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A new application of thermography

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SUMMARY. - *A new detection system to evidentiate plant internal cavities by a thermal infrared apparatus that combines the rapidity of research to the advantages of not requiring scaffoldings or crews and of not injuring the tree, is presented here. In fact the investigation is carried out at a distance, due to the non-contact type apparatus used, and the results are displayed in real time on a monitor-type screen.*

Introduction

The location of plant cavities is very important for plant pathologysts and for Municipalities because the injured tree can constitute a public safety hazard. The experience gained in 15 years remote sensing research has pressed us to use a thermal scanner to reveal the existence of internal cavities that create a break in the internal structure of the tree producing a discontinuity in the surface temperature distribution (Catena and Palla, 1989; Catena et al., 1990).

The methods usually employed to detect the existence of internal cavities in trees, are mainly based on the practice of boring into the trunk, or of tapping it with a hammer or again of measuring the variations of electric resistance across the tissues. Two of these methods risk of damaging or injuring the tree, while all are time-consuming and require the presence of ground crews and the use of scaffoldings, ladders, etc. and are difficult to use in the presence of tall trees. Compared with the three methods cited above, the one presented here offers two outstanding advantages: (*i*) the examination is carried out at a distance; (*ii*) the time required for the examination is very short since one scan, completed in a few minutes, is sufficient to show up any cavity present in trunk or branches; (*iii*) last, but not least, the final result can be documented in real time by using a polaroid-type camera.

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Materials and methods

The apparatus used is an i.r. thermal scanner, fitted with an indium antimonide sensing element cooled with liquid nitrogen and capable of measuring infrared radiations in the band between 2 and 5.6 microns. Briefly, the instrument operates in the following manner. The i.r. radiation impinges on the detector which generates an electrical voltage signal across its terminals that is amplified and used to modulate the intensity of the electron beam of a TV-monitor tube in the display unit. The image is displayed in black and white and consists of a pattern of different shades of grey, ranging from black to saturated white: a reference scale at the base of the image permits an immediate evaluation of surface thermal variations in the different regions of the object scanned, since the lighter the shade of grey, the higher the temperature of the emitting surface.

When a cavity is present in a trunk or in a branch, there is a variation in the thermal conductivity of the tissues. This produces an alteration in the surface temperature distribution that is showed on a TV-type monitor as darker or lighter in comparison with the nearest healthy tissues. A camera in front of the screen records the scene with normal b&w film.

Results

In order to test the validity of the method with different species of trees, we have examined some old lime-trees growing in Rome. Several specimen did not show any disturb in the distribution of the surface temperature and their thermograms are similar to the one presented in Fig. 1: the tone of grey of the bark is smooth and homogeneous, the darker tones of grey are the slender cracks of the bark typical of this species but there are not anomalous dark patches. The lighter band across the centre of the photograph is a recording defect due to the imperfect matching of the scanning rate (1/16 sec.) with the camera exposure (1/15 sec.).

On the contrary, when it was examined a tree with a large opening on the cutting surface of a main branch and with a large part of the trunk without bark (Fig. 2 - the letter *A* evidences the portion of trunk without bark), it produced a thermogram (Fig. 3) showing several anomalous dark patches in the area under the hole (the thermogram is taken from an angle of 90° on the left to that of the b&w photograph). Direct on-the-spot examination with the help of metal stylets confirmed the existence of an internal cavity, full of decaying tissue. Here, too, there is a lighter band across the thermogram due to the incorrect matching of the scanning rate of the thermal apapratus with the camera exposure.

The thermogram of Fig. 5 is relative to the base of another tree (Fig. 4) showing an identical situation to the one presented in Fig. 3:

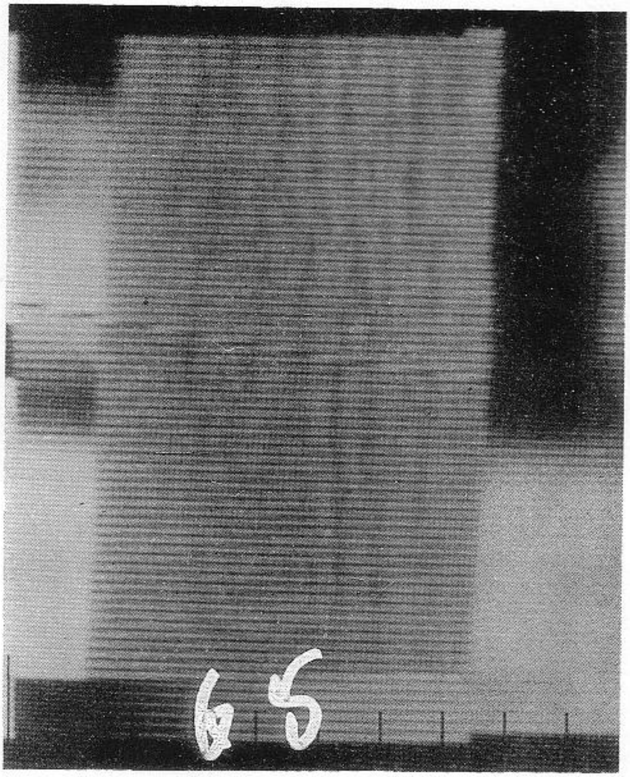

Fig. 1

Thermogram of a safe tree: the surface of the bark is rendered in homogeneous, light tones of grey; the darker stripes are due to the cracks of the bark typical of this species: no anomalous dark patches are present along the trunk.

several darker patches of grey are present along the trunk revealing the presence of an hidden cavity extending down to earth as confirmed the examination made by boring with a Pressler auger into the trunk (due to its seeming integrity): the b&w photograph of Fig. 4, in fact, does not show any evidence of the cavity.

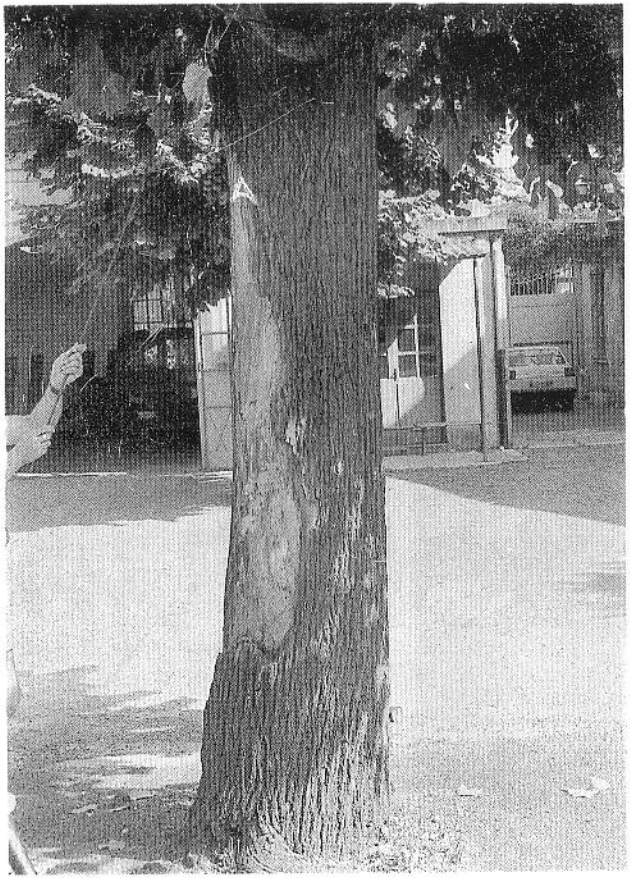

Fig. 2

This lime-tree presents a large opening on the cutting surface of a main branch and a large part of the trunk without bark, as indicated by the letter *A*.

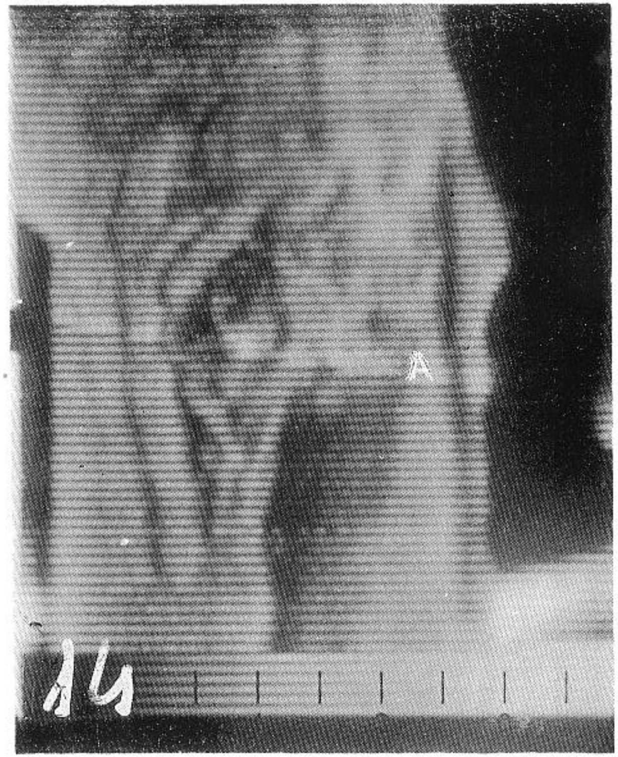

Fig. 3

Thermogram of the tree of Fig. 2, taken from an angle of 90° on the left to that of the b&w photograph. The large patches, darker than the surrounding surface, reveal the presence of a cavity.

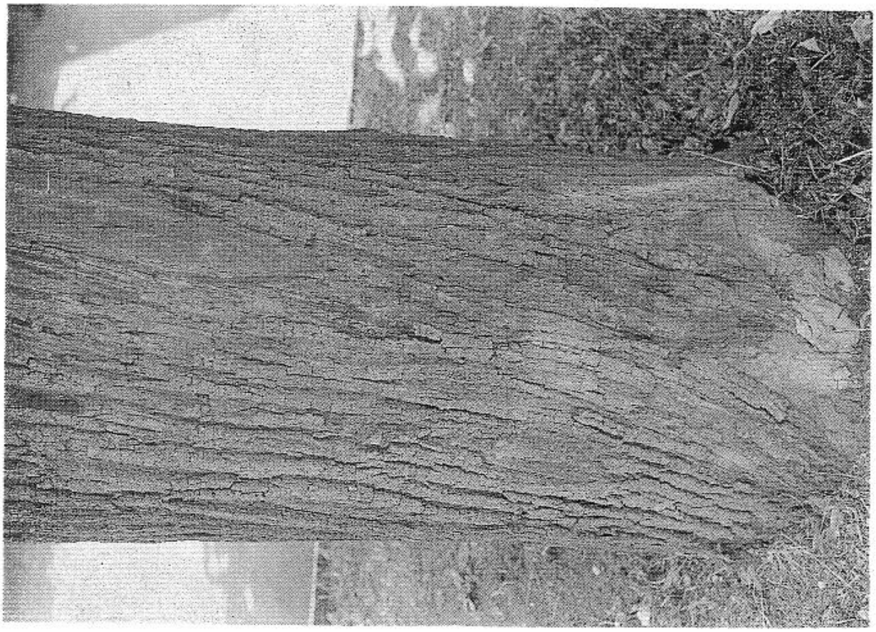

Fig. 4

B&w shot of the base of an apparently safe tree: it does not show any sign that could suggest the presence of an internal cavity.

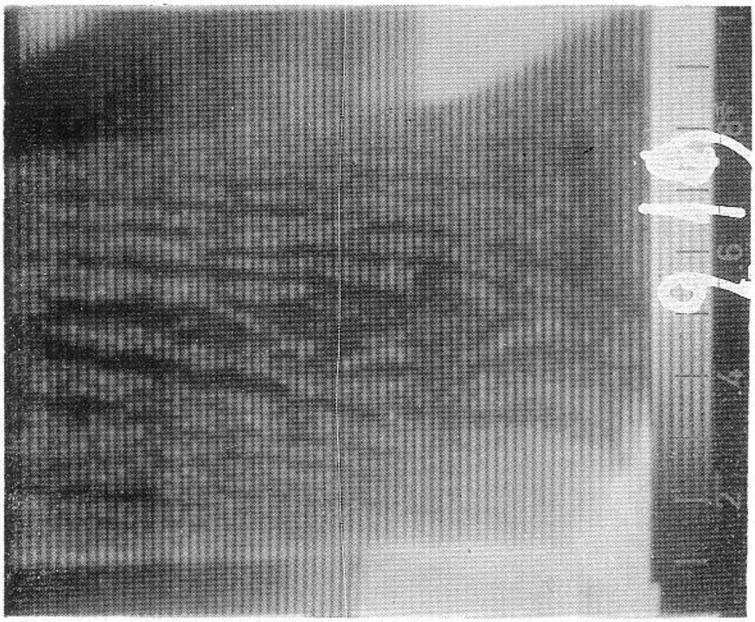

Fig. 5

The thermogram of the tree of Fig. 4 presents various patches darker than the surrounding tissues: this suggests the presence of an hidden cavity, extending down to the collar as confirmed by boring into it with a Pressler auger.

Conclusions

The results of this investigation confirm the validity of the method to detect internal cavities in plants. It is worthwhile to underline the opportunity of examining trees growing in open areas that, if damaged, can suddenly collapse and therefore constitute a public safety hazard to people passing by, as unfortunately often reported by newspapers.

The rapidity and the cost-effectiveness of the scan and the complete safety for the plant of the apparatus used, are favourable to a large diffusion of this method.

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