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EFFECT OF SOIL FATIGUE ON FROST RESISTANCE OF ONE-YEAR OLD APPLE-TREE SHOOTS, TOPAZ CULTIVAR

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Abstract. The presented studies have shown the effect of soil fatigue on the decrease of resistance to low temperatures in one-year old apple-tree shoots. The highest frost resistance was demonstrated by the shoots of apple-trees grown in localities so far not utilized for fruit-tree cultivation.In a replanted apple-tree orchard, the plantation of trees in the grass inter-rows of the old apple orchard did not cause any explicit increase of frost resistance by the apple-tree shoots.

Key words: replantation disease, frost resistance, conductometric method, one-year old apple-tree shoots

INTRODUCTION

A characteristic feature of modern fruit-tree cultivation is a frequent change of the species composition or the mono-species culture. Such necessity results from the intention of fruit growers to adjust their production to the changing demands of the market. In case of frequent changes in the plantation. it may happen that some species are grown in the same place where they were grown earlier. In such situation, a phenomenon may appear which is known as 'soil fatigue' which is demonstrated by the replantation disease [Rebandel 1987, Pacholak et al. 1995, Aldea 1998]. Several authors call attention to the fact that replanted plants experience difficulties in getting adjusted to the habitat conditions showing in result worse growth parameters in comparison with plants grown in localities not used for fruit-tree growing earlier, i.e. on the so called 'virgin soil' [Mai and Abawi 1978, Sewell and Preece 1988].

The objective of the presented work was the analysis of the effect of soil fatigue on the resistance of one-year old apple-tree shoots to low temperatures.

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MATERIAL AND METHODS

Materials for studying: one-year old apple-tree shoots of Topaz cultivar, were taken from an orchard established on the area of experimental farm in Przybroda belonging to the Fruit-Growing Department of Agricultural University in Poznań. Shoots were taken from trees grown in three types of localities (combinations):

– 'virgin soil' – soil not used earlier for fruit-tree growing (control),

– replanted locality – new trees were planted directly in the rows of the old trees,

– replanted locality – new trees were planted in the grass inter-rows of the previous apple-tree orchard.

One-year old shoots with similar diameters and lengths were taken from trees directly before frost treatment. The resistance to frost was estimated in three terms: in December, January and February. The first frost treatment was carried out in the second decade of December, the remaining frost treatments were done in one month intervals.

Shoots were frost-treated in laboratory conditions at the temperatures of: -20°C, -25°C, -30°C and -35°C. Temperature drop in the refrigerators occurred at the rate of 5°C per one hour until the required temperature was reached. After a 2 hrs exposure to the given temperature, the shoots were gradually defreezed maintaining the same rate, i.e. 5°C decrease per one hour.

Resistance of shoots to frost was determined by the conductometric method consisting in the measurement of electrolytes diffusion from tissues subjected to the action of low temperatures [Pieniążek and Wiśniewski 1961]. The calculated percent of electrolytes diffusion was transferred to the coordinate system which permitted to determine the critical temperature (T_{50})whose transgression destroys over 50% of cells and the plant looses its ability to regenerate [Hołubowicz and Pacholak 1973].

RESULTS

The critical temperature which causes the outflow of electrolytes from over 50% of tissues of one-year old shoots oscillated between -30 and -35°C in the months of December and January. In February, it oscillated between -25 and -30°C (tab. 1–3). Statistical analysis of the amount of electrolytes flowing out from the shoot cells damaged by the action of low temperatures indicated a significant differentiation depending on the combination. In each term of the frost resistance studies, independent of the applied frost-treatment temperatures, from the damaged apple-tree shoots grown on areas not utilized so far for fruit-tree cultivation (control), the outflow of electrolytes was significantly smaller than from trees grown in replanted localities. The differences were particularly visible in December (tab. 1) and at the freezing temperature of -20°C (tab. 2 and 3).

Results of our studies indicateed only a small effect of the locality in the combinations with replantations on the degree of tree shoots damage by low temperature. From the three terms in which the resistance to frost was studied, only in the December term, significantly greater electrolytes outflow was found to ooze out from the tissues of tree shoots planted directly in the rows of the old trees (replantation – tree rows) in compari-

Table 1. Mean percentage (from the years 2006 and 2007) of electrolytes outflow from one-year old shoots of apple-trees, Topaz cultivar, caused by damages done by low temperatures in December

Tabela 1. Średni z lat 2006 i 2007 procent wycieku elektrolitu z tkanek jednorocznych pędów jabłoni odmiany Topaz na skutek uszkodzeń przez niskie temperatury w miesiącu grudniu

Combinations Kombinacje	Frost-treatment temperatures, °C Temperatury mrożenia, ºC			
	-20	-25	-30	-35
Control Kontrola	19.50 a	27.82 a	38.13 a	49.57 a
Replantation – row of trees Replantacja – rząd drzew	22.20 b	33.85 b	43.83 c	54.7 c
Replantation – grass inter-row Replantacja – rząd murawy	21.61 b	28.78 a	40.47 b	51.9 b
LSD – NIR	1.68	2.04	1.89	1.73

Table 2. Mean percentage (from the years 2006 and 2007) of electrolytes outflow from one-year old shoots of apple-trees, Topaz cultivar, caused by damages done by low temperatures in January

Tabela 2. Średni z lat 2007 i 2008 procent wycieku elektrolitu z tkanek jednorocznych pędów jabłoni odmiany Topaz na skutek uszkodzeń przez niskie temperatury w miesiącu styczniu

Combinations Kombinacje	Frost-treatment temperatures, °C Temperatury mrożenia, ºC			
	-20	-25	-30	-35
Control Kontrola	20.40 a	30.10 a	44.76 a	53.63 a
Replantation – row of trees Replantacja – rząd drzew	21.96 b	32.72 b	45.90 b	53.075 a
Replantation – grass inter-row Replantacja – rząd murawy	22.01 c	32.75 b	46.57 b	53.93 a
LSD – NIR	0.18	2.48	1.18	3.29

Table 3. Mean percentage (from the years 2006 and 2007) of electrolytes outflow from one-year old apple-tree shoots of Topaz cultivar, caused by damages done by low temperatures in February

Tabela 3. Średni z lat 2007 i 2008 procent wycieku elektrolitu z tkanek jednorocznych pędów jabłoni odmiany Topaz na skutek uszkodzeń przez niskie temperatury w miesiącu lutym

Combinations Kombinacje	Frost-treatment temperatures, °C Temperatury mrożenia, ºC			
	-20	-25	-30	-35
Control Kontrola	35.72 a	48.23 a	52.07 a	62.13 a
Replantation – row of trees Replantacja – rząd drzew	37.88 b	49.30 ab	56.36 b	66.40 b
Replantation – grass inter-row Replantacja – rząd murawy	39.20 c	50.91 b	57.65 b	67.65 b
LSD – NIR	1.52	2.55	2.06	1.93

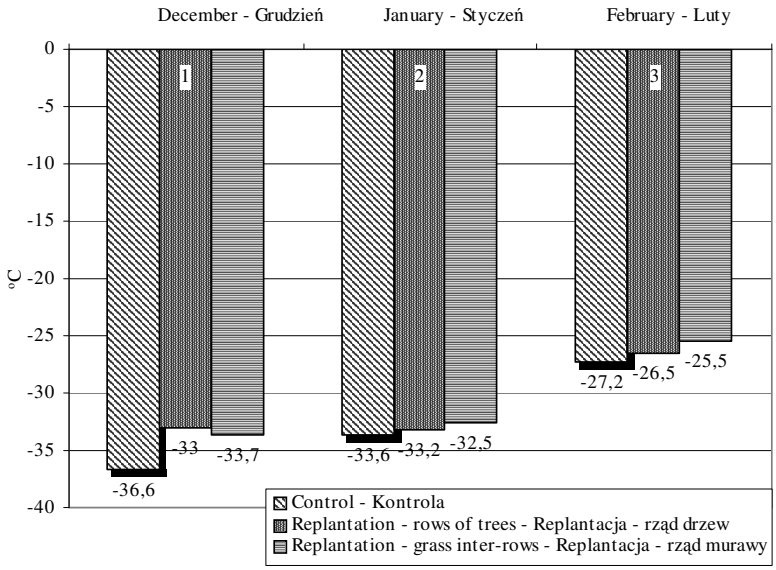

Fig. 1. Resistance to frost of one-year old apple-tree shoots, Topaz cultivar in the season 2006/2007
Rys. 1. Wytrzymałość na mróz jednorocznych pędów jabłoni odmiany Topaz w sezonie 2006/2007

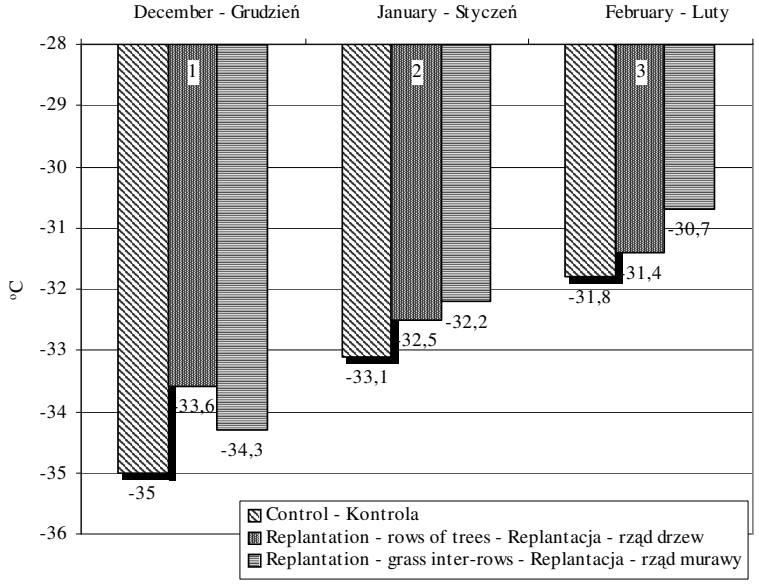

Fig. 2. Resistance to frost of one-year old apple tree shoots, Topaz cultivar in the season 2007/2008
Rys. 2. Wytrzymałość na mróz jednorocznych pędów jabłoni odmiany Topaz w sezonie 2007/2008

son with the combination where apple-trees were planted in the grass inter-rows of the old apple orchard (tab. 1). Such differentiations in the remaining two terms of freezing were not found (with the exception of the freezing temperature of -20°C which did not cause any irreversible changes in the cells).

In both study years, the greatest resistance of one-year old apple-tree shoots to low temperature was found in the December term. In the second half of February, the resistance to frost of apple shoots was distinctly decreased. For example, in the season 2006/2007, the temperature which reached about -27°C has shown to be lethal for the cells of one-year old shoots. Both in that season, as well as in the following one, independent of the term of the studies, the lowest temperatures (from -35°C to -36.6°C) were resisted by the shoots of apple-trees grown in localities which earlier were not used for fruit-tree growing (fig. 1 and 2).

DISCUSSION

Study results indicate that one-year old shoots of apple-trees grown in replanted localities, in compartison with trees grown in localities not used earlier for fruit-tree growing, were more sensitive to freezing. Plantation of trees in the place of old grass inter-rows increased only in a slight degree the resistance of apple-tree shoots to low temperature. One of the reasons of the increased plant sensitivity to the action of low temperatures may be the not well enough ripe woody tissue which, according to Kobel [1960] is more sensitive to the action of low temperatures. Curtis and Clark [1958] reported that the reason of an increased freezing is the too small amount of carbohydrates accumulated in the tissues. The replantation disease is caused by many factors of biotic and abiotic origin which lead to a poor tree growth, root necrosis, decrease and chlorosis of leaves [Lipecki 1999, Pacholak and Rutkowski 2000]. The higher sensitivity of replanted trees to damages caused by low temperatures can be explained by a worse condition of trees exposed to the action of replantation disease.

CONCLUSIONS

1. Shoots of apple-trees grown in replanted localities showed a lower resistance to frost in comparison with trees grown in localities not used before for orchard purposes.
2. In the seasons 2006/2007 and 2007/2008, one-year old apple-tree shoots of Topaz cultivar grown in localities not used earlier for orchard purposes resisted low temperatures even as low as -36.6°C.
3. No explicitly positive effect was found on the resistance of one-year old shoots to low temperature by planting new trees in the grass inter-rows of the old orchard

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WPŁYW ZMĘCZENIA GLEBY NA MROZOODPORNOŚĆ JEDNOROCZNYCH PĘDÓW JABŁONI ODMIANY TOPAZ

Streszczenie: Wykazano wpływ zjawiska zmęczenia gleby na obniżenie odporności jednorocznych pędów jabłoni na niskie temperatury. Największą mrozoodpornością cechowały się pędy drzew rosnących na stanowiskach nieuprawianych dotychczas sadowniczo. W replantowanym sadzie jabłoniowym wysadzanie drzew w rzędach murawy starego sadu jabłoniowego nie spowodowało jednoznacznego wzrostu mrozoodporności pędów drzew.

Słowa kluczowe: choroba replantacyjna, mrozoodporność, metoda konduktometryczna, jednoroczne pędy jabłoni.

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