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INFLUENCE OF ROOTSTOCK, CULTIVAR AND ERGOPLANT BIOSTIMULANT ON THE GROWTH OF MAIDEN PEAR TREES IN NURSERY AND PHYSIOLOGICAL COMPATIBILITY

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Abstract. Environmental protection imposes strict limitations in using fertilizers and plant protection products. This is why there is a need for research on using plant products in horticultural production. In the experiment conducted in the years 2009–2012 the influence of spraying of maiden pear trees with ERGOPLANT biostimulant was estimated. Growth of 'Isolda', 'Conference' and 'Uta' maiden pear trees budded on two types of quince rootstock S1 and MA was compared. The application of biostimulant ERGOPLANT increased significantly growth of maiden pear trees and their compatibility with the Polish Norm. The examined rootstocks influenced significantly number of roots of maiden pear trees. The biggest diameter and the best quality of maiden pear trees was obtained for 'Uta'. Maiden leaves of this cultivar had also a higher content of chlorophyll compared with the two remaining cultivars. In cross sections of anatomic connections of 'Isolda' or 'Uta', with quince rootstocks especially with MA, the presence of a layer of necrotic cells was observed.

Key words: maiden pear tree, type of quince, cultivars, spraying treatments, cross sections of graft union, chlorophyll content

INTRODUCTION

A positive influence of foliar fertilization of maiden apple and pear trees was found by many researchers [Delap 1967, Cheng et al. 2001, Neilsen et al. 2001, Cheng and Fuchigami 2002]. However, not all of them [Lananskas et al. 2006, Wójcik and Popińska 2009] obtained positive effects of this form of fertilization on the growth of plants.

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The care about environment protection and a big competition among producers makes them use much limited amount of fertilizers and plant protection products. A lot of studies have been undertaken both at home and in the world. Their goal was an application of environmentally safe plant preparations in horticultural production. Used so far plant products e.g. fermented fruit extract [Russo 2001], seaweed extract [Temple and Bomie 1989, Wiens and Reynolds 2008] to improve the growth and yielding of different plants. Not always, however, it brought uniform positive results [McHugh and Lawrence 2003, Masny et al. 2004, Michalski 2004, Wociór et al. 2004, Fornes et al. 2005, Basak 2008, Basak and Mikos-Bielak 2008, Błaszczyk 2008, Krawiec 2008, Krok and Wieniarska 2008, Wrona and Misiura 2008, Marjańska-Cichoń and Sapieha-Waszkiewicz 2011].

Due to high price of pear fruits there has been an evident increase in producers' interest in those trees production. Maiden pear trees that grow especially on dwarf rootstocks in a nursery do not grow too vigorously and they ramify very weakly [Lewko et al. 2007, Milosević and Milosević 2010, Świerczyński 2011]. Therefore there is a need for methods of stimulating their growth, and non-chemical preparations are considered as the most suitable nowadays.

A very serious problem in pear trees production on quince rootstocks is a possibility of the occurrence of physiological incompatibility and sensitivity to chlorosis. It was proved that a potential physiological incompatibility and sensitivity to chlorosis can be confirmed with a test checking the content of chlorophyll in maiden trees leaves. [De La Guardia and Alcantara 2002, Morales et al. 1994, Dolcet-Sanjuan et al. 2004, Zlati et al. 2007]. Also an anatomic cross section of the place of the connection of these two components of a pear tree can confirm or eliminate such a possibility [Gur et al. 1978, Ermel et al. 1997, Świerczyński and Stachowiak 2012]

The aim of these studies was to estimate the influence of ERGOPLANT biostimulant, three cultivars of pear and two types of quince on the growth of maiden pear trees in a nursery and physiological compatibility.

MATERIAL AND METHODS

The studies were carried out at the Agricultural Experimental Station of Baranowo (N 52º28' E 16º52'), related to Poznań University of Life Sciences, in the years 2009–2012. The experiment was set up in a randomized block design, with four replications and 50 rootstocks per one plot. All the planted rootstocks had a diameter of 7–8 mm. The experiment was located on a grey-brown padstolic soil. The soil, on which the rootstocks were planted had a high content of mineral elements and pH 6.9, its water holding capacity was medium. Every time the nursery was set up on a new site, where in a preceding year white mustard (*Sinapsis alba*) had been grown and ploughed down for green manure. In the nursery three pear cultivars, 'Isolda', 'Conference' and 'Uta' on two quince rootstock MA and S1 were studied. The rootstocks were budded with "T" method at the height of 10 cm above the ground in the last days of July in years 2009–2011. Maiden pear trees were sprayed with the ERGOPLANT plant preparation, containing only fermented extract from small nettle (*Urtica urens*) produced by 'Biorama

Italia'. Treatments were repeated five times at two-week intervals with 1% solution of ERGOPLANT every time. For the first time the maiden trees were sprayed in the middle of May, when they were about 20 cm high. For each spray a wetting agent Adpros 850 SL (5 $ml \cdot l^{-1}$) was added. The control maiden pear trees were sprayed with a water solution of Adpros only. Protection for pests and diseases and general plant management was carried out in accordance with the latest recommendations for a pome fruit tree nursery. The plots were not irrigated. During this research no herbicides were use; the nursery was mechanically and, if needed, manually weeded. Nitrogen fertilizer was applied three times in a cumulative dose of 90 kg $N \cdot ha^{-1}$. At the end of November, all obtained maiden pear trees were measured. Height of trees and their diameter of the height of 20 cm above the ground, as well as the length of lateral shoots was recorded. The number of roots was also determined. The percentage compatibility of maiden pear trees with the norm was calculated based on Polish Norm included in (Dz. U. 59, ann 9, item 565).

In order to ascertain a potential physiological incompatibility between the examined rootstocks and pear cultivars a content of chlorophyll a + b in a fresh mass of leaves was carried out using extraction method with dimethyl sulphoxide [Shoaf and Lium 1976, Hiscox and Israelstam 1978].

Additionally, cross sections of graft union of pear cultivars with particular quince rootstocks were examined. They were conducted using a method described by Gerlach [1972].

The statistical analysis of the obtained data was carried out employing STAT program, with the application of three-factorial analysis of variance. For mean separatio the Duncan's test, with confidence level $\alpha = 0.05$. Results shown in tables are mean values of three years of studies.

RESULTS AND DISCUSSION

Use of ERGOPLANT biostimulant had positive influence on the studied parameters of growth. Significantly higher maiden pear trees were obtained with the use of this preparation (tab. 1). 'Uta' and 'Conference' maiden trees on S1 rootstock showed the most beneficial effect of ERGOPLANT. On the average, the highest maiden pear trees were found for 'Uta' and the lowest for 'Conference' budded on S1 rootstock. The average height of trees for quince rootstocks S1 and MA did not differ. Independently from the rootstock 'Isolda' and 'Uta' maiden pear trees were higher than 'Conference'. It was noticed that there was a significant cooperation between the rootstock and the cultivar as well as between the rootstock and treatment of the maiden trees with ERGOPLANT biostimulant (tab. 1).

The diameter of maiden pear trees stem depended on the cultivar and the use of ERGOPLANT preparation (tab. 2). Almost always after the spraying treatments with ERGOPLANT preparation a significantly bigger diameter of maiden pear trees was obtained. Also Russo [2001] reported an increase in height of 21% and in the diameter of plants of 29% after the use of an extract from fermented fruit. In the present experiment such a big impact of foliar fertilization on the growth of maiden pear trees was not

Table 1. The effect of rootstock, cultivar and spraying treatment with biostimulant ERGOPLANT on the height of maiden pear trees (cm)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	147.3 f	136.2 d	141.8 c	140.9 b	
	Conference	125.8 bc	112.3 a	119.0 a		135.5 a
	Uta	152.8 g	138.5 de	145.7 d	122.0 a	
Quince MA	Isolda	145.7 f	134.4 d	140.5 c		
	Conference	128.0 c	121.7 b	124.8 b	142.2 b	134.7 a
	Uta	143.1 ef	134.4 d	138.7 c		
Mean for treatments		140.4 b	129.7 a			

Factor A (rootstocks) – 1.96
Factor B (cultivars) – 385.46
Factor C (treatments) – 265.71
Interaction A × B – 30.58
Interaction A × C – 9.92
Interactioin B × C – 0.54
Interaction A × B × C – 2.84

Means followed by the same letters are not significantly different at the level of α = 0.05. Means indicated in columns 3 and 4 were compared vertically and horizontally. Means indicated in columns from 5 to 7 were compared vertically and in 7 rows horizontally.

observed. However, in considered experiment the trees grew in good soil and climate conditions and smaller differences between the trees treated or not treated with spraying may result from these factors. The diameter of trees for 'Isolda' and 'Uta' obtained on quince S1 rootstock was higher than on quince MA but for 'Conference' an inverse relation was reported. Independently from the rootstock maiden pear trees of 'Uta' had the highest diameter. Data for 'Uta' on MA rootstock indicate the highest benefit of ERGOPLANT treatment for the tree diameter. The used rootstock did not significantly affect the average value of this parameter of growth. Also Fischer [2005] did not find any difference in height and diameter of two-year-old maiden pear trees of 'Conference' budded on S1 and MA quince rootstock. Similarly Lewko et al. [2007] obtained the same diameter of one-year-old maiden pear trees of 'Conference' grafted on these two types of quince. Compared results of this experiment with the results from Kobělușa et al. [2007] experiment much higher maiden pear trees of 'Conference' growing on quince S1 and MA rootstocks also with a bigger diameter were obtained. However, these diameters were smaller compared with the results of Lewko et al. [2007]. Variance analysis showed a significant cooperation between the rootstock and cultivar (tab. 2).

Both the ERGOPLANT preparation as well as the budded cultivar had a significant influence on the cumulative length of lateral shoots (tab. 3). On the average, maiden pear trees were characterized with a doubled sum of lengths of lateral shoots after the spraying with ERGOPLANT preparation. Exceptionally beneficial influence of 'EGROPLANT' preparation was noticed for pear trees cultivars budded on MA quince

Table 2. The effect of rootstock, cultivar and spraying treatment with biostimulant ERGOPLANT preparation on the diameter of maiden pear trees (mm)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	13.3 c	12.5 b	12.9 c	12.5 a	13.1 a
	Conference	11.6 a	11.3 a	11.5 a		
	Uta	15.3 e	14.3 d	14.8 e	12.3 a	
Quince MA	Isolda	12.6 b	11.5 a	12.0 b		13.1 a
	Conference	13.5 c	12.6 b	13.1 c	14.5 b	
	Uta	14,8 e	13.5 c	14.2 d		
Mean for treatments		13.5 b	12.6 a			

Factor A (rootstocks) – 0.01
Factor B (cultivars) – 18.00
Factor C (treatments) – 7.29
Interaction A × B – 5.55
Interaction A × C – 0.36
Interactioin B × C – 0.23
Interaction A × B × C – 0.02

For explanation, see table 1

Table 3. The effect of rootstock, cultivar and spraying treatment with biostimulant ERGOPLANT on the cumulative length of lateral shoots of maiden pear trees (cm)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	24.0 a–c	9.6 a	16.8 a	21.4 a	44.4 a
	Conference	131.8 h	64.3 f	98.0 d		
	Uta	19.7 ab	17.1 ab	18.4 a	89.2 b	
Quince MA	Isolda	37.0 cd	15.0 ab	26.0 a		48.3 a
	Conference	112.5 g	48.0 de	80.3 c	28.6 a	
	Uta	52.1 ef	25.5 bc	38.8 b		
Mean for treatments		62.8 b	29.9 a			

Factor A (rootstocks) – 34.81
Factor B (cultivars) – 4154.10
Factor C (treatments) – 2440.36
Interaction A × B – 289.21
Interaction A × C – 51.12
Interactioin B × C – 617.47
Interaction A × B × C – 34.70

For explanation, see table 1

rootstock. Significantly the highest value of this parameter of growth was obtained for 'Conference' as compared to the two other cultivars on the two considered rootstock. Lewko et al. [2007] obtained similar results of the cumulative length of lateral shoots of 'Conference' on two tested types of quince The average cumulative value for different types of quince did not differ significantly. Also studies conducted by Milosević and Milosević [2010] confirmed that the type of quince did not affect this parameter but budded cultivars influenced branching of maiden pear trees. It was also confirmed in case of maiden apple trees [Poniedziałek et al. 1997, Wociór et al. 1998, Stachowiak and Świerczyński 2011]. Opposite opinion has Lipecki [1994]. It is evident that for the lateral shoots the benefit of ERGOPLANT use was the most pronounced for 'Conference' on both MA and S1 rootstocks. Variance analysis showed a very significant influence of all examined factors on one another (tab. 3).

The number of maiden pear trees' roots depended on all considered factors (tab. 4). The use of ERGOPLANT preparation increased significantly the number of roots of maiden pear trees. Only in case of 'Isolda' there was no significant influence of the biostimulant on the number of roots. Maiden trees of 'Conference' growing on two types of quince had the biggest number of roots. All cultivars of pear trees budded on S1 quince were characterized with a bigger number of roots. Also the average value for this rootstock was higher. In case of this growth parameter there was no significant affect of the examined factors (tab. 4).

Table 4. The effect of rootstock, cultivar and spraying treatment with biostimulant ERGOPLANT on the number of roots of maiden pear trees

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	16. 4 f	16.0 ef	16.2 d	16.0 b	16.6 b
	Conference	18. 6 i	18.0 h	18.3 f		
	Uta	15.5 c	14.8 b	15.2 b	17.8 c	
Quince MA	Isolda	16.0 de	15.6 cd	15.8 c		15.8 a
	Conference	17.5 g	17.1 g	17.3 e	14.7 a	
	Uta	14.8 b	13.8 a	14.3 a		
Mean for treatments		16.5 b	15.9 a			

Factor A (rootstocks) – 5.06
Factor B (cultivars) – 28.64
Factor C (treatments) – 3.06
Interaction A × B – 0.29
Interaction A × C – 0.00
Interactioin B × C – 0.17
Interaction A × B × C – 0.05

For explanation, see table 1

The use of ERGOPLANT preparation does not increase significantly the percentage of compatibility of maiden pear trees with the standard (tab. 5). Only in case of the maiden trees of 'Conference' budded on S1 rootstock a positive influence of the biostimulant was noticed. The best compatibility with the standard was obtained for 'Uta' grafted on two considered rootstocks and the worst for 'Conference' on quince S1 rootstock. The rootstock did not influence the compatibility of maiden pear trees with the norm. Variance analysis showed a significant cooperation between the rootstock and cultivar (tab. 5).

Table 5. The effect of rootstock, cultivar and spraying treatment with biostimulant ERGOPLANT on the compatibility with standard of maiden pear trees (%)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	93.0 de	91.3 cd	92.1 bc	91.7 a	92.4 a
	Conference	89.0 b	86.5 a	87.8 a		
	Uta	96.2 f	95.8 f	96.0 d	89.4 a	
Quince MA	Isolda	91.7 cd	90.8 bc	91.3 b		91.8 a
	Conference	91.5 cd	90.4 bc	91.0 b	94.5 b	
	Uta	93.7 e	92.2 c–e	93.0 c		
Mean for treatments		92.7 b	91.4 a			

Factor A (rootstocks) – 0.77
Factor B (cultivars) – 19.13
Factor C (treatments) – 3.50
Interaction A × B – 7.26
Interaction A × C – 0.04
Interactioin B × C – 0.03
Interaction A × B × C – 0.22

For explanation, see table 1

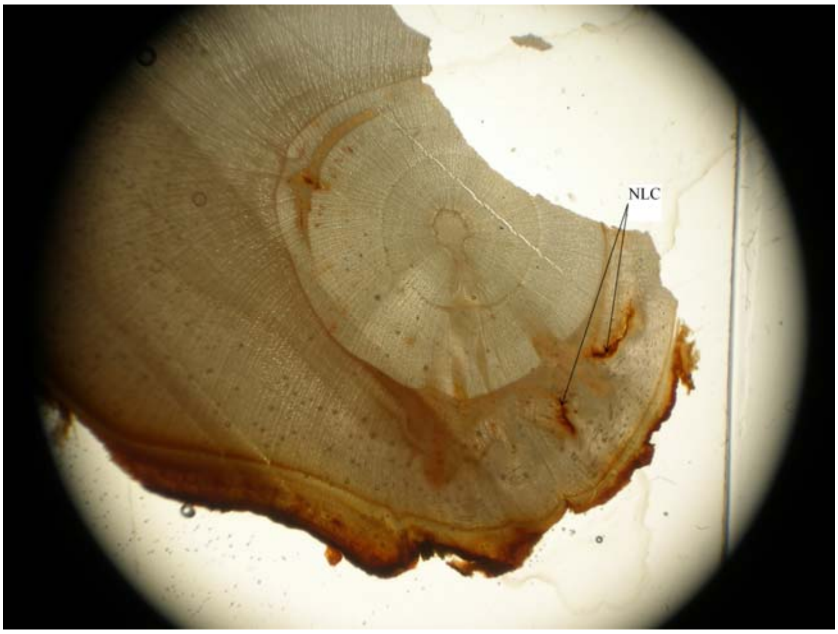
Table 6. The effect of rootstock and spraying treatment with biostimulant ERGOPLANT on the obtained maiden pear trees (%)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	74.9 d	72.4 c	73.7 c	68.7 a	77.7 b
	Conference	84.2 f	82.9 e	83.6 f		
	Uta	75.8 d	74.8 d	75.3 d	82.7 c	
Quince MA	Isolda	64.5 b	62.5 a	63.5 a		72.6 a
	Conference	81.6 e	81.9 e	81.8 e	73.4 b	
	Uta	72.0 c	71.1 c	71.5 b		
Mean for treatments		75.8 b	74.6 a			

Factor A (rootstocks) – 339.60
Factor B (cultivars) – 923.60
Factor C (treatments) – 19.93
Interaction A × B – 67.63
Interaction A × C – 2.47
Interactioin B × C – 2.70
Interaction A × B × C – 0.80

For explanation, see table 1

Phot. 1. The anatomical section of rootstock MA quince and ‘Conference’ connection (magnification 20×, phot. I. Świerczyńska)



Phot. 2. The anatomical section of rootstock MA quince and ‘Isolda’ connection (indicated by arrows – necrotic layer of cells), (magnification 20×, phot. I. Świerczyńska)

Table 7. The effect of rootstock and spraying treatment with biostimulant ERGOPLANT on the chlorophyll content in fresh mass of maiden pear trees leaves (%)

Rootstock	Cultivar	Treatments		Mean for rootstock × cultivar	Mean for cultivar	Mean for rootstock
		ERGOPLANT	control			
Quince S1	Isolda	2.00 a	1.93 a	1.96 a	1.99 a	2.04 a
	Conference	1.95 a	1.89 a	1.92 a		
	Uta	2.25 b	2.22 b	2.23 b	1.95 a	
Quince MA	Isolda	2.01 a	2.02 a	2.02 a		2.01 a
	Conference	1.99 a	1.97 a	1.98 a	2.20 b	
	Uta	2.18 ab	2.16 ab	2.17 ab		
Mean for treatments		2.06 a	2.03 a			

For explanation, see table 1

In the conducted experiment significantly better results of growth of maiden pear trees were obtained after the foliar fertilization with the use of ERGOPLANT preparation. This preparation especially increased the cumulative length of lateral shoots by over 100%. Also experiments of Temple and Bomie [1989] and Wiens and Reynolds [2008] confirmed the usefulness of some foliar fertilization with the other plant preparations. On the other hand the studies conducted by McHugh and Lawrence [2003] and Masny et al. [2004] did not give uniform results. However the mentioned authors examined different species of orchard plants, hence it is very difficult to draw unambiguous conclusions.

Percentage number of the obtained maiden trees compared with the number of budded rootstocks differed depending on examined factors (tab. 6). The influence of ERGOPLANT was not unambiguous. In case of half of the cultivar-rootstock combinations this influence was significant, contrary to the other half. However, a better mean value was obtained for combination with ERGOPLANT. The best efficiency of maiden trees was observed for 'Conference' budded on two examined rootstocks, the worst for 'Isolda' growing on MA quince rootstock. The efficiency of maiden trees growing on S1 quince rootstock was significantly better than of the ones growing on MA quince rootstock. In case of percentage number of obtained maiden trees it was observed a very significant cooperation between the rootstock and cultivar (tab. 6).

The chlorophyll content in fresh mass of the leaves of maiden pear trees depended solely on the budded cultivar of pear trees (tab. 7). 'Uta' had a higher content of chlorophyll in leaves, compared with the two remaining cultivars, which was influenced by a stronger growth. That supports the opinion expressed by Martin et al. [1997]. A similar content of chlorophyll in the leaves of 'Conference' pear trees growing on quince rootstock MA (2.0%) was found by Dolcet-Senjuan et al. [1992].

The most frequent symptom of incompatibility between a pear tree cultivar and a quince rootstock is the occurrence of a layer of necrotic cells [Gur et al. 1978, Ermel et al. 1997]. On the basis of taken photos of cross sections of anatomic connections of the rootstock and the cultivar it was found that 'Conference' was characterized by lack of incompatibility symptoms with the two examined quince types (phot. 1). However, in cross sections of anatomic connections of 'Isolda', especially with MA quince rootstock, the presence of a layer of necrotic cells was observed (phot. 2). It can suggest a difficulty in symphysis of those quite newly grown pear tree cultivars with quince rootstocks, which shows up already in a nursery.

CONCLUSIONS

1. Not always the use of ERGOPLANT preparation influenced significantly the growth of maiden pear trees. This preparation especially raised the cumulative length of lateral shoots.
2. Maiden pear trees obtained on S1 quince rootstocks had a higher number of roots than on rootstock MA. The rootstocks' effect on the other studied features was not significant.
3. Maiden pear trees of 'Uta' were characterized with the highest diameter, but they had the smallest number of roots. Maiden trees of 'Conference' had both the highest cumulative length of lateral shoots and number of roots.
4. Microscopic pictures of cross sections of anatomic connections of 'Isolda' and 'Uta' with a quince rootstocks confirmed a problem of physiological compatibility of these trees' components.

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WPŁYW PODKŁADKI, ODMIANY I BIOSTYMULATORA ERGOPLANT NA WZROST OKULANTÓW GRUSZY W SZKÓŁCE I ZGODNOŚĆ FIZJOLOGICZNĄ

Streszczenie. Ochrona środowiska przyrodniczego wymusza ograniczenie zużycia nawozów i środków ochrony roślin, stąd konieczność prowadzenia badań nad stosowaniem preparatów roślinnych w produkcji ogrodniczej. W doświadczeniu przeprowadzonym w latach 2009–2012 oceniano wpływ zabiegu opryskiwania okulantów gruszy biostymulatorem ERGOPLANT. Porównywano wzrost okulantów trzech odmian gruszy: Isolda, Konferencja i Uta okulizowanych na dwóch typach pigwy: S1 i MA. Zastosowanie biostymulatora ERGOPLANT zwiększyło istotnie wzrost okulantów gruszy i ich zgodność z Polską Normą. Badane podkładki wpływały istotnie na liczbę korzeni drzewek gruszy. Największą średnicę okulantów i najlepszą ich jakość uzyskano dla odmiany Uta. Również liście okulantów tej odmiany miały większą zawartość chlorofilu w porównaniu z dwoma pozostałymi odmianami. W przekrojach anatomicznych połączeń odmian Isolda i Uta, szczególnie z podkładką pigwy MA, zaobserwowano obecność warstwy komórek nekrotycznych.

Słowa kluczowe: okulant gruszy, typy pigwy, odmiany, zabiegi opryskiwania, przekrój poprzeczny połączenia zrazu, zawartość chlorofilu

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