27	20	40	42	51	40	27	0
MM 106	5 IX	5 XI	G	16	20	17	20	37	50	53	23	57	60	—	41	32
Alnarp 2	17 VI	1 VIII	H	86	93	100	100	91	86	94	99	96	96	96	86	89
Alnarp 2	31 VII	24 IX	H	2	1	9	—	5	5	5	19	33	25	—	—	0
M VII	1 VIII	24 IX	H	4	—	7	—	—	18	—	—	25	—	—	0	21
M 26	1 VIII	24 IX	H	7	—	—	—	—	50	32	18	50	43	—	—	—
Gooseberry																
cv. Resistenta	16 VI	1 VIII	G	14	24	38	38	9	9	0	8	7	2	—	10	17
cv. Resistenta	6 IX	5 XI	G	46	43	53	50	30	33	7	25	13	15	—	—	53
Pyracantha coccinea (dormant cuttings)	4 XI	10 I	G	86	83	80	75	95	97	87	93	90	90	—	—	—
Syringa Meyri	17 VI	19 VIII	G	22	—	60	—	55	70	78	75	76	95	—	—	—
Weigela cv. Vanhouttei	5 IX	6 XI	G	62	65	95	98	95	98	93	83	78	90	—	73	65

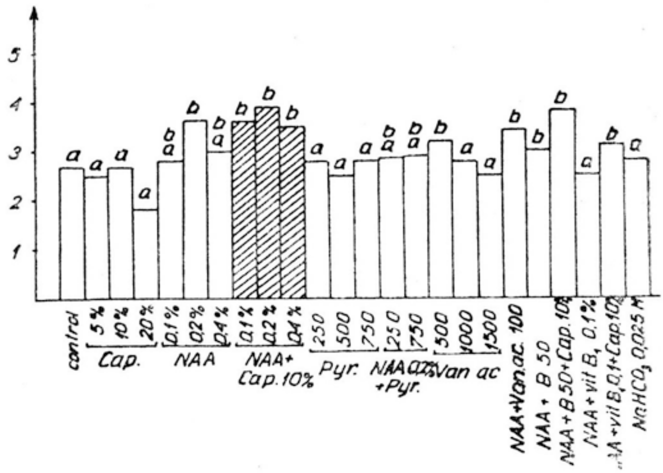
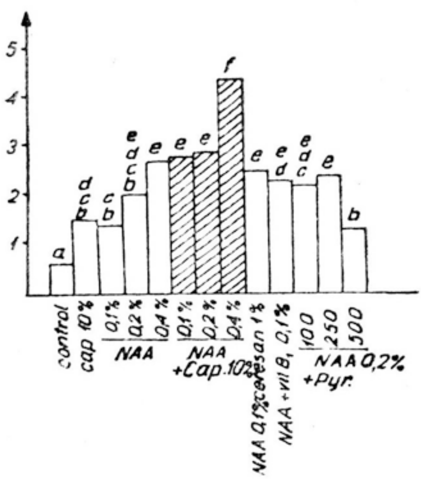


Fig. 5. Rooting of cuttings of *Pyracantha coccinea* Roem. The cuttings were taken when fully dormant and lignified

For other details see Fig. 1 and Tab. 1



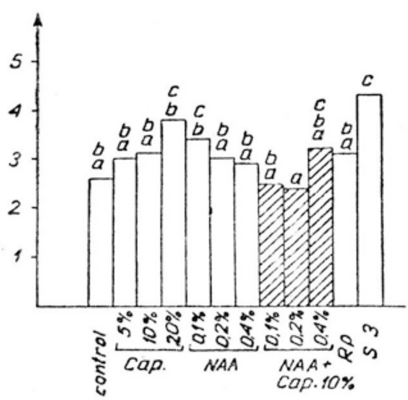


Fig. 6. Rooting of cuttings of *Syringa Meyeri* Schneid.

Fig. 7. Rooting of cuttings of *Weigela cv.* Vanhouttei.

For other details see Fig. 1 and Tab. 1

NAA. The Commercial root-inducing preparates Seradix 2, Seradix 3 (May and Baker) and Rooting Powder (Boots) caused good rooting but not consistently better than the mixture of NAA with Captan. The phenolic substances pyrogallol and vanilic acid in the concentrations used did not influence rooting and even diminished the rooting of MM 106 cuttings taken in July (Compare the results for NAA+Captan with those for NAA+Captan+phenolic substances). Boron and vitamin B_1 in the concentrations used had no significant influence on the root production of cuttings. Alar, a preparate of succinamic acid 2,2-dimethylhydrazide, seems to promote the rooting of M 26 cutings and should be used in future experiments.

Gooseberry cv. Resistenta. The cutting taken in the middle of June evidently did not root as well as those taken in early September, but this difference could be accidental (Fig. 4, Tab. 1). In both cases the auxin had an inhibitory effect on root production. Captan used separately consistently increase drooting in the experiment started on June 16, but applied in a mixture with NAA was not able to surmount the detrimental effect of the auxin. Ceresan, vitamin B_1, vanilic acid, and pyrogallol used in the same concentrations as on other plants, as well as Seradix and Rooting powder were without effect.

Ornamental plants. The cuttings of *Syringa Meyeri* Schneid. and *Pyracantha coccinea* Roem. (Fig. 5 and 6, Tab. 1) generally rooted better with the mixture of NAA and Captan than with NAA alone, however, the differences between effects of these two treatments were not always significant. Vanilic acid in the lowest concentration promoted the rooting of *Pyracantha* whereas pyrogallol, $NaHCO_3$ solution, boron, and vitamin B_1 showed no stimulative effect on rooting. The cuttings of *Weigela* cv. Vanhouttei produced roots abundantly (Fig. 7, Tab. 1) and showed little response to Captan, NAA, and the mixture of both. Only Seradix 3 produced significantaly better rooting than that of untreated controls.

DISCUSSION

The beneficial effect of auxin treatment on the rooting of apple roostock cuttings and those of ornamental plants was expected since such effects have been noted by several authors. It was, however, interesting to find that a mixture of auxin with the fungicide Captan in talc powder often improved rooting substantially better than auxin alone. Captan applied separately in most cases had no effect on the production of adventitious roots. It is therefore suggested that Captan improves the effect of NAA treatment by protecting the tissues, made delicate due to the process of auxin-induced root differentiation, against the attack of fungi. Guerriero and Loretti (1968) have found an unfavourable effect of Captan, however, they used the method of dipping the cuttings in a solution of Captan. This method was also unsuccessful in our preliminary trials. According to Hermann (1968), the auxin acts better when used in talc than in the "quick dip" method.

Our results with gooseberry corroborate those of Czynczyk (1968) who found no root-promoting effect of auxin treatment on softwood cuttings of this species. Less harmful effects with lower concentrations of auxin indicate that possibly the concentrations used were too high and that further lowering of concentrations may lead to promotive effects. The substantially better rooting of gooseberry cuttings with Captan alone may be of interest for nursery practice.

Although the mixtures of Captan with NAA generally caused the best rooting response of the ornamental plants investigated, *Weigela* responded significantly only to Seradix 3.

Phenolic substances used alone or in mixtures with auxin and Captan did not improve the rooting of apple and ornamental cuttings, with the exception of *Pyracantha* cuttings, which produced more roots than controls with the lowest concentration of vanilic acid. Possibly the concentrations suggested by Poapst and Durkee (1967) were too high for the plants investigated (Basu et al. 1969; Lee and Tukey 1971; Bojarczuk and Jankiewicz, unpublished).

The lack of effect of boron on the rooting of cuttings might be due to the already sufficient content of this element in the cuttings at planting time. The effects obtained with this element by other authors vary: Domański (1967) found a synergistic effect of boron with auxin in stimulating the root production of *Salix* cuttings. Sobczykiewicz (1968) found no effect or a harmful effect of boron on the rooting of red current cuttings. The lack of response of cuttings to vitamin B_1 treatment noted in our experiments has also been found in several other plants (Thimann and Behnke-Rogers 1950) but a promotive influence of this vitamin is more often encountered (Turetskaya 1961; Thimann and Behnke-Rogers 1950; Sobczykiewicz 1968).

Further development of the work on natural root-promoting substances (Kawase 1971) and on the environement conditions for rooting (Tarasenko and Prokhorova 1966), may bring the progress in the methods of treating cuttings to induce root formation.

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Zastosowanie auksyny, fungicydów i innych substancji dla polepszenia zakorzenienia sadzonek zielnych jabłoni, agrestu i niektórych roślin ozdobnych

Streszczenie

Badano zakorzenianie się sadzonek zielnych w warunkach zamgławiania i podgrzewania podłoża w szklarni, albo też w warunkach zwykłego inspektu. Do doświadczeń wzięto sadzonki następujących roślin: podkładek jabłoniowych MM 106, Alnarp 2, M VII, M 26, agrestu odmiany Resistenta, oraz roślin ozdobnych *Syringa Meyeri* Schneid., *Pyracantha coccinea* Roem., *Weigela* odmiana Vanhouttei. Traktowanie sadzonek auksyną — kwasem naftylooctowym łącznie z fungicydem Captanem w preparacie talkowym powodowało w większości przypadków silniejsze zakorzenienie się niż traktowanie samą auksyną. Sam Captan w preparacie talkowym był w większości przypadków nieaktywny, ale polepszał zakorzenienie sadzonek agrestu.

Pirogallol i kwas waniliowy zastosowane w stosunkowo wysokich stężeniach, same lub łącznie z auksyną, nie pobudzały zakorzeniania z wyjątkiem kwasu waniliowego, który pobudził zakorzenianie sadzonek *Syringa Meyeri* w stężeniu 500 mg/l.

Traktowanie kwasem bornym i witaminą B_1 nie wpływało na zakorzenienie sadzonek zarówno wtedy, gdy związki te zastosowano same, jak i wtedy gdy podano je łącznie z auksynami.