Athens Institute for Education and Research
ATINER

ATINER's Conference Paper Series
AGR2018-2493

Determination of Spraying Deposit Distributions of a Vision-based Real-Time Weed Detection and Control System

Ömer Barış Özlüoymak
Electrical and Electronics Engineer
Çukurova University
Turkey

Ali Bolat
Agricultural Engineer
Republic of Turkey, Ministry of Food Agriculture and Livestock, Eastern Mediterranean Agricultural Research Institute
Turkey

Ali Bayat
Professor
Çukurova University
Turkey

Emin Güzel
Professor
Çukurova University
Turkey

An Introduction to ATINER's Conference Paper Series

Conference papers are research/policy papers written and presented by academics at one of ATINER's academic events. ATINER's association started to publish this conference paper series in 2012. All published conference papers go through an initial peer review aiming at disseminating and improving the ideas expressed in each work. Authors welcome comments.

Dr. Gregory T. Papanikos
President
Athens Institute for Education and Research

This paper should be cited as follows:

Barış Özlüoymak, Ö., Bolat, A., Bayat, A. and Güzel, E. (2018). **"Determination of Spraying Deposit Distributions of a Vision-based Real-Time Weed Detection and Control System",** Athens: ATINER'S Conference Paper Series, No: **AGR2018-2493.**

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm
Printed in Athens, Greece by the Athens Institute for Education and Research.
ISSN: 2241-2891
27/08/2018

Determination of Spraying Deposit Distributions of a Vision-based Real-Time Weed Detection and Control System

Ömer Barış Özlüoymak
Ali Bolat
Ali Bayat
Emin Güzel

Abstract

Recent advances in technologies such as sensors, computers and digital image processing systems make a major contribution to the agriculture. In recent years, machine vision systems are being used extensively for detecting and spraying the weeds in fields. By using digital image analysis techniques, the herbicide consumption and environmental pollution risks decrease to the minimum level. In this study; a vision-based automation system, which was effective and convenient for spraying herbicides in the site-specific applications, was developed and tested for real-time detection, tracking and spraying of artificial weeds. The imaging system could capture images of artificial weed samples moving on a conveyor belt which could be controlled by an inverter drive system and 3 phase 4 pole electric motor at speeds of 0.5, 0.75, 1, 1.25, 1.5 and 1.75 km/h, respectively. Both the webcam and solenoid-activated spray nozzle were mounted at a height of 50 cm above the conveyor belt consecutively. The LabVIEW programming language was used for image processing and software development. The green target objects were identified using the greenness method, which compares the red, green, and blue intensities while processing the image. A data acquisition card and a relay card were used to activate the solenoid valve of spraying nozzle according to the green color pixels of artificial weed and its coordinates. Filter papers were used to detect the amount of deposits on the artificial weeds for aforementioned test speeds. A spraying solution with 0.4 g/l tap water of Brilliant Sulpho Flavin (BSF) was sprayed to the targets. The amount of BSF deposition on filter papers was determined by a spectrofluorophotometer device. Consequently, the automation system could detect and spray the artificial weeds successfully but spraying performance decreased with increasing in spraying speeds of the system.

Keywords: Digital image processing, Greenness method, LabVIEW, Site-specific application.

Acknowledgments: Our thanks to the Çukurova University Scientific Research Projects Department (Project Number: FBA-2016-6793) for supporting this project.

Introduction

Weed control is an important issue in the production of agricultural crops. Nowadays, there is a clear tendency of reducing the use of chemicals in agriculture. Weeds compete with crop plants for sunlight, moisture, nutrients and if uncontrolled they may have a detrimental effect on yield and quality of crops (Slaughter et al., 2008; Tellaeche et al., 2008). Herbicides are applied homogeneously to the field to eradicate the weeds in the conventional method. The extra agrochemicals have become the ecological hazard and reducing the harmful effects of herbicide usage on environment and water contamination is becoming increasingly important (Jafari et al., 2006a; Yang et al., 2002; Yang et al., 2003; Wan Ishak and Abdul Rahman, 2010). Moreover, there is a strong relationship between the high volume agrochemical usage and some types of cancer, leukemia, and Parkinson disease (Sabanci and Aydin, 2016).

Today, advances in machine vision and computer technology provide a great advantage for increasing automation technology in the agriculture. Site-specific spraying can reduce the herbicide usage instead of the conventional spraying if the presence of weeds could be correctly detected and localized by using image processing techniques.

The objective of this study was to develop a machine vision based real-time site-specific spraying system by using LabVIEW software program and to evaluate the deposit concentrations according to the conveyor belt speeds of 0.5, 0.75, 1, 1.25, 1.5 and 1.75 km/h under laboratory conditions. A vision-based automation system for site-specific spraying applications was developed and tested for real-time detection, tracking and spraying of artificial weeds to determine the amount of deposits on the artificial weed samples moving on the conveyor belt.

Literature Review

Shirzadifar et al. (2013) developed and evaluated a real-time, site-specific, machine vision based herbicide application system. LabVIEW and MatLab softwares were used to process the image frames to evaluate the effect of travel speed on spraying delay. Greenness method was chosen for separating soil from plants. Three herbicide application treatments, which were patch spraying, conventional spraying and no spraying, were compared each other. The patch spraying application was found as effective as the conventional spraying application for the eradication of weeds. Wan Ishak and Abdul Rahman (2010) developed an on-line automated weedicide sprayer system to locate the existence and intensity of weeds in real-time environment and to spray the weedicides automatically and precisely. The sprayer nozzle was turned on/off depending on the percentage or intensity of the green color pixel value of weeds. Tian (2002) developed and tested a smart sprayer, which includes new technologies, to estimate weed size and density and spray real time as site-specific. The effectiveness and performance of the smart sprayer were evaluated under varying commercial field conditions. Loghavi and Mackvandi (2008) studied a prototype patch sprayer for target oriented weed control system. Geographical Information System (GIS), differential global positioning system (DGPS), and solenoid-activated spray nozzles were integrated to the prototype. Patch spraying method was determined as effective as the conventional method in controlling the weed existence. Besides, the patch spraying application was found more economical than the conventional application. Sabanci and Aydin (2016) developed an intelligent spraying robot, which applies the variable levelled herbicide on weed by using image processing algorithms. Greenness method was used to obtain the green color value and the spraying liquid was implemented on the weed when the green color value exceeded the threshold value. A reduction of the spraying liquid to the weed was determined. Loni et al. (2014) designed, developed and evaluated a targeted-discrete flame weeder in laboratory and compared it with the continuous (uniform) flame weeding with targeted flaming of inter-row weeds in an organic maize production field. Greenness method was used in the image processing program to recognize and discriminate the green plants from the soil. The results showed that targeted-discrete flame weeding by using machine vision technology was a potential alternative to the uniform flaming. Yang et al. (2003) used a digital camera to take a series of grid-based images covering the soil between rows of corn in the field. The greenness method, in which the red, green, and blue intensities of each pixel were compared, was used to determine the weed coverage in the images. A fuzzy logic model was developed for determining the site-specific herbicide application rates by using the weed coverage as inputs. Timmermann et al. (2003) realized site-specific weed control with a GPS-guided sprayer on five fields in order to evaluate its economic impact and ecological effect. They reported that an average of 54% of the herbicides was saved at the end of the 4-year experiment. Jafari et al. (2006b) investigated several color feature extraction techniques in order to separate soil from the plants. At the end of the experiments, they concluded that the greenness method was the best segmentation method for separating soil from plants because it eliminated the light intensity effect better than the other methods. Jafari et al. (2006a) extracted the relation between three main components (red, green & blue) of the images from image data using discriminant analysis to detect the weed in sugar beet fields using machine vision. And discriminant functions and their success rate in weed detection and segmentation of different plant species evaluated in that study. Yang et al. (2002) developed the image processing component of weed detection and mapping system that can be applied to precision farming. The greenness method, which determines the greenness ratio of images taken from the fields, was used on the image processing application. The weed detection and mapping system reduced herbicide costs and environmental pollution with the help of site-specific application. Perez et al. (2000) developed near-ground image capture and processing techniques in order to detect broad-leaved weeds in cereal crops under actual field conditions. Color information was used to discriminate between the vegetation and background. In addition that, shape analysis techniques were applied to distinguish between the crop and weeds.

Methodology

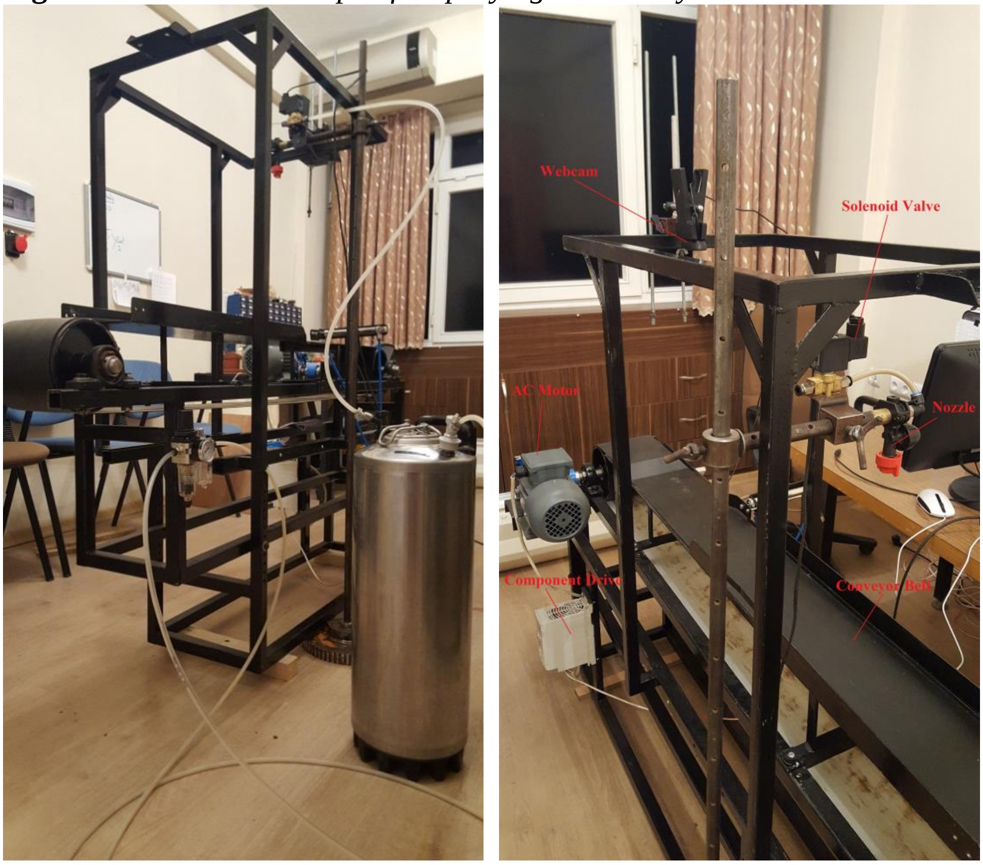
Material

Research was carried out in the automation laboratory at the Department of Agricultural Machinery and Technologies Engineering of Çukurova University, Adana, Turkey. The system, which includes the image processing and automation units, was consisted of a webcam (Logitech C270), a data acquisition device (National Instruments, NI USB-6009), a control card, a solenoid valve (Tork, S101003145N), a spray nozzle (Lechler standard flat fan nozzle, 110-02) and other necessary hardware. LabVIEW as automation and image processing software (National Instruments, Austin-Texas-USA) was used in the proposed weed control system. An air compressor (Typhoon, TW2501-24) was used in order to provide air pressure. A premix tank was used to mix the Brilliant Sulpho Flavin (BSF) as tracer material and tap water. A laptop computer (Acer, Aspire, 4830TG) was used to capture the artificial weed images via USB port instantaneously. Artificial weed samples used in the experiments were shown in Figure 1.

Figure 1. *Artificial Weed Samples used in the Experiments*

The artificial weeds moved on the conveyor belt with a 0.37 kW 3 phase 4 pole electric motor (GAMAK, AGM714b), at an adjustable speed using component drives (ABB micro drives, ACS150). To determine the amount of deposit in the spraying pattern of the nozzle, filter papers (Schleicher & Schuell, Whatman) were used. A shaking device (Nüve, SL 350) was used to transfer the tracer material on the filter papers into the distilled water placed in jars to be analyzed. A spectrofluoro-photometer (Shimadzu, RF-6000) was used to measure the deposit concentration on the filter papers. The distance between the lens and the artificial weeds was 50 cm. Real-time site-specific spraying system was shown in Figure 2.

Figure 2. *Real-time Site-specific Spraying Control System*



Method

Digital imaging process was used for separating the object and the background from each other. Weed coverage was determined by using greenness method in which the red, green, and blue intensities of each pixel were compared. Weed existence was estimated based on that method (Yang et al., 2003; Jafari et al., 2006b; Shirzadifar et al., 2013; Loni et al., 2014; Sabanci and Aydin, 2017).

The greenness method was chosen for this study because it could eliminate the light intensity better than the other methods. Each pixel of the image has three color components, which are red (R), green (G) and blue (B). After capturing RGB image and separating its components as R, G and B values instantaneously, greenness method was applied to highlight the green color information as shown in Equation 1.

$$EG = 2G - R - B \qquad (1)$$

Where EG means "excessive green" and R, G, and B are the color components of the image.

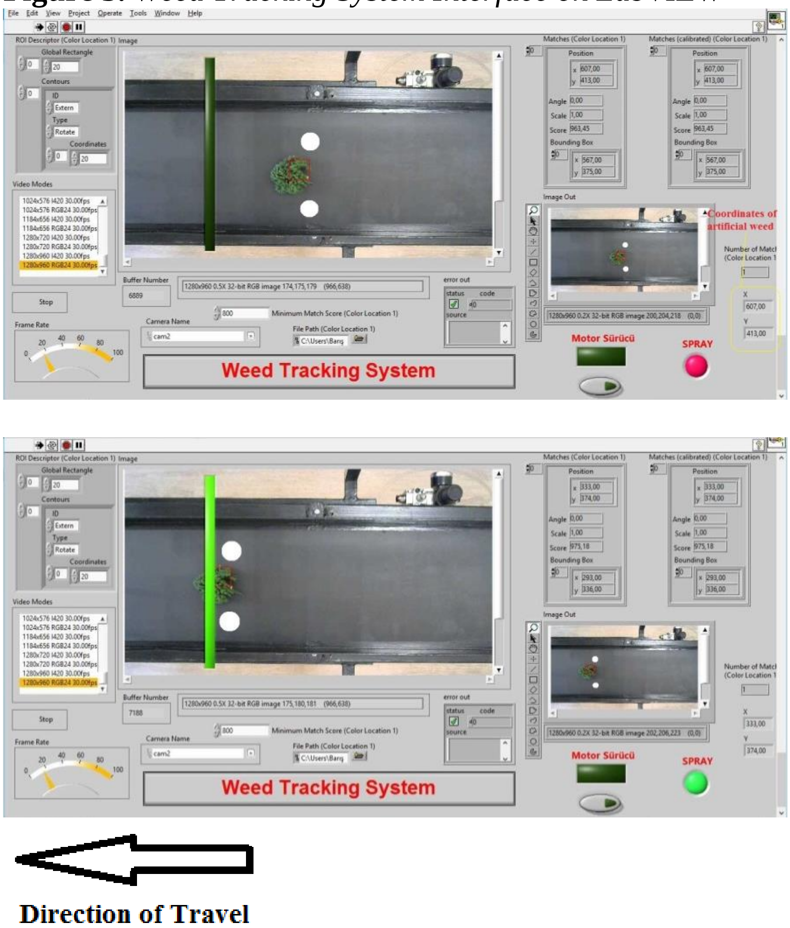
The existence of artificial weed samples could be determined with the help of image thresholding method by selecting a threshold value. The artificial weeds could be extracted from the conveyor belt by using that method as shown in Equation 2.

$$g(x,y) = \begin{cases} 1 & if\ f(x,y) > T \\ 0 & if\ f(x,y) \leq T \end{cases} \qquad (2)$$

Where *g(x,y)* is the processed image; *f(x,y)* is the pixel value of the image on the x_{th} column and y_{th} row; *T* is the selected threshold value (Gonzalez and Woods, 2008).

The artificial weeds, whose pixels were greater than a predetermined threshold value, were tracked instantaneously according to its coordinates by using a LabVIEW interface while it was moving on the conveyor belt. Filter papers located on both sides of the artificial weeds (Figure 3) were used to detect the amount of deposits on the artificial weeds for the speeds of 0.5, 0.75, 1, 1.25, 1.5 and 1.75 km/h, respectively.

Figure 3. *Weed Tracking System Interface on LabVIEW*



While the artificial weed passing under the predefined coordinates, spraying process was carried out by activating the solenoid valve. Solenoid-activated spray nozzle and camera were mounted at a stationary position and at a height of 50 cm above the conveyor belt while weeds were on a movable belt.

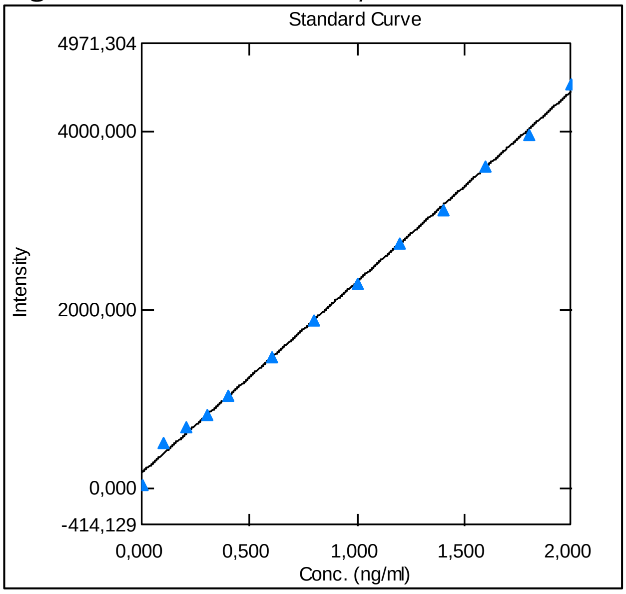
Deposition Measurements

Filter papers located on both sides of the artificial weeds were used in order to determine the deposits in nozzle spray pattern. Experiments were repeated three times for six speeds. After the spraying application, the filter papers were removed from the conveyor belt and placed in glass jars separately. BSF concentration was 0.4% in tap water and the spraying pressure of the system was set to 200 kPa. 20 ml distilled water was added into the jars and each jar was shaken for 10 minutes. Then, the filter papers taken from each glass jar were put into the sample chamber of the spectrofluorophotometer to be analyzed and determine the amounts of tracer on filter papers. The following equation was used to convert the fluorometric reading to the real concentration of samples. Standard curve of BSF material was given in Figure 4.

$$y = 2131{,}21x + 180{,}052 \quad (3)$$

$$r^2 = 0{,}99793$$

Figure 4. *Standard Curve of the BSF Material*

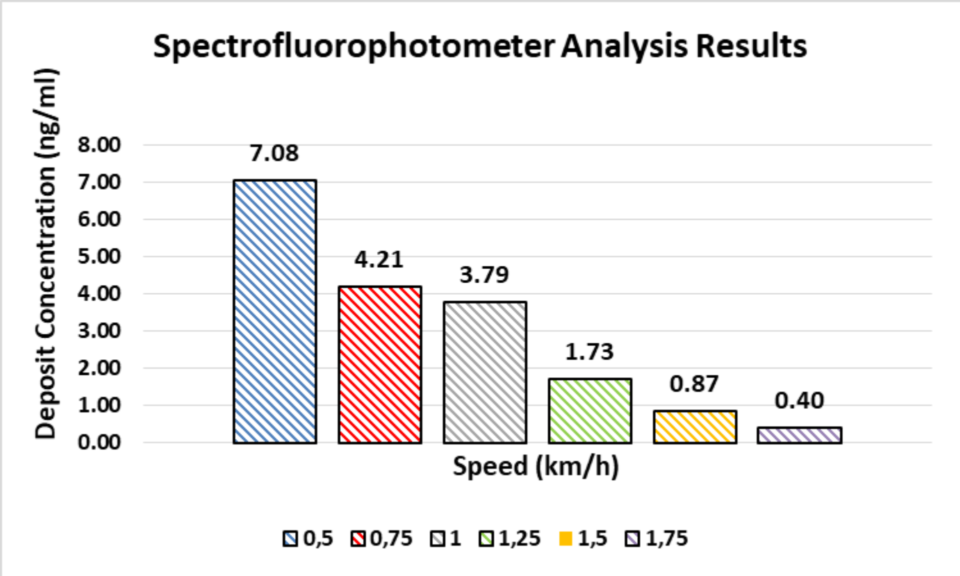


Findings/Results

While real-time object tracking performance of the system was not affected from the conveyor belt speed, travel speed of the artificial weeds on the conveyor belt affected the spraying accuracy negatively. That is, the speed parameter was significant on the spraying performance of the system. These spraying delays could be related to the solenoid valve response time, system pressure fluctuations resulting from sudden opening and closing of spray nozzles, camera quality, etc.

The average deposit concentration values for the spraying system speeds of 0.5, 0.75, 1, 1.25, 1.5 and 1.75 km/h were given in Figure 5. Although the spraying pressure of the system did not change, the amounts of deposit on artificial weeds were significantly decreased with the increasing spraying speed.

Figure 5. *Average Deposit Results at Different Spraying Speeds*



Discussion

In this study; a real time, machine-vision based, site-specific system was developed and evaluated by using LabVIEW software. Image processing and automation algorithms were used to track the coordinates of artificial weeds and apply site-specific spraying process. The accuracy of the spraying performance decreased at higher travel speeds based on the laboratory evaluation. The site-specific spraying system could detect and track the artificial weeds and realize the spraying application successfully. It obviously provided economics in the use of herbicides when compared to the conventional spraying method. Main advantage of this system was that the spraying application was only for the artificial weed samples instead of the whole area. The amount of deposits on the artificial weeds decreased when the conveyor belt speed increased. Although the spraying pressure of the system did not change, the spraying deposit was significantly reduced depending on the speed according to the spectrofluorophotometric analysis results.

Conclusions

Developed system will be both cost effective and environmentally friendly. This study will be a model for researchers who are interested in working on similar issues and will have a positive effect on system design in similar areas.

References

Gonzalez, R. C., and Woods, R. E., 2008. Digital Image Processing. 3rd ed. Pearson International Edition, USA: Prentice Hall.

Jafari, A., Mohtasebi, S. S., Jahromi, H. E., and Omid, M., 2006a. Weed Detection in Sugar Beet Fields Using Machine Vision. *International Journal of Agriculture & Biology*. 8 (5), 602-605.

Jafari, A., Mohtasebi, S. S., Jahromi, H. E., and Omid, M., 2006b. Color Segmentation Scheme for Classifying Weeds from Sugar Beet Using Machine Vision. *Iranian Journal of Information Science & Technology*. 4 (1), 1-12.

Loghavi, M., and Mackvandi, B. B., 2008. Development of a Target Oriented Weed Control System. *Computers and Electronics in Agriculture*, 63, 112-118.

Loni, R., Loghavi, M., and Jafari, A., 2014. Design, Development and Evaluation of Targeted Discrete-Flame Weeding for Inter-Row Weed Control Using Machine Vision. *American Journal of Agricultural Science and Technology*. 2 (1), 17-30.

Perez, A. J., Lopez, F., Benlloch, J. V., and Christensen, S., 2000. Colour and Shape Analysis Techniques for Weed Detection in Cereal Fields. Computers and Electronics in Agriculture. 25, 197-212.

Sabanci, K., and Aydin, C., 2016. Image Processing Based Intelligent Spraying Robot for Weed Control. *Fresenius Environmental Bulletin*. 25 (12), 5305-5312.

Sabanci, K., and Aydin, C., 2017. Smart Robotic Weed Control System for Sugar Beet. *Journal of Agricultural Science and Technology*. 19, 73-83.

Shirzadifar, A. M., Loghavi, M., and Raoufat, M. H., 2013. Development and Evaluation of a Real Time Site-Specific Inter-Row Weed Management System. *Iran Agricultural Research*. 32 (2), 39-54.

Slaughter, D. C., Giles, D. K., and Downey, D., 2008. Autonomous Robotic Weed Control Systems: A Review. *Computers and Electronics in Agriculture*. 61, 63-78.

Tellaeche, A., Burgos-Artizzub, X. P., Pajaresa G., and Ribeirob, A., 2008. A Vision-Based Method for Weeds Identification through the Bayesian Decision Theory. *Pattern Recognition Society*. 41, 521-530.

Tian, L., 2002. Development of a Sensor-Based Precision Herbicide Application System. *Computers and Electronics in Agriculture*. 36, 133-149.

Timmermann, C., Gerhads, R., and Kühbauch, W., 2003. The Economic Impact of Site-Specific Weed Control. *Precision Agriculture*. 4, 249-260.

Wan Ishak, W. I., and Abdul Rahman, K., 2010. Software Development for Real-Time Weed Colour Analysis. *Pertanika Journal of Science & Technology*. 18 (2), 243-253.

Yang, C., Prasher, S. O., Landry, J., and Kok, R., 2002. A Vegetation Localization Algorithm for Precision Farming. *Biosystems Engineering*, 81 (2), 137-146.

Yang, C., Prasher, S. O., Landry, J., and Ramaswamy, H. S., 2003. Development of an Image Processing System and a Fuzzy Algorithm for Site-Specific Herbicide Applications. *Precision Agriculture*. 4, 5-18.