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IDENTIFICATION OF THE INTENSITY OF WEEDS IN MAIZE PLANTATIONS BASED ON AERIAL PHOTOGRAPHS

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Abstract

This research was carried out in order to investigate the evaluation of aerial photographs taken from a low altitude in the identification of weed infestations within a field crop. The aerial photographs were taken with a digital camera from a Cessna airplane at an altitude of 300 m above a maize field. The maize plants were at the growth stage of BBCH 32. A map of the weed infestation was then created, which encompassed areas on the map that were estimated according to their density as heavy, medium heavy weed infestation, as well as non-infested areas, and places where maize plants did not grow. By applying this method of identifying mapped areas of a high density of weeds, allows a formulated plan to pinpoint the application and dosage of herbicides to the field crop.

Key words: weed detection, remote sensing, spatial analysis, MEGI (Modified Excessive Green Index).

Introduction

The rational utilisation of chemicals in modern agriculture is becoming a great challenge for farmers, who decide to apply precise farming methods. Different treatments, including the application of plant protection compounds, need to obtain spatial information, which can be used for the planning of different but effective field practices. The chemical precise application can be done based exclusively on the maps, which are adapted entirely to possessed mechanical equipment and real spatial differentiation on proper field /Moran et al., 1997; Thorp, Tian, 2004/. These kinds of maps can be prepared into geographical information systems (GIS), based on results received from remote sensing methods /Kozyra, Pudełko, 2006/. Remote sensing methods are a source of continuous spatial data, which decide about their effectiveness under scientific investigations and agricultural practice /Vrindts et al., 2002; Nieróbca et al., 2007/. Nowadays there exist several methods in obtaining low altitude aerial photography. The cheapest method belongs to non-metric digital photography, taken from small light aircraft such as a Cessna or alternative air platforms like UAV, kites, balloons /Lamb, Brown, 2001; Herwitz et al., 2004; Hunt et al., 2005; Sugiura et al., 2005; Jensen et al., 2007/.

Materials and Methods

The aim of the investigation was the application of low altitude remote sensing for identification of different intensities of weed infestation within the field crop. The aerial photographs were taken on 11.06.2007 using a Sony alfa (RGB, digital camera) from a Cessna airplane, flying at an altitude of 300 m a. g. l. The maize plants were at the growth stage of BBCH 32.

On the basis of an initial analysis of aerial photographs, it was possible to isolate several compact areas in the overall scope of a field that significantly differ with a registration in the green channel. A local inspection confirmed the large spatial variability of the weed infestation. The field was assessed and identified with the following clusters: absence of weed in cultivation, low presence of weed, high presence of weed and local absence in the vegetation (Figure 1).

The selected aerial photograph was compiled in the geographical information system (GIS). The Erdas Imagine 8.4 program was used /Erdas Field Guide, 1997/. The photograph was orthorectificated and then processed with image analysis. Based on the registration of reflected radiation in the RGB channels, the photograph was converted to the MEGI colour index (Modified Excessive Green Index), which was calculated based on the following formula:

if $g<r$ or $g<b$ then MEGI = 0, else MEGI = $2g-r-b$

where:

R, G, B: images raw RGB colours

r, g, b: normalised red, green and blue; $r = R/(R+G+B)$, $g = G/(R+G+B)$, $b = B/(R+G+B)$

Figure 1. Weed extent. A – Weed zone, B – Weakness of weed zone, and no vegetation spots, C – No weed

MEGI showed the potential for plant-soil and plant-pebble segmentation /Golzarian et al., 2007/. Then the map index was processed with non-supervised classification ISODATA in order to obtain classes that are characterised with similar spectral properties. Based on the initial image analysis, classification of the photograph was developed into four classes. In addition, a trial classification of the image was made in order to see if it was suitable for other classes (3, 5, 6, 7, 8). In the last phase of the image analysis, the generalisation of the spatial resolution was performed. Focal statistic-geostatistical method from the neighbourhood group was used, estimating the most significant value for the environment in a specified radius. In order to estimate the possible level of the generalisation in the maps, lower resolution maps were generated, being multiplications of the row spacing width: 0.8 m (x1), 4 m (x5), and 8 m (x10).

Results and Discussion

The conversion of the unprocessed RGB photographs into the MEGI index, significantly strengthened the spectral resolution of the image (compare Figure 2A/B). The performed classification with the ISODATA method allowed obtaining classes of conforming levels of weed infestation (Figure 2C). Tests that were performed for the different number of classes (3–8) demonstrated the high index sensitivity of the greenness detection. For this reason, the method did not allow a clear differentiation of areas without weeds or local absence in vegetation. However, regarding the weed infestation level, the ISODATA method used for the delimitation of four classes, best corresponds with the actual spatial variability, which is represented by classes 1, 2, 3 (Figures 2 and 3). This method also separated areas of weed infestation from areas where there was an absence of weeds (class 4). The efficiency of the classification, also confirms the visual comparison of both maps – Figure 2 B and C.

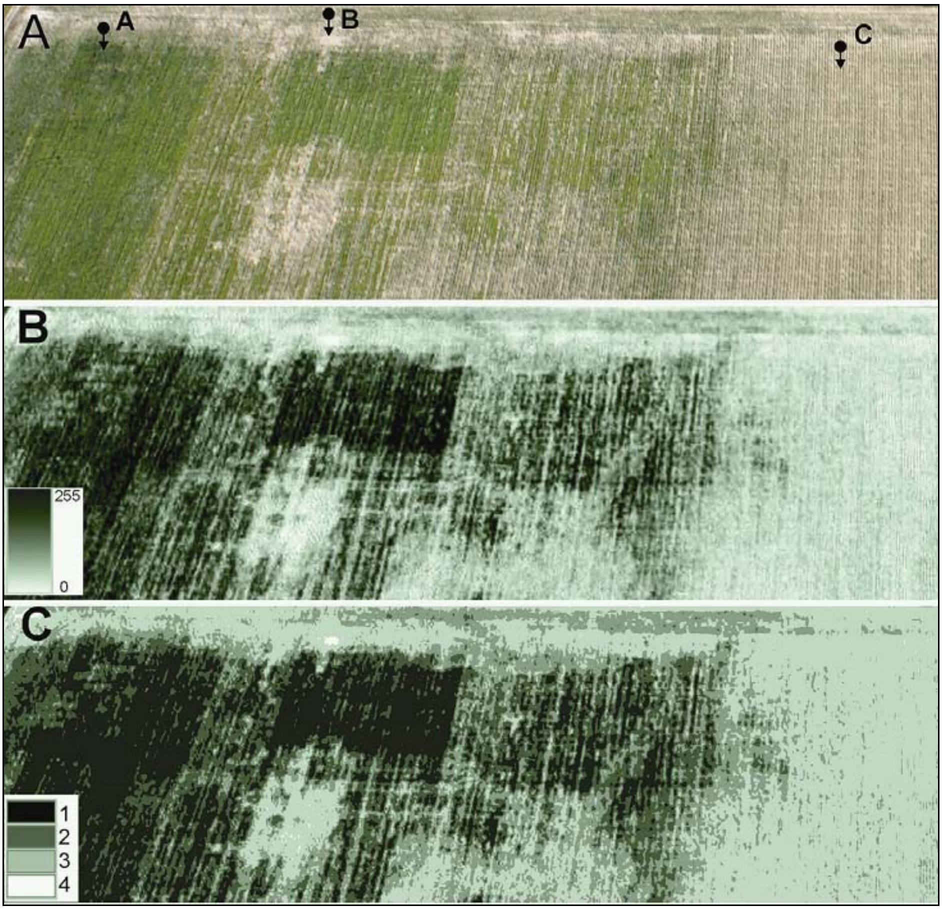

Figure 2. A) Aerial photograph (orthophoto). The points labelled as A, B, C point to the localisation of the pictures showed on the Figure 1, and the arrows indicate their azimuth. B) Map of the MEGI index. C) Result of ISODATA non-supervised classification (4 classes) of the MEGI map

Because of the high resolution of the photographs, (ca. 0.08 m pixel size), a high resolution index MEGI map was obtained. Then the generalisation with focal statistic method was done, which allowed obtaining an image with a resolution that can permit agrotechnical possibilities for performing protective treatments. Therefore, 10, 50, and 100 times generalisation were established, allowing obtaining maps where the resolution complies to those sizes: single multiplications of the row spacing (0.8 m), 5x (4 m) and 10x (8 m) (Figure 3). In the case of the first map, the generalisation was inadequate (Figure 3A). This complied with the expectation, and the map with a spatial characterised direction of the tillage was obtained. Following the levels of the generalisation, this demonstrated the possible isolation of compact areas, which can determine the result for the drawing up of maps for different protective treatments. The comparison of the map with a resolution of 8 m (pixel size) and a map with resolution of 4 m, illustrates the possible upper level for the generalisation of this type image, by using focal statistic method. Further enlargement of the distance buffer, can lead to spatial variability distortions that were observed on the original photograph. This is already visible on the most generalised map, especially in places characterised with distinct borders in the variability of weed infestation. These places were marked with arrows on Figure 3 C.

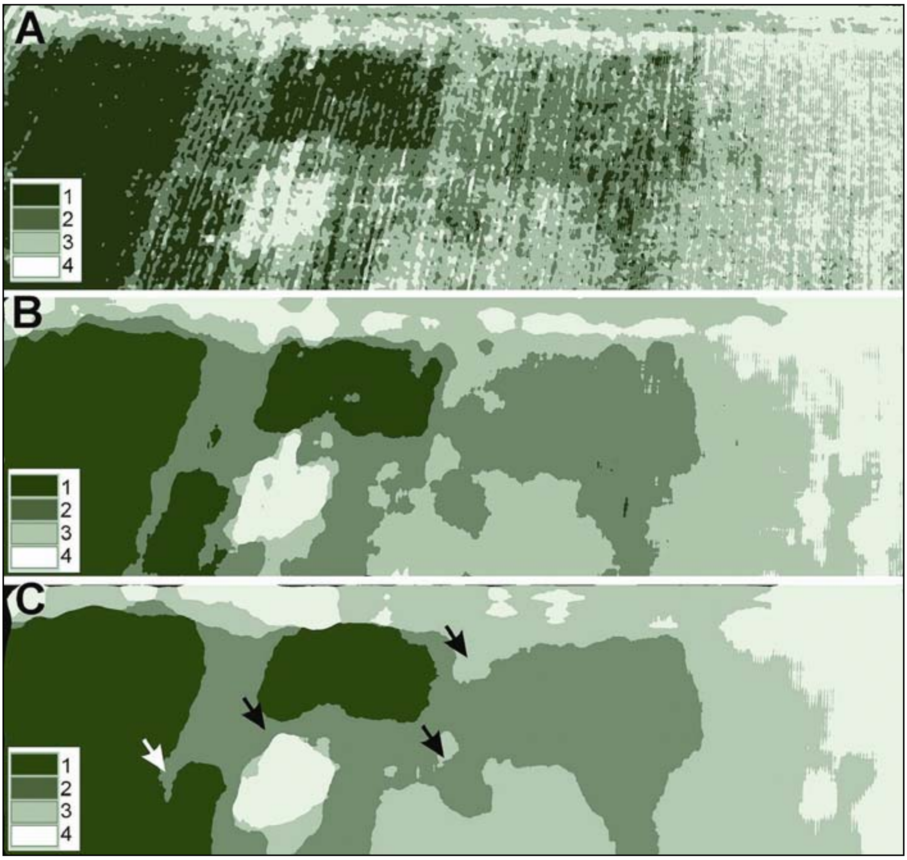

Figure 3. Generalisation of MEGI map A) 0.8 m pixel resolution, B) 4 m pixel resolution, C) 8 m pixel resolution

Conclusions

Remote sensing is an effective tool that allows spatial diversification of a given farmland's features. The weed mapping based and made on the aerial photographs, allows an evaluation of the weeds' extent and zoning possibilities. Further classification of this kind of data with the zone-dose method, can produce a map for the variable dose of herbicide for farmland. The diversified (intentional) applications of herbicide, which at present is only possible with spraying machines that are adapted for precision agriculture; significantly reduce the costs of carrying out the treatment, as well as limiting unnecessary discharge of chemicals into the environment.

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