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# Automatical detection of insect pests in cole crops (*Brassica oleracea*)

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## 1. Introduction, Knowledge, Objectives

Yield as well as the crop quality of vegetables, fruits and field crops can be diminished by insect pests. Insect infestation can be controlled in conventional farming by synthetic chemical substances (insecticides), however according to the guidelines of integrated pest management and good agricultural practice the use of insecticide applications should be limited to an essential extent only. In this context assessment of pest density in combination with estimated pest population in the field is a cornerstone of a sustainable integrated management (Riley 2008). Depending on the insect and crop species, different methods or combination of methods for estimation of pest densities in the field are recommended. Crop scouting, a visual monitoring of pest populations (Muirhead-Thomson 1991; Forster et al. 1992, Meyer 1996; Dixon et al. 2002; Smith et al. 2002) and forecasting models (Otto & Hommes 2000) are possible decision making Tools in the field. The currently available estimation methods for assessment of insect pest population under field condition are labor-intensive, time-consuming or not area-specific and for this reason rarely applied in practice. Monitoring could be eased by automation. For instance in orchards technically modified pheromone-traps for automatic detection of codling moth ( *Cydia pomonella* L.) are commercially available such as TrapView (Efos; Slovenia) or Z-Trap (Spensa Technologies; USA). Comparable tools for field vegetable scouting are not yet available. Therefore, a main aim of this research was to work out area-specific and easy-to-handle monitoring methods for pests in field vegetables based on automated recording, transmission and evaluation of pest-specific data. Systems described in this paper were tested in cabbage (*Brassica oleracea*) crops.

## 2. Material and Methods

The automated recording focused on three Systems which were TrapView, Triangel Camera System (TCS) or Opto Electronic Object Scanner (OEOS) for digital detection of adult cruciferous insect pests in the years 2013 and 2014. The size of insects varied according to species between 6 mm (e.g. *Delia radicum* L.) and 50 mm (e.g. *Pieris rapae* L.). Experimental set-ups differ depending on the digital method and year.
TrapView (Efos, Slovenia) is a commercially available, technically modified delta pheromone-trap. For the first time, TrapView was used under field conditions with pheromones of the diamondback moth (*Plutella xylostella* L.). The trap consisted of a green colored plastic housing (25 X 19.5 X 21 cm), solar panel (size: 18 X 13 X 1.8 cm, Vpm: 6 V,

Voc: 0.333 A, Isc: 0.349 A, maximunm system voltage: 750 V), sticky card (24 X 19 cm) and a device equipped with 4 cameras (2 Mpix each), SIM card Slot, rechargeble Li-ion battery (3.7 V/ 220 mAh) and LED diodes for camera illumination. The system took regularly ones a day in the night photos from the sticky plate which were transmitted via GPRS (General Packet Radio Service) and archived in a cloud-based account (www.trapview.com). The TrapView data were compared with the number of male adults trapped in conventional, brown coloured delta pheromone traps (Andermatt Biocontroll, Switzerland) and with the number of caterpillars visually counted at ten fixed control points with five white cabbage plants (*Brassica oleracea* L. convar. *capitata* (L.) Alef. var. *alba* DC. c.v. 'Storema') each. Crop scouting took place once a week and traps were controlled twice a week. Traps were tested in 2013 and 2014 at two different locations: Brunswick (ca. 0.2 ha) and Hötzum (ca. 1 ha). At Brunswick savoy cabbage, brussels sprouts, broccoli, cauliflower and white cabbage were planted and at Hötzum (8 km south of Brunswick) cauliflower, white cabbage, brussels sprouts and broccoli. The experimental setup differed between 2013 and 2014. First, the suitability of the digital trap for catching diamondback moth in the field was verified in 2013 by placing one TrapView and one conventional trap in 50 m distance. In 2014 the trap eligibility for estimation of the moth population was evaluated establishing two control points per plot 50 m apart from each other. On each control point two traps were arranged in a 15 m distance (delta trap vs. TrapView and delta trap vs. delta trap). The correlation between the number of caterpillars and adults were evaluated with the Pearson correlation test. TrapView and conventional Trap catches were evaluated with generalized linear mixed models using AD Model Builder (glmmADMB package) and least-squares means package. For statistical analysis the software R version 3.2.1 was used (http://www.R-project.org).

The Triangle Camera System (TCS) was developed in collaboration with the University of Applied Science Osnabrück. The TCS is a video surveillance system aimed at the detection of the cabbage root fly (*Delia radicum* L.) near the ground. The system consists of a triangular housing with yellow-colored inner walls (..) and three webcams with 1080p-HD sensors (Microsoft, USA). The images were directly processed using algorithms of the OpenCV(Open Computer Vision Library) software on a joined notebook (operating system Windows). In 2013 a first 3 weeks recording was performed in the field on dry days at Brunswick. 2014 for economical and practical reasons the operating systems was changed to RaspbaryPi and Raspbian (Linux, open-source) and tested on broccoli ( *Brassica oleracea* L. convar *botrytis* (L.) Alef. var. *cymosa* Duch. c.v. 'Marathon'). For comparison in the field felt traps (Freuler & Fischer 1982) recorded the number of deposited eggs and a video camera (Sony, Japan) recorded the number of insects. The video camera was focused on the lower part of the plant with TSC and was manually turned on daily.

The Opto Electronic Object Scanner (OEOS) (iotec, Germany) is a commercially available light barrier system for the detection of plant parameters e.g. plant height. The OEOS consists of emitter, receiver, computer with inoex software and network adapter. The emitter generates parallel line laser beams of the wavelength between 635 and 640 nm. Receiver is a CCD (charge-coupled device) line sensor with a resolution of 0.064 mm (1 X 1536 Pixels, pixel size 64 X 64 µm) and 4000 Hz measurig frequency. Between emitter and 50 cm apart receiver was a two dimensional light field. If an optically opaque object interrupts the laser beams the shadow will be recorded on the reciever side as a LLD file (Loan Level Disclosure Data). The system was tested 2014 under controlled conditions in the greenhouse in a rearing cage (47 X 47 X 60 cm) for detection of flying insects such as small white (*Pieris rapae* L.), cabbage moth (*Mamestra brassicae* L.) and cabbage root fly (*Delia radicum* L.). Therefore, cabbage moth was reared on white cabbage and cabbage

root fly on turnip at the Institute for Plant Protection in Horticulture and Forests, Julius Kühn-Institute. 10 small whites were sampled on the day of the experiment with a sweep net in a white cabbage field. Insects were maintaind at 20°C, under a photoperiod of 16 hours light and 1008-1150 lm light intensity.

## 3. Results

TrapView was easy to handle and the transfer of data was unproblematic. On the sticky plate in addition to the diamond back moth other insects (e.g. flies) were trapped which disturbed the Efos algorithms for the automatic detection of the moth. For that reason the automatic evaluation had to be checked visually on the basis of transmitted photos of the sticky card. The diamond back moths were well identifiable on the screens. The number of moths in the digital trap did not differ significantly from the catches of the conventional trap. Furthermore the number of caterpillars counted in the plant canopy (white cabbage) correlated significantly with the number of moths cought in the TrapView as well as in the conventional delta-trap at Brunswick and Hötzum (Table 1). The strong positive relation between the numbers of adults and caterpillars was higher in Hötzum than in Brunswick.

Table 1: Values of Pearson correlation test (numbers of caterpillar vs. number of diamond back moths adults) (α=0.05).

| Trap type | Brunswick | | Hötzum | |
|---|---|---|---|---|
| | p-value | Correlation coefficient | p-value | Correlation coefficient |
| Conventional delta trap | 0,0005 | 0,7 | $6{,}53e^{-0{,}6}$ | 0,9 |
| TrapView | 0,002 | 0,7 | $1{,}2e^{-0{,}5}$ | 0,8 |

Cabbage root flies were recognized by the TCS in the field. During the field experiments in 2013 with TCS all in all 7295 pictures was made by the system. On 810 pictures the movements of 10 flies were recorded and marked by image processing of the system on the lower part of the broccoli plant stem. 10 flies moving to the lower part of the plant were as well recorded with the video camera. According to the data of felt traps and TCS oviposition of five flies was proven and the duration of the stay on the lower part of the plant was between 7 and 13 minutes. In contrast the five flies without egg deposition stayed only between 1 to 4 minutes. Other insects such as aphids or parasitoid wasps were not spuriously identified as cabbage root flies. However, the TCS worked stable only for 15 minutes because of difficulties with the operating system to control the three webcams and became obvios when 1700 images with incorrect color which differ from the usual picture in color. Restart of the system was necessary. During the day the position of the sun as well as the illumination of the plant changed. Some sides of plants were shadowed and parts of a plant were shadowed and falsely marked as fly. For that reason 4785 pictures were wrongly recorded. In 2014 the outdoor stability of the system was improved by the modified operating system, though the interface between the camera and data processing was still not properly working.

The preliminary results indicate that the size and shape of an insect can be measured based on digital data of the OEOS (Figure 1). The differentiation between moths, butterflies and flies is possible under controlled conditions with the sensor. The OEOS can record the data continuously for several hours. However the currently available iotec software for the system can convert the data to CSV (comma-separated values) or BMP (Bitmap) file only for a maximum of four minutes recording time. The conversion of the raw data for data analysis and image processing for recorded pest under controlled condition is in process.

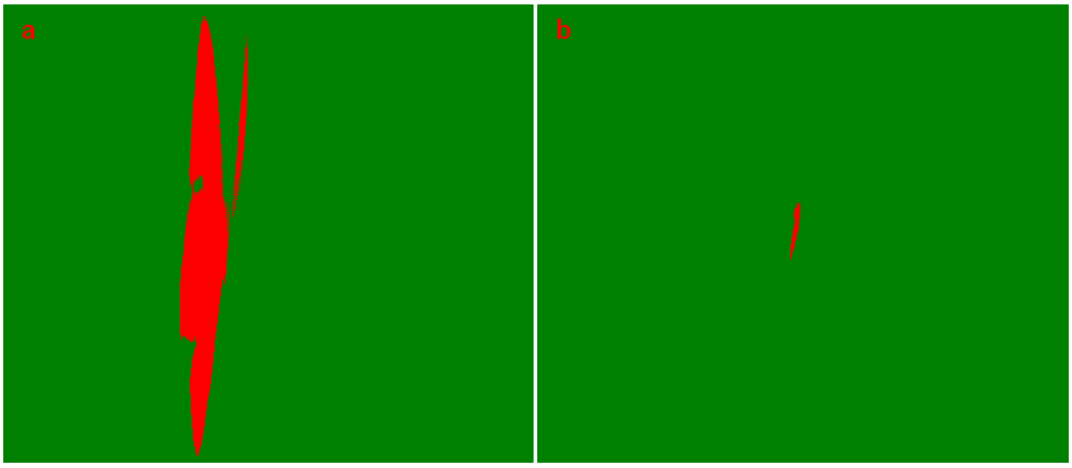


Figure 1: Shadow picture of small white (a) and cabbege root fly (b). The Pixel size of both images is 489 x 417

## 4. Discussion

Monitoring of insect pests in the field in combination with economic thresholds can reduce the application of insecticides up to 60 % in vegetable crop (Smith et al. 2002; Forster et al. 1992). Insect pest monitoring can be eased and standardized by digital surveillance methods.

Different types of digital decision support systems for the detection of certain adult pests species were tested under controlled as well as under field conditions. The tested digital methods for detection of adult insect pests showed different stages of development. TrapView was the most advanced system and was easy to handle. Weekly control of the trap in the field was not necessary which led to savings in time, only a monthly attendance of TrapView was required to replace the sticky card and pheromones. The system was generally suitable for the detection of lepidopteran pests like diamond back moth. Following points should be considered by the utilization of the trap: insects of interest should have a minimum size of 3 mm and proper pheromones should be available.

TCS as well as OEOS are prototypes which have to be optimized, nevertheless the systems are promising. Cabbage root fly is an important pest with limited control possibilities for *Brassica oleracea*. The development of digital decision support systems is of greater importance as it would direct application to the point. With image processing of TCS it was possible to detect the cabbage root fly during the oviposition process. Better assessment of the oviposition period would improve the already existing computer based estimation method PASO (Hommes at al. 1993). The final evaluation of the system is not possible at the moment, since it is not apparent how firm and reliable the TCS works during everyday

use. Optimizations are necessary at the interface between the camera and data processing unit. OEOS was the only tool able to record both flies and moths simultaneously and differentiated under controlled conditions. According to current knowledge, the system could be installed outdoor above plant canopy and monitor an area of 4 $m^2$. For automatic detection of insects an algorithm should be developed and tested under field conditions.

## 5. Conclusions

The development of a robust field suitable digital monitoring method requires extensive work for calibration and automation. The preliminary results indicate that the three described systems are generally suited for the detection of adult insect pest. However, further optimization and testing in the field are necessary to evaluate the quality of the systems for practical use.

## 6. Literature


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