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Snapshot Hyperspectral Imaging: Hand-held Image Acquisition for Ground Inspection

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The CTBT permits the use of hand-held multispectral cameras during OSI ground inspections. Spectral scanners have successfully mastered several applications over broad spectral ranges; however hand-held scanning has its limitations in mobility and flexibility. To overcome these limitations, snapshot imaging or a spectral frame camera technique can be used. Such a device captures the entire spectral dataset/image during a single integration (one shot takes about 1 ms). During in-field and close-field applications weight, speed and power uptake are important considerations. In the context of an agricultural research project, a hand-held snapshot spectral camera with more than 100 spectral channels in the visible and near infrared region was tested.

One of the biggest challenges facing raspberry production in Hungary is the unfavourable effect of climate change. The maturation phase of main varieties within this region falls in a period of extremely high temperature - reaching, or even exceeding 35-40 °C - and atmospheric drought. This delays fruit growth. Dedicated plant breeding or biological treatments alone are not enough to protect the plantation. There has been a need for physical defence against excessive direct radiation. In order to restore, or even save domestic raspberry production and market, greenhouse or polytunnel solutions are needed. Experimental plantations of three different raspberry varieties were set in two repetitions: covered and uncovered versions. Covered plantations are developing under protective tunnels covered with experimental materials. Field measurements were carried out in the control area and under two different types of tunnels. Data acquisition was made with ASD FieldSpec 3 MAX portable spectroradiometer. As a reference the full sky irradiation in the control plantation was measured without any cover material above. A reference panel was used as a standard surface that reflects 95 percent of all incident radiation.

Using this etalon the light conditions between treatments (tunnels) could be compared. Following this further measurements were carried out under black and white tunnels. Measurements were carried out in the range of 350 to 2500 nm. In parallel, temperature, humidity and global radiance (400-1100 nm) were measured with Almemo 2890-9 data logger. Beside the above described non-contact data acquisition, contact measurements were also carried out. In order to compare the light utilization efficiency, the water and nitrogen management of plants under various circumstances PlantProbe sensor head was used to measure the reflectance characteristic of plant leaves within each treatments. In this case the illumination is provided by an internal halogen light source. From these spectra photochemical reflectance index, water index and normalized nitrogen index were calculated. Results showed rather high differences within spectra and global radiance but relatively small difference could be detected between other environmental indicators. Besides the above mentioned non-imaging spectral measurements an imaging technique has been applied. In the context of the project, a hand-held Cubert snapshot spectral camera was used in 400 to 1000 nm spectral range.

Preliminary results show significant differences between covered and uncovered plantations. Different spectral characteristics of the two experimental cover materials are revealed. The light utilization efficiency was higher under both tunnels than it was in the control area. In case of black tunnel the photochemical index was the highest. In case of water and nitrogen content of leaves no significant different was found. It means that soil preparation, nutrient supply and irrigation could create favourable homogeneity for the plantation. Biological indicators such as growth, flowering, yield (quantity and quality) are registered and still being monitoring. The first synthesis show close correlation between the cover materials and raspberry yields. Some species produced more than 100 % more yield with bigger berries. Further measurements and analysis are necessary to identify the best cover material and production practice.

The project proved to be a good opportunity to study the capabilities of proximal spectral data acquisition both with non-imaging spectroscopy (integrates the area to a point) and imaging snapshot technology (integrates the area to area). Different spectro-phenological parameters were inspected. The usability, data delivery, spectral data quality and spectral documentation potential of the imaging camera were evaluated. It is concluded that it provides a rapid and easy-to-use data set for spectral mobile mapping. It worked as a portable non-invasive and non-destructive sampling method with an extreme short data acquisition time – akin to taking a simple digital photograph. Data processing turnaround times were of the order of minutes enabling rapid phenological and physiological characterisation of vegetation cover..



Tunnels with different cover materials



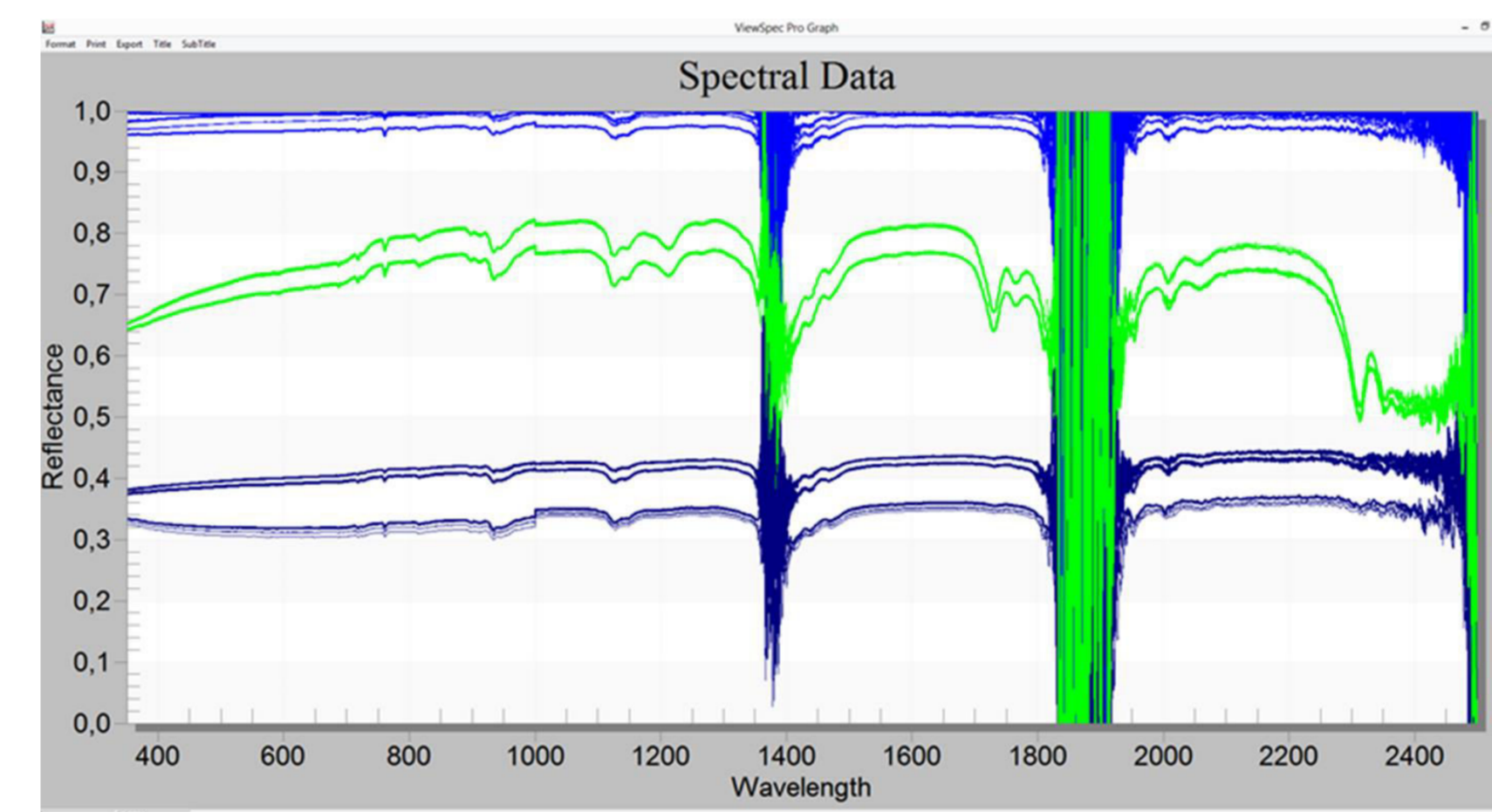
White reference measurement under black cover material



Image acquisition with Cubert Cam

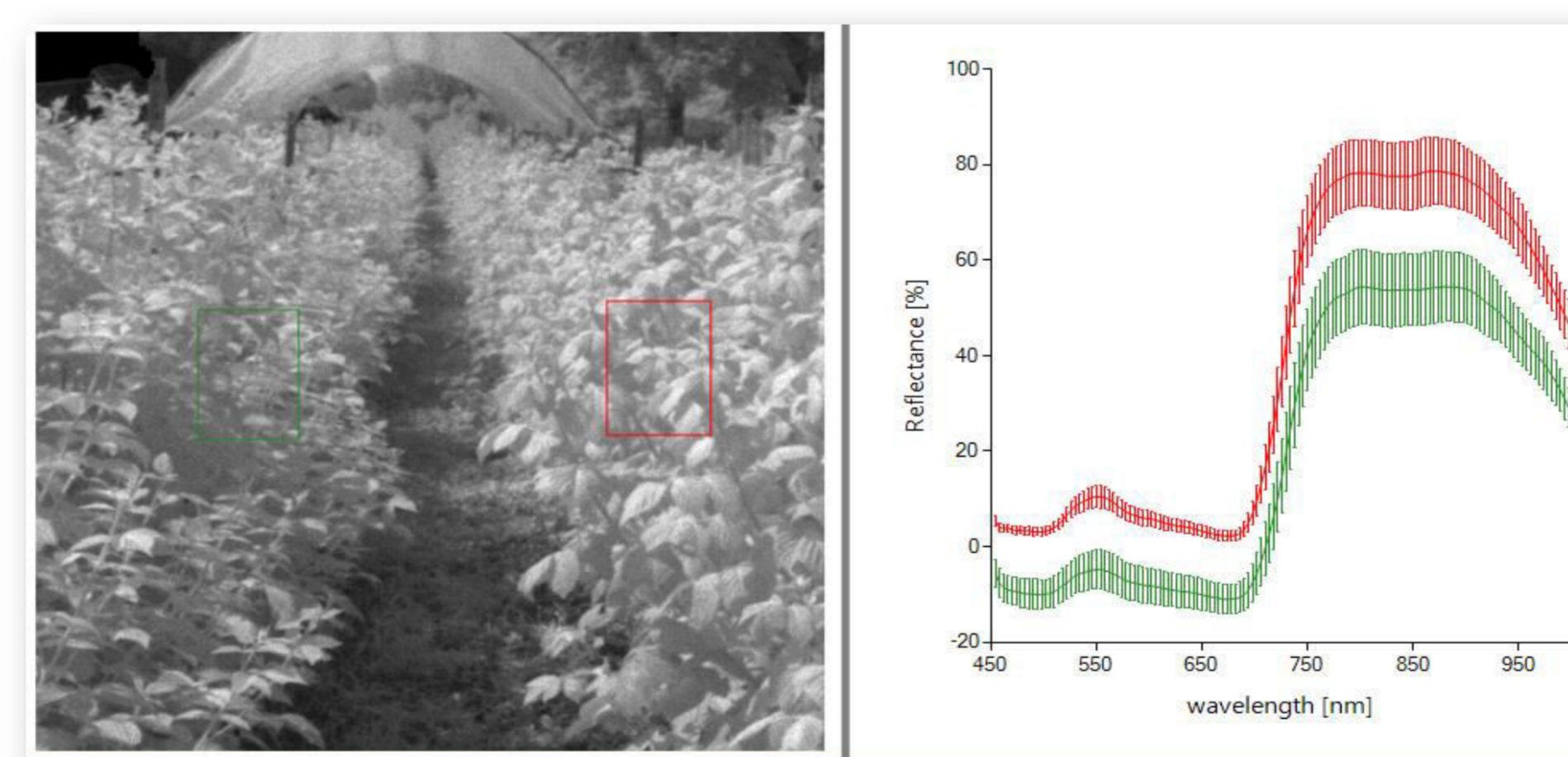


Spectral sampling with Contact Probe

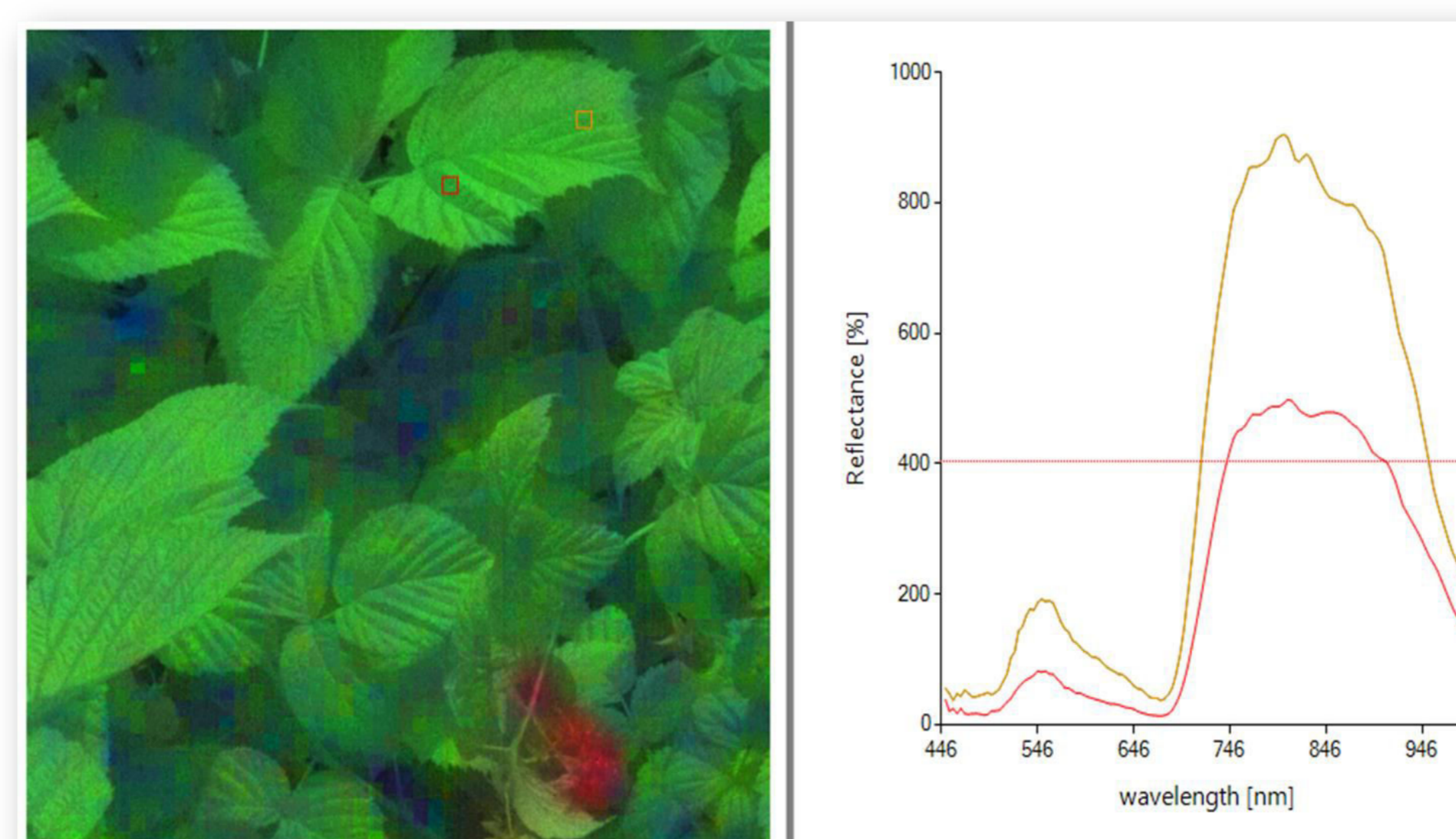


Reflectance curves:
Full sky (bright blue),
black tunnel (dark blue),
white tunnel (green)

	White tunnel	Black tunnel	Control	
Photochemical reflectance index	0.048	0.075	0.044	Spectral plant indicators in different treatments
Water reflectance index	2.946	2.950	2.956	
Normalized nitrogen index	0.143	0.139	0.143	



Reflectance between the canopies



On-Leaf morphology

