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QUALITY ASSESSMENT OF GRAPE PLANTING MATERIAL

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Abstract

At present, the main documents regulating the requirements for planting materials of grapes are: Federal Law "On Seed" and GOST R 53050-2008 and GOST 31783-2012. These regulations define the category of planting material, as well as the compliance with the varietal purity and appearance. The essence of the definition of quality indicators is reduced to a visual inspection for external signs. The main advantage of this method is the relative simplicity and efficiency. However, if there are any internal anomalies visually they are no longer fixed and require additional verification, which provides for the total or partial destruction of the object of control. Currently, there are methods and means of non-destructive study of the internal structure of the object and place in it processes using various physical methods, such as X-rays. The X-ray method allows without destroying the object of research to determine all its volume and linear anomalies. This article describes methods for determining the quality parameters of grapes planting material using a microfocus X-ray, in particular, the technique of determining the germination of grape seeds, the method of determining the quality of accretion rootstock-inoculation components grafted grape seedlings, the method of determining the degree of infestation of wood grapes vascular necrosis. The article provides detailed characteristics of radiographic signs of Shadow X-ray image corresponding to the internal state of the object. Knowledge of radiographic evidence of a particular type of defect allows the accurate and quick determination of the degree of damage, and facilitates the training and work of the operator. Recommendation of using this method in the research work and in practical viticulture is suggested.

Key words: grapes, planting material, grape seeds, grape seedlings, vascular necrosis, latent defect, microfocus X-ray, diagnostics.

INTRODUCTION

Viticulture is one of the oldest agricultural pursuits, and production of grapes and winemaking account for a major share of the agriculture in many countries. Before you harvest the grapes you have to do a selection job breeding new varieties combining a set of useful economic traits with resistance to biotic agents and abiotic factors, and you have to go through certain stages of plant material propagation having a good knowledge of agro technological peculiarities for the maintenance of grape plantings. All this conditions the profound scientific research aimed at the development of agro production technologies in the wine and grape industry.

Due to the spread of the grape phylloxera the viticulturists had to change over to grafted grape plants. Every year, from 800 to 1000 million grape grafts are produced in the world to satisfy the demands of vineyards and wineries in planting materials [1].

The primary task of every nursery is producing of healthy and sturdy plants of released varieties free of any quarantine pests or seeds or dangerous diseases, which meet certain quality standards. Vineyards planted with high quality grape plants show 1.5-2 times increased plant life and 40-50% increased productivity. Capital investments in vineyards replanting also decrease signi-ficantly. If we combine these factors, we will have, on the one hand, improved economic performance and, on the other hand, increased competitive capacity of commodity producers [2, 3, 4].

At the present moment the main documents regulating the requirements to grape planting materials are as follows: the Federal Law of the Russian Federation of 17 December 1997 No.149-FZ "On Seed Industry", as revised on 23/06/2014 by No.160-FZ, and GOST R 53050-2008 and GOST 31783-2012. These regulations define the category of planting materials, as well as its compliance with the requirements to purity of variety, appearance, condition of one-year-old scions, and other parameters [5, 6].

The essence of the methods used to determine the quality of grape planting materials (cuttings and grafts) is reduced to visual control for symptoms. The main advantage of this method is its relative simplicity and efficiency. However, if there are any internal abnormalities you cannot visualize them, and they require additional verification resulting in the total or partial destruction (dissecting) of the item monitored.

Nowadays there are methods and means for non-destructive testing of the internal structure of the item and processes running inside it using various physical techniques, such as imaging methods.

These methods are widely used in research and development practices by our colleagues abroad and in our country as well.

MATERIALS AND METHODS

Since 2006, the Anapa ZESV&W, St. Petersburg Electrotechnical University "LETI" and AFI have been carrying out the research on the microfocus X-ray method used in viticulture for the study of the structure of certain organs and of the grape plant on the whole, with regard to the exploratory work of the previous years and technical support by the JSC "ELTEch-Med" [6].

A great deal of work was done during that period, and we developed a number of new methods to assess the quality of grape planting materials, as the result.

We used the following X-ray equipment in our studies: a portable X-ray machine PRDU-02.1 and a mobile X-ray system PRDU-02.2. The research was done on grape seeds of the varieties selected by Anapa ZESV&W, and grape grafts and rootings. Exposure modes were different for various items, namely: seeds – voltage 29 kV, tube current 150-160 μA, exposure 0.3 seconds; grafts and rootings – voltage 35-40 kV, tube current 150 μA, exposure 0.3-0.35 seconds. These exposure modes gave us the sharpest and the most informative shadow X-ray images of the structure of the items under study.

RESULTS AND DISCUSSION

Assessment of grape seeds germinating ability. Grape seeds are mostly used in viticulture for the purposes of selecting when breeding new varieties only. Seeds germinating ability is low, and they come up slowly and very often sprout after a month in a patchy way. In this connection the critical task is to prepare the seeds in advance, which means that they must be selected individually. We use the flotation method here separating empty seeds and light debris, which yet fails to reveal the seeds with internal defects having an adverse effect on the germinating ability of the seeds [7].

We have developed the recommendations as to the method assessing the germinating ability of the seeds using microfocus X-ray [8, 9].

This X-ray method used for the assessment of the seeds quality is based on the fact that different parts of the seeds show different absorption of soft radiation and, consequently, may differ on the X-ray images. Therefore, heavy viable seeds are highlighted on the X-ray images, while cavities, necrosis, microcracks and other damage appear as dark image regions due to their weak absorption. This allows assessing of the structure and development of embryos and endosperms and revealing of mechanical injuries and damages caused by insects and pathogens, and at the same time small radiation doses have no impact on seeds viability. X-ray images of grape seeds with various internal disturbances are given in Picture 1.

Seed injuries are characterized with the following X-ray findings: *natural seed* – two endosperm cotyledons, the caruncle, the embryo area, the seed cover highlighted evenly, with no irregular obscurations (Pic. 1.1); *seed with development abnormali- ty* – irregular optical density throughout X-ray projection area, both increasing and decreasing, caused by (from the left to the right) irregular development of the endosperm, its absence and incomplete development (Pic. 1.2); *insect-attacked seed* – tunnels eaten out by insects appear as dark slightly spiral lines on the highlighted background of the intact endosperm tissue. Highlighted projections of maggots are sometimes seen inside the tunnels (Pic. 1.3); *no embryo seed* - obscurations in the embryo area have contrast boundaries with the endosperm (Pic. 1.4).

For the purposes of selecting such separation can be useful when we identify the seeds as damaged (underdeveloped, diseased, injured) or having "plus" traits, i.e. traits (morphological, physical) that would have correlations with positive characteristics of the plant on the whole that will grow from such seeds, e.g. with rapid growth, high productivity and early maturity, and fruit quality.

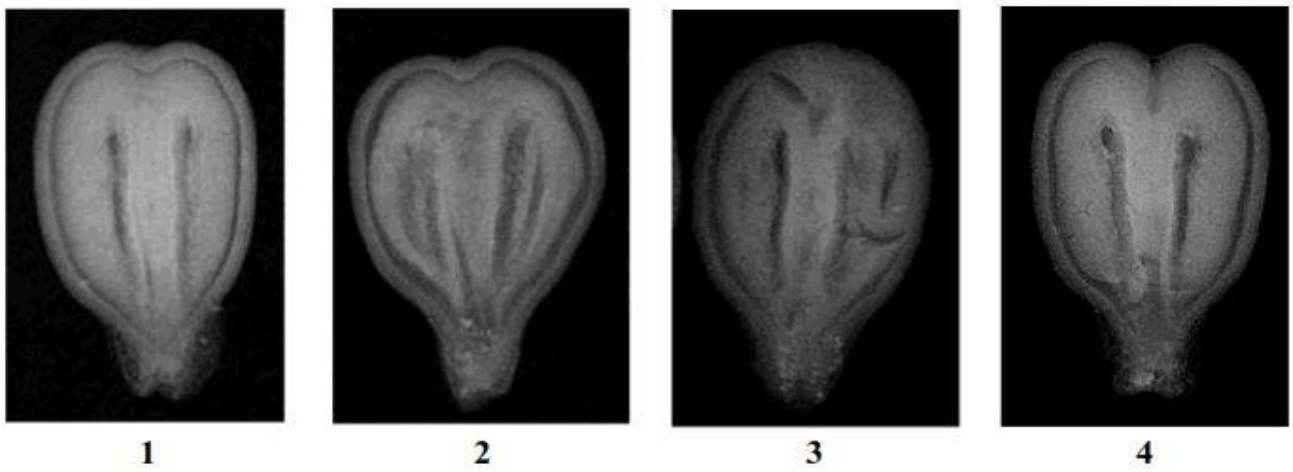
The developed method was tested in the field, and the obtained results proved high efficiency of the developed method.

Assessment of quality of grape plantings grafting. At present one of the most important challenges in production of planting materials is to produce properly grafted plantings (rootstocks and scions), with no rings of callus which points to the failure of the grafting and is easily detected at the early stage of production of planting materials [10]. Such defective grafts can be rejected. However, hidden internal defects of the graft union are quite difficult to identify and cannot always be visualized.

We have developed the recommendations as to the method assessing the quality of grape plantings grafting using microfocus X-ray [11, 12].

To make the images most informative we placed the plantings in such a way so that their flat and hollow sides were perpendicular to the X-ray flow direction to give a better projection of the omega shaped graft union. If the plantings were placed incorrectly the graft union images were not informative and we required another imaging.

Images obtained were analyzed to decide if we had this or that type of defects or not (Pic. 2).



1 – natural seed without disturbances, 2 – seed with development abnormality, 3 – insect-attacked seed, 4 – no embryo seed

***Pic. 1.** X-ray images of grape seeds internal disturbances*

1 – normal grafting, normal rings of callus tissue, 2 – graft union defect – no callus on the one side ("yawn"), 3 – graft union defect – abundant callus tissue without functional vascular system, 4 – graft union defect – mechanical injury

***Pic. 2.** Images of various graft union defects on grafted grape plantings*

Various types of defects are characterized with the following X-ray findings: *normal grafting* – line structural features of the trunk survive on the position where the scion and rootstock are joined by grafting, and the graft union is slightly highlighted which allows visualizing the vascular tissue continuity and absence of marked transverse black lines (pic. 2.1); *total absence of callus or its absence on the one side ("yawn")* – the graft union has a black contoured line showing the line of contact of the scion and the rootstock or a black tapered line thickening to the edge, which point to some empty space between the graft partners (pic. 2.2); *abundant callus tissue without the establishment of the functional vascular system* – line structural features of the trunk are disturbed by a light mass with extremely bright regions that make vascular tissue invisible (pic. 2.3); *mechanical injury* – the graft union has transverse black inclusions of various thickness that fail to repeat the specific profile of the line of contact of the scion and the rootstock (pic. 2.4).

The developed method was tested in the field, and the obtained results proved high efficiency of the developed method.

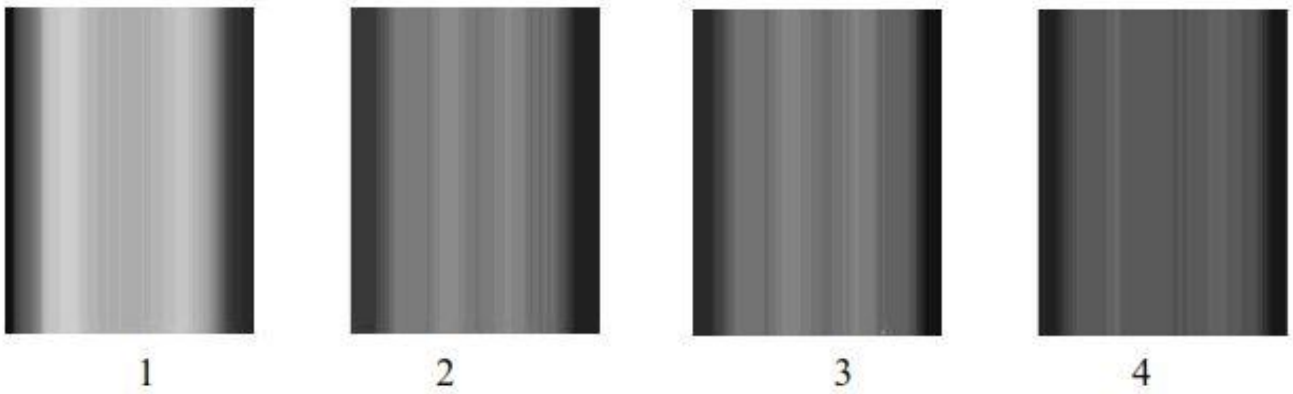
Assessment of vascular necrosis incidence in grape planting materials. Vascular necrosis holds a specific position among the basic diseases of grape plantings. The reasons of necrosis are diversified. Studies show that 80% of plantings have vascular necrosis, but to a varying degree. With low grade vascular necrosis the opening-up rate for the third year after grapevines' planting is 3-4%, while with high grade vascular necrosis it reaches 100% [13]. To identify and assess the degree of vascular necrosis incidence in grape planting materials you should cut the items transversely and vertically thus failing to preserve the item under study in case of absence of the disease.

Taking this into account we have developed the recommendations as to the method assessing the degree of vascular necrosis incidence in grape planting materials using microfocus X-ray [14, 15].

Vascular tissue necrosis manifests itself in the desolation of vessels, drying of their content and sheath cells, and partial filling of dead cells with tannin-type preserving substances. On the whole, the density of the dead tissues is lower, and we can identify them on X-ray images as dark strands along the trunk, of various width and degree of obscuration; necrosis of vascular tissues and adjacent cells occurs at the dorsal and ventral sides.

To make the X-ray images most informative we placed the plantings in such a way so that their flat and hollow sides were perpendicular to the X-ray flow direction. Two images (of the graft union and heel) were enough for the grafts, and one (of the heel) – for the rootings.

Degree of vascular necrosis incidence in the wood of grapevine planting materials is characterized with the following X-ray findings: *no necrosis* – quite high total brightness of the image, line structural features of the trunk without contrast transitions, regular vertical obscurations of the pith and core, single thin dark lines may occur (pic. 3.1), *low grade necrosis* – dark wide strands on the edges in the projection, on the one or both sides of the pith (pic. 3.2), *medium grade necrosis* – expanded projection of the pith and dark side strands on both sides of the pith, weaker total brightness of the image (pic. 3.3), *high grade necrosis* – totally very dark projection, expanded projection of the pith and dark side strands, single thin light lines of primary xylem and remaining healthy vessels (pic. 3.4).



1 – no necrosis, 2 – low grade necrosis, 3 – medium grade necrosis, 4 – high grade necrosis

***Pic. 3.** X-ray images of various degree of vascular necrosis in planting materials*

Analysis of the optical density of the X-ray images of the cuttings with various grades of necrosis shows that a cutting's tissues transmit radiation much worse with no necrosis (the image is much lighter as a negative), and besides, the entire pattern of the image's "relief" changes: a healthy cutting has a profile with slope edges and a hollow in the center where the pith is; with high grade necrosis it changes to the profile with deep hollow in the center where the dried out tissue of the pith is and light strands pointing to the hardened dead tissue on the line between the pith and vascular tissues of the wood.

The obtained results of the research carried out afford stating that the microfocus X-ray method used for the assessment of quality of grape planting materials is a highly efficient method.

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