WEED BIOMASS EVALUATION IN AN INTENSIVE APPLE ORCHARD BY REMOTE SENSING INSTRUMENTS

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Abstract

Weeds compete with the cultivated plant for the nutrient and water, thus weed coverage could a great influence on the profitability of fruit production. Some traditional and modern methods are available to detect weed patches. Remote sensing is an effective tool to survey the ground coverage on a fruit plantation. The investigation was carried out of in an intensive apple orchard at the Study and Regional Research Farm of the University of Debrecen near the town of Pallag. Weed coverage map was created in different software environment to evaluate the spatial distribution of weeds. Weed mapping and imaging surveys were executed and compared with the two instruments, where a middle correlation (r=0.691) was detected between the two techniques. The results could contribute to precision weed detection and it could help in pesticide saving farming system.

Key words: Weed detection, apple orchard, remote sensing, NDVI, GreenSeeker 505, Tetracam ADC.

INTRODUCTION

Growing weeds have some harmful effects, which influence develop of cultivated plants. One of the most common competitions is for available growth factors, such as water, nutrient, light, etc. (Lipecki, 2006), and indirectly, weeds could cause various diseases (Meziere et al., 2013) in an agricultural field or a horticultural plantation.

Distribution of weeds could be excessively heterogeneous (Nagy, 2004). The spatial distribution of weeds is important to know for appropriate weed management. Traditional weed-scouting techniques were time-consuming, difficult and not so effective (Wiles et al., 1993). Farmers used practically homogenous pesticide application to decrease the amount of weeds on a field by conventional weed control techniques (Clay S.A., Johnson, 1999; Nagy, 2004). However, development of weed detection techniques, variable rate application was widespread (Wells, Dollarhide, 1998; Mohammadzamani, Rashidi, 2009).

Presently, some effective, quick, time-consuming methods are available to investigate real time weed coverage on an agricultural field or a horticultural plantation. Active and passive remote sensing methods acquire information about objects or areas at the Earth's surface without being in direct physical contact with the object or area. The basis of remote sensing is incoming electromagnetic radiation (E_I) to the object. When the radiation incident upon the object's surface, it is reflected (E_R) by that surface, transmitted (E_T) into the surface or absorbed (E_A) by the surface. Thus, it could be established that the reflection, absorption and transmission are equal to the total incoming radiation on a given wavelength (Aggarwal, 2004). Most remote sensing systems are designed to collect reflected radiation (Short, 2011).

Remote sensing is an effective tool for monitoring biomass production. By using certain reflectance values of adequate spectral bands vegetation indices can be calculated, which correlate well with the biomass. The plants reflect the visible (VIS) band in a small compass, but in the near infrared (NIR) band, the reflectance increases depend on the chlorophyll content of leaves and changes proportionally to produced biomass (Tucker, 1979). Using the reflection of the RED (630-690 nm) and the NIR bands (760-900 nm), a plant's green mass may be determined by the following equation: NDVI = (NIR-RED)/(NIR+RED).

The aims of this study are, to investigate the spatial variation of weed coverage on an intensive apple orchard and compare both NDVI sensor systems.

MATERIAL AND METHOD

The active and passive remote weed scouting were carried out at the Study and Regional Research Farm of the University of Debrecen, near the town of Pallag. The study area was an intensive apple orchard with a drip irrigation system, protected with a hail net. There are six rows of apple trees on the pilot area. Weed scouting was worked out only in the five row spacing. The date of ground cover measurements were before the fall of leaves at 01.10.2013.

To investigate the spectral characteristics of the whole study area's ground, GreenSeeker 505 vegetation indexmeter was used. The instrument uses red band (656 nm) and near infrared band (774 nm) of the electromagnetic spectrum to calculate NDVI values.

Data collecting was carried out 60-80 cm from the foliage. As an interface of GreenSeeker 505 was working, an AgGPS FmX integrated display by Trimble, which collected the coordinate data beside the NDVI values. The acquired data was stored in the hardware of the job computer each second. Both the AgGPS FmX and the Greenseeker 505 were mounted on a tractor. Uniform data collection was provided by the continuous speed of a tractor. For processing of data, Surfer 11 software was used. To evaluate the data, an NDVI map was created using a spatial interpolation technique (Kriging method).

To investigate the active ground cover on the pilot area, other spectral instrument was used. Tetracam ADC, broadband multispectral passive remote sensing camera surveys the test site. Resolution of the camera is 1280x1024 pixel. The camera creates spectral reflectance images in three bands (green – 520-600 nm, red – 650-750 nm and infrared – 750-950 nm). Based on the reflectance values, vegetation indices could be created in appropriate software environment (PixelWrench2).

RESULTS AND DISCUSSION

The active ground cover of the investigated apple orchard was carried out by GreenSeeker 505 active remote sensing instrument. Special software environment was used to create and evaluate of the weed coverage map (Figure 1).

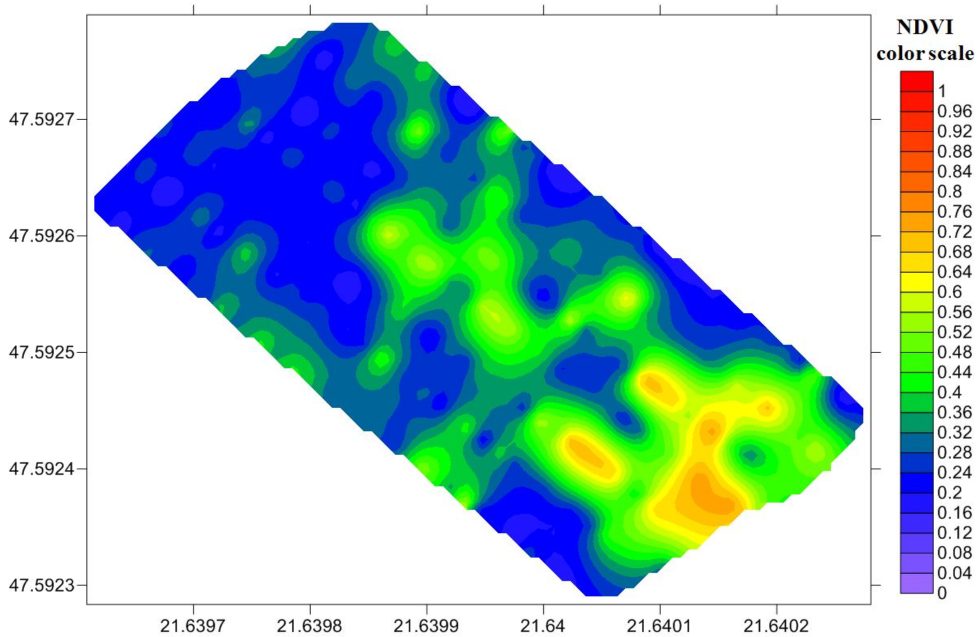

Fig. 1. Interpolated NDVI map by GreenSeeker 505 indexmeter in Surfer 11 software environment

Higher active ground cover is indicated by higher NDVI values. The average NDVI values of the whole study area were 0.353 in various distributions. Based on the NDVI values, it could be classified the total area in other software environment. The histogram of the investigated area was created in IDRISI Taiga pixel based software, where 0.001 class widths were used (Figure 2). The pixel resolution of the interpolated map was 1 arc degree.

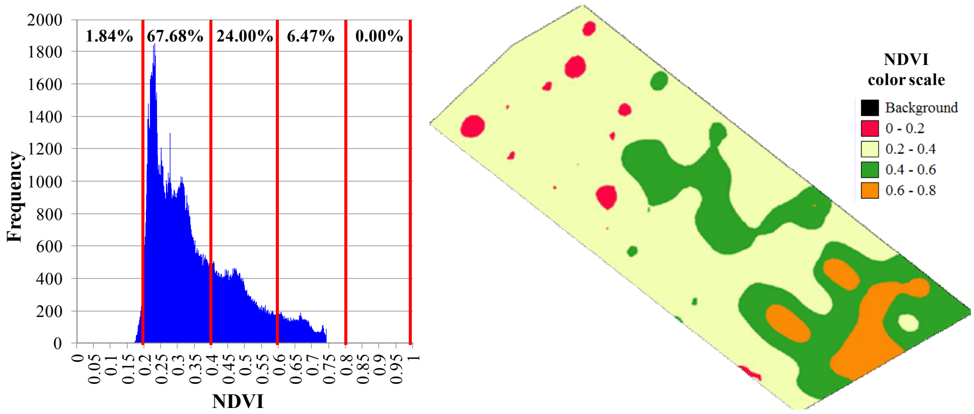

Fig. 2. Histogram of classified NDVI map and reclassified NDVI map
(Frequency of histogram indicates the number of pixels)

The histogram shows, that the most pixels were in the lower NDVI classes. Then the investigated area was reclassified to evaluate the weed coverage. New class width was 0.2, thus five classes where created. Weed patches with 0.2-0.4 NDVI values covered the largest area (67.68%) of the investigated orchard floor. On the larges reclassified area (NDVI=0.8-1) was not extremely dense vegetation (Figure 2). The spatial distribution of patches is also important for site-specific weed management. The reclassified NDVI map shows the Figure 2. In order to investigate the weed coverage, an imaging multispectral camera was used. We used 25 camera stations to survey the whole area. In the row spacing, from 5 locations were taken the images, which surveyed about a 10 m long section. Multispectral images contained pixels (canopy of trees, hail protection net, sky, etc.), which could be caused errors during the evaluation. Thus, the processing was carried out only a swath (track of tractor, between wheels), which similar with GreenSeeker data collection zone. Based on the multispectral data, canopy coverage were determined (average canopy coverage was 24.42%) in the PixelWrench2, which is the own software of Tetracam ADC. The canopy coverage data was compared with the GreenSeeker-NDVI values and a middle correlation (r=0.69) was detected. Without selecting of swaths, due to the error pixels, weak correlation could be obtained (r=0.32).

CONCLUSIONS

In our research, weed distribution investigations were carried out by two remote sensing instruments in an intensive apple plantation. Based on the spectral features of weeds, a weed coverage map was created. By combination of software solutions, the NDVI vigor map was reclassified.

The GreenSeeker proved an effective and fast technique to scouting for weeds. The results could help for site specific weed control. Further investigations are needed to examine the context of NDVI map and herbicide application.

Imaging systems could be useful for determine weed coverage of the study area, from which could be concluded to the amount of transpirated water by weeds. The camera could provide the species level identification of weeds, which is an effective tool to know a more accurate water usage of plants.

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