Chemical defoliation of apple rootstocks and the influence of rootstocks type on the defoliation of 'Jonathan' scion

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Abstract

The following substances were used to defoliate apple rootstock instead of hand defoliation before digging out: KI, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{Mg}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$, ethephon (Ethrel 68-250 and CKB 1131), preparation N252, and the mixtures: ethephon (Ethrel) with copper sulphate, or with gibberellic acid, morphactin (EMD) with ethephon, and morphactin with ethephon and copper sulphate. Among the inorganic defoliant tested, only $\text{Mg}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$ gave satisfactory results in defoliating apple rootstocks. When applied at the end of September this chemical did not decrease winter hardiness of the rootstocks. Ethrel and the preparation CKB 1131, caused satisfactory defoliation, but when used in optimal concentrations for defoliation they decreased the winter hardiness of plants. The mixture of ethephon with copper sulphate in which both components were used in low concentrations also appeared highly effective. Ethephon in low concentration mixed with EMD caused only partial defoliation of the rootstocks. Addition of gibberellic acid did not improve the effectiveness of ethephon. Preparation N252 in a concentration of 0.15% effectively defoliated the rootstocks and did not cause a subsequent decrease of frost hardiness in the conditions of this experiment. The response of 'Jonathan' scions to defoliant was modified by the rootstock.

INTRODUCTION

In our earlier publications (Basak et al., 1973a; Czynczyk et al., 1977) it was shown that the effectiveness of chemical defoliation of one-year-old fruit trees depends on the plant species cultivar, and the age of the plants. As it was shown by Pridham (1952) and Tudosecu and Andreies (1968) this is also true for various types of apple rootstocks.

The present experiments were performed to determine the possibility of using chemical defoliation for several kinds of apple rootstocks cultivated in Poland and to check the influence of the rootstock type on 'Jonathan' scions defoliation. For defoliation KI, CuSO_4 , $\text{Mg}(\text{ClO}_3)_2$, ethephon and a mixture of ethephon

with CuSO_4 were used. These compounds gave satisfactory defoliation of nursery trees (Basak et al., 1973a, b; Basak and Jankiewicz 1976a, b). Some of these substances and their mixtures were also successfully applied by Marczyński (1977a, b) and other authors (Larsen, 1973; Sergeev and Daukaeva, 1967; Daukaeva, 1964). Good defoliation of nursery trees with a mixture of ethephon with morphactin was obtained by Liebster (1974). Satisfactory results of defoliation with N252 are reported by Knight (1979). The latter two defoliant as well as CKB 1131 (containing ethephon) were included in the present investigation. Trials were also made to accelerate abscission of the youngest leaves by addition of gibberellic acid to ethephon spray (Morgan and Durham, 1975).

MATERIALS AND METHODS

The experiments were carried out at the Fruit Growing Experiment Station of the Institute of Pomology at Prusy and in the Experimental Orchard of the Institute of Pomology in Skierniewice.

During the first two years of experiments the following defoliant were tested: Potassium iodide (KI) in concentrations of 0.15 and 0.3%.

Copper sulphate ($\text{CuSO}_4 \cdot \text{H}_2\text{O}$) in concentrations of 1.0, 2.0 and 3.0% denoted further in the text by CuSO_4 .

Magnesium chlorate ($\text{Mg}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$) in concentrations of 0.4 and 0.5% denoted further in the text by $\text{Mg}(\text{ClO}_3)_2$.

The defoliant were applied on two dates — September 18 and September 28. One-year-old seedlings of 'Antonovka' were treated in two years and the vegetative rootstock M26 in one year. Each treatment involved 120 seedlings of 'Antonovka' (30 plants per plot $\times$ 4 blocks). Some experiments were conducted with rootstocks M7 and *Malus robusta*. In this case the following compounds and their mixtures were applied on September 25:

N252 (2,3-dihydro-5,6-dimethyl-1,4-dithin-1,1,4,4-tetroxide) in concentrations of 0.075, 0.15 and 0.3% (Uniroyal Ltd., Great Britain),

CKB 1131 preparation containing ethephon in concentrations of 2000 and 4000 mg/l of ethephon (Bitterfeld, Deutsche Demokratische Republik)

Ethrel 168-250, (Amchem, USA) in concentrations of 2000 and 4000 mg/l of ethephon,

mixture of ethephon in concentrations of 1000 mg/l with 1.0% copper sulphate

ethephon in concentrations of 250, 500 and 1000 mg/l with 20 and 40 mg/l of morphactin (EMD 7311)

ethephon in concentrations of 2000 and 4000 mg/l mixed with gibberellic acid (in the form of preparation Gibrescol, produced by Polfa, Kutno, Poland).

In all cases when ethephon was used in mixtures it was applied in the form of the preparation Ethrel 68-250. Three mother plants of M7 and 3 plants of *Malus robusta* were used per plot. The experiment was set up in 4 randomized blocks.

The influence of rootstock type on defoliation of the scion was investigated on one-year-old 'Jonathan' trees propagated on 5 different types of rootstocks differing in vigor. These were: seedlings of 'Antonovka', 'Alnarp 2', M11, MM106 and M7. The trees were defoliated with 1.5% or 2.5% copper sulphate applied on September 28 in one year and with 2.0% copper sulphate applied on September 27 in another year. Each treatment involved 12 trees propagated on each rootstock type (3 trees per plot $\times$ 4 blocks). Observations were made on the influence of defoliations on leaf fall, health condition of shoots, winter hardiness and growth of trees in the next year after treatment. The methods applied in all the above experiments were similar to those reported by B a s a k et al. (1973a). The results were statistically elaborated by analysis of variance and Duncan's multiple-range test at $P = 0.05$.

Average minimal winter month temperatures (Dec. – Feb.) in 1969/70 and 1970/71 were -12° and -10° , respectively. Absolute minimal temperatures were -21° and -24° , respectively (data important for trials with frost resistance).

RESULTS

Defoliation of rootstocks

Effectiveness of defoliation was investigated during two year experiments with 'Antonovka' seedlings. Among the 3 investigated inorganic defoliant magnesium chlorate proved to be best for 'Antonovka' seedlings (Table 1). This compound used in a concentration of 0.4 or 0.5% and applied on September 28, defoliated the seedlings 3 weeks after treatment in 80%. The remaining 20% of leaves were very weakly attached to the stem and could be easily removed by hand. Potassium iodide and copper sulphate were less effective.

Defoliation of the rootstock M26 by each of these 3 defoliant was only partial. Usually, only the upper part of the plants was defoliated (data not presented in tables). A higher degree of defoliation in this cultivar was usually accompanied by bark and shoot injury.

In a separate experiment several compounds were tested on *Malus robusta* plants: the compound N252 was effective in defoliating this rootstock (Table 2), the concentration of 0.15% seems to be optimal (74% of defoliation in 2 weeks and 94% in 4 weeks). Ethephon in the form of the preparation Ethrel, used in concentrations 2000 and 4000 mg/l, defoliated *Malus robusta* plants quickly but not effectively. From vigorous shoots, as are usually formed on this rootstock,

Table 1

Influence of inorganic defoliants on leaf fall of 'Antonovka' seedlings and on the health and subsequent growth of defoliated rootstocks

Treatment		Defoliation in 1969		Defoliation in 1970			Mean number of dead bud	
		percent of fallen leaves on:		growth of rootstocks after defoliation**		freezing injury of rootstocks in field		
		Oct. 16	Oct. 17	sum of current growth of shoots (cm/plant)	increase of stem cross section in %	% frozen plants		average rate of freezing in 0.5 scale
Control unsprayed		0	5	180.0	247.9	0	0	2.1
1st date of spraying (Sept. 15-18)								
Potassium iodide	0.30%	5	40	115.5	205.4	6.3	2	2.6
	0.50%	20	65*	129.7	180.4	6.7	3	5.7
Copper sulphate	1.00%	7	8	—	—	—	—	—
	2.00%	25	20	180.6	253.2	0.0	0	2.2
	3.00%	55	50	131.6	204.5	6.7	3	—
Magnesium chloride	0.40%	—	50	—	—	—	—	—
	0.50%	—	53	153.3	218.1	12.5	2	4.3
2nd date of spraying (Sept. 25-28)								
Potassium iodide	0.30%	35	30	134.7	237.7	0.0	0	4.3
	0.50%	50	60*	164.1	256.2	6.3	3	5.6
Copper sulphate	1.00%	50	10	—	—	—	—	—
	2.00%	70	33*	181.0	250.6	0.0	0	5.9
	3.00%	—	63*	155.4	235.5	0.0	0	—
Magnesium chlorate	0.40%	—	80	—	—	—	—	—
	0.50%	80	87*	156.0	261.8	0.0	0	2.2

*Bark and shoot injuries occurred.

**Differences among treatments are not significant at $P = 0.05$. Neither were these differences significant in 1969 so the data are not included in this table.

only 50.6% of the leaves had fallen 2 weeks after treatment < Table 2 >. Gibberellic acid < GA₃ > used in concentration 1000 mg/l, did not improve defoliation induced by ethephon < Table 2 >. The youngest leaves sprayed with ethephon and afterwards with GA₃ retained chlorophyll and did not drop earlier than from trees treated with ethephon alone or from control trees. Ethephon in the form of preparation CKB 1131 used in a concentration of 2000 mg/l showed a similar defoliating activity as Ethrel used with the same ethephon concentration < Table 2 >. The leaves sprayed with these two chemicals had not changed color before dropping. The preparation CKB 1131 was more effective than Ethrel if both compounds were used with 4000 mg/l of ethephon.

In a separate experiment with the rootstock M7 and *Malus robusta* the mixture of ethephon in the form of the preparation Ethrel with morphactin was used. It caused quick yellowing and dropping of leaves starting at the base and

Table 2

Influence of N252, ethephon in the form of preparations Ethrel or CKB 1131 and of the mixtures of ethephon with N252 or with gibberellic acid (GA₃) on defoliation and winter hardiness of *Malus robusta* rootstock. Date of treatment – Sept. 25th 1975

Treatment	Observations on leaf fall in % after		Electric conductivity of shoots after freezing at -32°C*
	2 weeks	4 weeks	
Control untreated	22.7 a	—	35.3 ab
N252 0.075%	55.6 bcde	81.3 cd	33.6 ab
N252 0.15%	73.6 e	94.2 de	33.8 ab
N252 0.3%	70.6 de	96.4 e	30.6 a
Mixtures:			
N252 0.15% + ethephon 2000 ag/l	65.9 cde	78.7 bc	—
N252 0.15% + ethephon 4000 mg/l	61.8 cde	72.2 abc	—
Ethephon 2000 mg/l (in Ethrel)	38.2 ab	52.4 a	35.0 ab
Ethephon 4000 mg/l (in Ethrel)	50.6 bcd	61.0 ab	43.0 c
Mixtures:			
Ethephon 2000 mg/l (in Ethrel) + GA ₃ **1000 mg/l	50.5 bcd	57.1 a	35.3 ab
Ethephon 4000 mg/l (in Ethrel) + GA ₃ 1000 mg/l	52.2 bcd	59.6 ab	37.3 abc
Ethephon 2000 mg/l (in CKB 1131)	46.3 bc	59.2 a	37.2 abc
Ethephon 4000 mg/l (in CKB 1131)	73.8 e	85.2 cd	49.6 d

The means in each column designated with the same letter do not differ significantly at P = 0.05. *Electric conductivity is expressed as % of diffusion of electrolytes from shoots. The higher this percent severer freezing injury of shoots. **The whole trees were sprayed with ethephon and then after a few days only the youngest leaves, which usually persist longest, were additionally sprayed with GA₃.

Table 3

Influence of ethephon applied with morphaction (EMD) or with copper sulphate on the defoliation and winter hardiness of the rootstock M7 shoots

Treatment	Leaf fall in % after		Electric conductivity after freezing at -32°C
	2 weeks	4 weeks	
Control untreated	13.2 a	29.2 a	46.5 a
Hand defoliation at time of spraying	—	—	39.4 a
EMD 20 mg/l + ethephon 250 mg/l	11.6 a	25.2 a	—
EMD 20 mg/l + ethephon 500 mg/l	17.4 a	28.6 a	—
EMD 20 mg/l + ethephon 1000 mg/l	19.8 a	30.9 a	43.8 a
EMD 40 mg/l + ethephon 250 mg/l	18.0 a	33.2 a	—
EMD 40 mg/l + ethephon 500 mg/l	14.0 a	30.8 a	—
EMD 40 mg/l + ethephon 1000 mg/l	19.8 a	28.5 a	41.8 a
Ethephon 3000 mg/l	21.9 a	31.1 a	47.2 a
EMD 20 mg/l + mixture of ethephon 1000 mg/l + CuSO_4 1%	65.3 b	93.3 b	45.1 a
EMD 40 mg/l + mixture of ethephon 1000 mg/l + CuSO_4 1%	54.8 b	80.5 b	45.6 a
Ethephon 1000 mg/l + CuSO_4 1%	56.9 b	89.7 b	46.5 a

Explanations as in Table 2.

Table 4

Influence of morphaction (EMD) applied with ethephon (in Ethrel) on defoliation and winter hardiness of *Malus robusta* rootstock. Date of treatment — Sept. 25th

Treatment	Leaf fall in % after		Electric conductivity of shoots after freezing at -32°C
	2 weeks	4 weeks	
Control untreated	15.0 a	30.5 a	46.2 a
EMD 20 mg/l + ethephon 250 mg/l	21.0 a	44.7 b	48.8 a
EMD 20 mg/l + ethephon 500 mg/l	24.4 a	46.5 bc	47.2 a
EMD 20 mg/l + ethephon 1000 mg/l	30.5 a	52.7 bcd	48.4 a
EMD 40 mg/l + ethephon 250 mg/l	34.9 a	62.8 de	46.6 a
EMD 40 mg/l + ethephon 500 mg/l	30.9 a	54.6 bcd	48.1 a
EMD 40 mg/l + ethephon 1000 mg/l	29.2 a	59.6 cde	45.3 a
Ethephon 3000 mg/l	54.4 b	69.3 e	47.2 a

Explanations as in Table 2.

advancing up the leader, but the degree of defoliation was not satisfactory (Tables 3, 4). This mixture used in different concentrations was not more effective than ethephon alone in 3000 mg/l concentration, however, leaves treated with the mixture yellowed before dropping (in contrast to those treated with ethephon only). Ethephon and morphactin defoliated better *Malus robusta* than M7 plants. The mixture of ethephon in 1000 mg/l concentration with 1% copper sulphate was more effective than ethephon alone in 3000 mg/l concentration (Table 3). Addition of morphactin to the mixture of ethephon and CuSO_4 did not improve the effectiveness of this mixture when tested on M7 (Table 3).

Bark and shoot injury

Such injury was sometimes noticeable on defoliated plants of 'Antonovka' seedlings and M26. Usually, the injuries occurred on plants which were better defoliated. Some of the inorganic defoliants induced shoot tip injury. In the case of 'Antonovka' the most severe injuries occurred after treatment with 0.5% KI applied in mid September. Plants of M26 were injured most by copper sulphate applied in mid September. No injuries were observed on plants treated with other defoliants.

Influence on frost resistance

The influence of defoliation with KI, CuSO_4 and $\text{Mg}(\text{ClO}_3)_2$ on winter hardiness of the rootstocks was determined in the field after winter. Some winter injury was observed in 'Antonovka' seedlings treated with defoliants in mid September (Table 1). Among the defoliants applied at the end of September only 0.5% KI decreased the winter hardiness of 'Antonovka' seedlings.

The influence of other defoliants on winter hardiness was determined by measuring the electric conductivity of electrolytes of shoots kept at -32°C (Tables 2, 3, 4). The preparation N252, the mixtures of ethephon with morphactin or ethephon with copper sulphate and morphactin did not change the winter hardiness of *Malus robusta* plants. Ethrel and the compound CKB 1131, used both in 4000 mg/l concentration of ethephon decreased substantially winter hardiness of the rootstock. Application of gibberallic acid in a mixture with ethephon had no influence on winter hardiness of shoots.

Influence of rootstock type on the defoliation of 'Jonathan' scions

One-year-old 'Jonathan' trees were treated with CuSO_4 . During the first year of the experiment the trees propagated on vegetative rootstock responded to the defoliant more readily than those on seedlings. The differences between 'Jonathan' trees on 'Antonovka' and those on other rootstock were not the same

Table 5

Influence of type of rootstock on leaf fall from one-year-old 'Jonathan' trees after treatment with copper sulphate.
Treated on Sept. 25-28

Rootstock	Treatment		1970		1971	
			percent of fallen leaves after weeks:			
			2	4	2	4
'Antonovka' seedlings	control untreated		14.9 b	33.8 ab	17.2 a	55.2 ab
	copper sulphate	1.5-2.0%*	33.3 c	74.0 fg	61.5 d	83.5 d
		2.5	42.0 de	86.7 g	—	—
M 11	control untreated		4.1 a	11.4 a	—	—
	copper sulphate	1.5-2.0%	58.7 g	75.5 fg	—	—
		2.5	47.9 ef	66.0 ef	—	—
'Alnarp 2'	control untreated		17.5 b	27.9 bc	28.1 abc	57.3 ab
	copper sulphate	1.5-2.0%	59.3 g	74.0 fg	43.1 abcd	61.3 bc
		2.5	39.6 cd	56.6 de	—	—
MM 106	control untreated		16.4 b	30.1 bc	29.9 abc	48.8 a
	copper sulphate	1.5-2.0%	67.4 h	80.6 fg	51.2 bcd	71.7 c
		2.5	53.2 fg	66.1 ef	—	—
M 7	control untreated		9.0 a	42.8 cd	26.1 ab	60.8 abc
	copper sulphate	1.5-2.0%	73.7 i	84.6 g	64.3 d	83.2 d
		2.5	44.1 de	68.9 ef	—	—

Explanations as in Table 2. *In 1970 copper sulphate was used in a concentration of 1.5% and in 1971 in a concentration of 2.0%.

in the two years of the experiment. The probable reason for that was that the growth of trees budded on 'Antonovka' was very weak in the second year of the experiments for same unknown reason. The trees which responded most to the defoliant were those propagated on dwarfing rootstock M7. The concentration of 2.5% CuSO_4 was too high for 'Jonathan' trees grown on vegetative rootstock. It caused dessication of leaves and many of them remained on the trees after drying up. Better defoliation was obtained with 1.5% CuSO_4 .

The type of rootstock also modified the influence of defoliants on frost resistance of defoliated trees. In both years trees propagated on M7 showed the highest winter hardiness (Tables 6, 7). Hand defoliation carried out at the end of September had no influence on winter hardiness of trees grown on M11, MM106 and M7. However, it decreased the winter hardiness of trees grown on vigorous rootstock such as 'Antonovka' and 'Alnarp 2'.

Table 6

Percent of diffusion of electrolytes from shoots of one-year-old 'Jonathan' trees propagated on different rootstock after freezing them at -35°C . First year experiment (1969/70)

Rootstock	Control untreated	Hand defoliated on Sept. 28	Hand defoliated on Oct. 7	Copper sulphate 1.5% applied on Sept. 28
'Antonovka' seedlings	57.9 abcd	77.6 fg	61.0 abcd	81.9 g
M 11	50.1 ab	55.6 abc	51.8 ab	66.6 cdef
'Alnarp 2'	48.4 a	68.7 def	61.5 bcde	80.3 g
MM 106	54.9 abc	50.3 ab	56.4 abc	72.9 cefg
M 7	52.0 ab	54.7 abc	55.7 abc	53.9 ab

Values designated with the same letter do not differ at $P = 0.05$.

Table 7

Percentual diffusion of electrolytes from shoots of one-year-old 'Jonathan' trees propagated on different rootstock. Second year experiment (1970/71)

Rootstock	Shoots taken from the field and not frozen in laboratory		Shoots frozen in laboratory to -35°C	
	control untreated	copper sulphate 2% applied on Sept. 25	control untreated	copper sulphate 2% applied on Sept. 25
'Antonovka' seedlings	23.9 a	24.7 a	55.9 d	74.3 f
'Alnarp 2'	31.5 b	30.7 b	57.8 d	65.3 e
MM 106	24.9 a	23.2 a	63.3 e	59.0 d
M 7	25.4 a	21.4 a	50.6 c	56.0 d

Explanations as in Table 6.

DISCUSSION

Comparison of the results of this experiment with earlier ones (Basak et al., 1973a, b, Basak and Jankiewicz 1976a, b; Czynczyk et al., 1977) shows that apple rootstocks are more difficult to defoliate than one-year-old scions of this species. The rather weak response of rootstocks to defoliant is probably caused by their long period of growth and more juvenile character. Plants of *Malus robusta* with a shorter period of growth were defoliated easier than plants of M7 which grew longer. On the other hand, vegetatively propagated M26 rootstocks were more difficult to defoliate and more susceptible to defoliant injuries than 'Antonovka' seedlings.

Among the investigated inorganic defoliant only magnesium chlorate caused satisfactory defoliation of two types of apple rootstocks *Malus robusta* and 'Antonovka' seedlings. The other two compounds — copper sulphate and potassium iodide — were less effective in defoliating them, although these compounds were effective in defoliation of one or two-year-old apple scions of several cultivars (Basak et al., 1973a). All investigated inorganic compounds defoliated rather the upper part of plants, while the lower part did not show any symptoms of browning or drying up. The low rate of defoliation of rootstocks also seems to depend on the way of spraying the trees (Ebettulayev, 1968). The small size of the plants, dense foliage and dense spacing makes it difficult to cover all the leaves exactly with the defoliant. As shown by Marczyński and Jankiewicz (1978a) defoliant KI was easily transported within the leaf but not outside it, to the stem.

In these experiments as in earlier ones (Basak et al., 1973a) inorganic defoliant applied early (mid September) decreased winter hardiness of the rootstocks. However, when the defoliant was applied at the end of September, only KI used in higher concentration significantly decreased winter hardiness of the rootstocks. The decrease of winter hardiness due to some defoliant seems to be related to anatomical changes occurring in the shoots (Basak and Jankiewicz, 1976b) and to the shortened period in which the leaves can produce the substances responsible for induction of frost resistance (Fuchigami et al., 1971). Among organic defoliant the preparation N252 effectively defoliated *Malus robusta* plants. Its optimal concentration seems to be 0.15%. Plants defoliated with N252 lost enough leaves to be dug up 2-3 weeks after treatment. For some nurserymen such a period is, however, still too long. Also Knight (1979) reports that this compound seems to be a good defoliant, but the period from its application to defoliation is long. Leaves sprayed with N252 remained green even after becoming dry. Browning occurred later. The first leaves fell 4 days after spraying — these were the leaves attached to the shoot tip. Such a manner of defoliation is typical for dessicants. When an optimal concentration was used no shoot or bark injury occurred. Neither was there any

evidence of change in winter hardiness of shoots. In our experiments addition of ethephon to N252 did not increase its efficiency.

Rootstocks were defoliated by ethephon faster than by inorganic defoliant. The same was observed with scions (Basak et al., 1976; Czynczyk et al., 1977). The preparation CKB 1131 (ethephon preparation produced in GDR) behaved in a similar manner. Both compounds did not induce shoot injury but when used in 4000 mg/l (of ethephon) concentration decreased winter hardiness of the rootstocks. This seems to be the limiting factor in practical use of preparations of ethephon.

It should also be considered that the effectiveness of ethephon depends on the weather at the time of application. The mixture of ethephon and copper sulphate, both used in low concentrations defoliated the rootstocks well and did not decrease their winter hardiness. Such a mixture seems to be useful for defoliation of apple seedlings. From previous work it is known that such a mixture has no influence on further flowering and growth of the trees after defoliation. In contrast ethephon alone used in concentration optimal for defoliation inhibited drastically growth and caused premature flowering.

It is known that auxin transport in plants is limited by morphactin (Krelle and Libbert, 1968). Morgan and Durham (1972) have shown that this property of morphactin may be used to increase the defoliating action of ethephon. Their results were supported by our experiments. *Malus robusta* plants sprayed with a mixture of morphactin and ethephon showed yellowing and shedding of the leaves which started at the base of the shoots and spread upwards. The effectiveness of this mixture in defoliating apple rootstock was not high. The leaves in the upper parts of the shoots did not change their color and did not fall. Perhaps higher concentrations could be advised for future experiments.

Although morphactin with ethephon did not decrease winter hardiness of the rootstocks it is not known whether these substances at higher concentrations would not influence the plants. Morphactin in the concentration used in this experiment did not improve the defoliating activity of the mixture of ethephon with copper sulphate. It is probable that apple rootstocks grown in central Poland requires higher concentrations of morphactin and ethephon for defoliation than the concentrations used for promotion of cherry fruit abscission (Liebster, 1974).

Our results obtained with defoliation of *Malus robusta* plants with a mixture of ethephon and GA₃ did not support the results of Morgan and Durham (1975). In our conditions GA₃ had no effect on defoliation. Thus, the phenomenon observed by Morgan and Durham seems limited to only some species of plants. Neither did GA₃ increase the winter hardiness of plants.

It was found that defoliation of 'Jonathan' scions depends on the rootstock type. Better defoliation of one-year-old 'Jonathan' plants was obtained on vegetative rootstocks. This was particularly evident with trees on the dwarfing

rootstock M7. This phenomenon seems to be related to the early accomplishment of growth by this rootstocks. The relationship between winter hardiness and the type of rootstock used for a given scion requires elucidation. In both years of the experiment, defoliated 'Jonathan' trees showed highest winter hardiness when grafted on M7.

The present experiment shows that rootstocks can be effectively defoliated with some defoliant or their mixtures. When the defoliant were applied in late September they did not influence markedly the frost resistance of the rootstocks. Since the factor inducing frost resistance in shoots is generated in leaves, it seems obvious that later defoliation and the application of rapidly acting defoliant like N252 or a mixture of ethephon with CuSO_4 may be most promising for future experiments. In other words we should try to prolong as much as possible the period in which uninjured leaves can induce the ability for cold acclimation in shoots and roots. However, even with the best defoliant used in this experiment the optimal time for the defoliant treatment seems to be: the last days of September or first days of October and the time of digging out — about 3 weeks later, (around 17-22 October). Defoliant used later would probably be more effective since their action is markedly increased at low positive temperature (Marczyński and Jankiewicz, 1978b). It might be worthwhile to delay digging out of the trees for some days in relation to the present practice (digging starts in Poland on October 15th), this would enable the application of defoliant. On the other hand frost-susceptible cultivars like 'Jonathan' should probably not be chemically defoliated or the date of their defoliation should be still further delayed. It would also be advisable to synthesize defoliant which do not interfere or only slightly interfere with the production and export from leaves of the factor inducing frost resistance, up to the time close to leaf shedding. It is not known whether N252 has such properties. This should be tested in further experiments.

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Chemiczna defoliacja podkładek i wpływ typu podkładki na defoliację drzewek jabłoni odmiany 'Jonathan'

Streszczenie

Dla defoliacji podkładek jabłoni, celem zastąpienia ręcznego usuwania liści przed ich wykopaniem, zastosowano następujące środki: KJ, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{Mg}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$, etefon (w formie preparatów Ethrel lub CKB 1131) a także preparat N252, oraz mieszaniny: etefonu z siarczanem miedzi, morfaktyny (EMD) z etefonem, EMD z etefonem i siarczanem miedzi oraz etefonu z kwasem giberelinowym (GA_3). Spośród zastosowanych nieorganicznych defoliantów tylko chłórzan magnezu defoliował w sposób zadowalający podkładki jabłoni. Związek ten, zastosowany w końcu września, nie obniżał mrozoodporności podkładek. Preparat Ethrel, oraz preparat CKB 1131,

powodowały zadowalającą defoliację, lecz gdy były użyte w stężeniu optymalnym z punktu widzenia defoliacji, powodowały obniżenie mrozoodporności roślin. Mieszanina etefonu z siarczanem miedzi, w której oba składniki występowały w niskim stężeniu, również skutecznie defoliowała rośliny i nie obniżała ich mrozoodporności. Etefon w niskim stężeniu, zmieszany z EMD, powodował tylko częściową defoliację podkładek. Dodatek GA_3 do etefonu nie zwiększał jego skuteczności. Preparat N252 w stężeniu 0,15% skutecznie defoliował podkładki i nie powodował obniżenia ich mrozoodporności w warunkach tego doświadczenia. Siarczan miedzi defoliował w różnym stopniu jednoroczne drzewka odmiany 'Jonathan' w zależności od zastosowanej podkładki.