ANATOMICAL AND MORPHOLOGICAL PROPERTIES AND MINERAL CONTENT OF APPLE ROOTSTOCKS ON PSEUDOGLEY

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Abstract

The paper presents the results of histological and chemical root analyses under the standard conditions of pseudogley and in microdepressions, i.e. in the deteriorated conditions of water and air regime in three apple rootstocks (M.9, M.26 and MM.106).

1. Introduction

The root of fruit trees is difficult to analyze under orchard conditions, since no single method can provide fully precise data (Atkinson, 1980). However, there has been a continuous interest in root analysis under field conditions due to the specificities of the scion/rootstock - soil substrate - climate complex (Kawase, 1981; Visser, 1983; Beukes, 1984; Olien, 1987; Karpenchuk *et al.*, 1993).

Knowledge of specific root reactions under particular conditions is important in defining characteristics and components of various substrates favoring its development. In fruit culture, the use of substrates is restricted to nursery production, whereas in commercial fruit growing it has been mainly directed to combining them with soil components and defining the interaction under field conditions. The objective of the present paper was to investigate the specific root reactions at the histological level and the mineral composition of apple rootstocks M.9, M.26 and MM.106 under varying water and air regimes on pseudogley.

2. Material and methods

In our previous study in 1994, reduced growth and cropping of trees were assessed in microlocalities in an orchard established in 1989 on pseudogley with a cross-drainage system. The analyses of the rhizosphere indicated an unfavorable water and air regime due to microdepressions. The rhizosphere has low organic matter content (below 1.8%) and a markedly acid reaction (pH 3.59 to 5.40), characteristic of this soil type, and liming failed to produce satisfactory effects due to shallow cultivation and inadequate dissolution, particularly in depressions (Tab. 1). Under such conditions of soil substrate, levels of mobile Al are increased and those of physiologically active P reduced, which is more pronounced in depressions considering longer water retention in them. Silt and clay particles make up over 80% of the texture, with no significant differences in the texture between localities with depressions and those devoid of them. The surface horizons are light, loose, of unstable structure and medium soil moisture capacity. Deeper layers are more compact, of greater bulk density. They have very low soil air capacity (below 3.92%), and are slowly-permeable or impermeable to water and roots (permeability in the rhizosphere of the depression is below 1.64 m/day).

Research was therefore conducted in 1995 on the morphology and distribution, histological characteristics and chemical composition of roots in the localities with

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depressions and those without them. The samples of skeleton roots, fine roots and root tips were taken for histological analyses from the monolith block. They were fixed according to Nawaschin, embedded in paraffin, sectioned at 10 μm and stained with Delafield's hematoxylin (Sass, 1958) and according to Gerlach (1969). Standard methods were used for analyses of the mineral composition of roots with diameter below 2 mm at the base.

3. Results

Under depression conditions, the roots system in apple rootstocks is dark brown to black, with poorer branching and thinner skeletal roots. The greatest root mass was recorded at the distance of up to 50 cm from the trunk, and at the depth of up to 25 cm. The highest number of roots in the profile was found with M.9, and the lowest with M.26 rootstocks.

Histological root analyses revealed the following:

- Histological differences on primary roots were not observed, except that a greater number of root hairs was recorded on them under the conditions with no microdepressions (Fig.1).
- In secondary roots, considerable differences were found at the histological level, regardless of the conditions. The roots growing under the microdepression conditions had a less developed cortex (Fig. 2) and a markedly thicker layer of phellem cells (Fig. 3). Also, the signs of premature lignification were noticed in the inner zones of the parenchyma tissue in the primary cortex, which indicates an accelerated loss of their viability and thus of the overall root activity (Fig.4).

Although the analyses of the roots developed under field conditions do not usually yield precise data on the mineral element content since a large amount of these nutrients is lost due to injuries from root lifting, and subsequent washing in the laboratory, we carried out the analyses of fine roots smaller than 2 mm, taken from the monolith block. Longer water retention in the root zone, accompanied by poor physical and chemical properties of pseudogley, resulted in a series of undesirable processes. Anaerobic conditions led to the increased Al solubility and to Mn and Fe reduction and their higher levels in the soil solution. An increased concentration of Al^{3+} ions is known to block the uptake of the physiologically active P (Mengel and Kirkby, 1982), and in this case the content of available P is very low even in the rhizosphere. The roots of all three rootstocks grown in the depression had by 50% lower P_2O_5 and up to 91% higher Mn contents compared to those outside the depression (Tab. 2). In such conditions, an increased Fe level was recorded in the depression, being by about 80% higher in the roots growing in the depression. The mentioned element concentrations can result in the antagonism of individual ions (e.g. Fe/Mn), which may reflect in metabolic disorders of fruit trees.

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