

# Hairy root disease: Digitized images based method to monitor the hairy root development on eggplants growing on soilless substrate in greenhouse

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## Introduction

In greenhouses, *A. Rhizogenes* is a bacteria responsible for Hairy Root Disease that mainly affects crops grown on substrate. Contaminated plants produce excessive roots in rockwool slabs.

In the framework of the C-IPM project C-RootControl, one of the objectives of which is to reduce the symptoms created by the disease, a digitized method for easy and accurate monitoring of the root development has been developed and validated.

## Plant Material and greenhouse conditions

- Eggplant
- Venlo type glasshouse
- Rockwool substrate
- Planting density of 4.7 shoots/m<sup>2</sup>.
- Variety/Rootstock: Scorpio/Kaiser in 2017 and Kylie/Beaufort in 2018.
- Temperature 18-22-24°C (night-day-aeration).

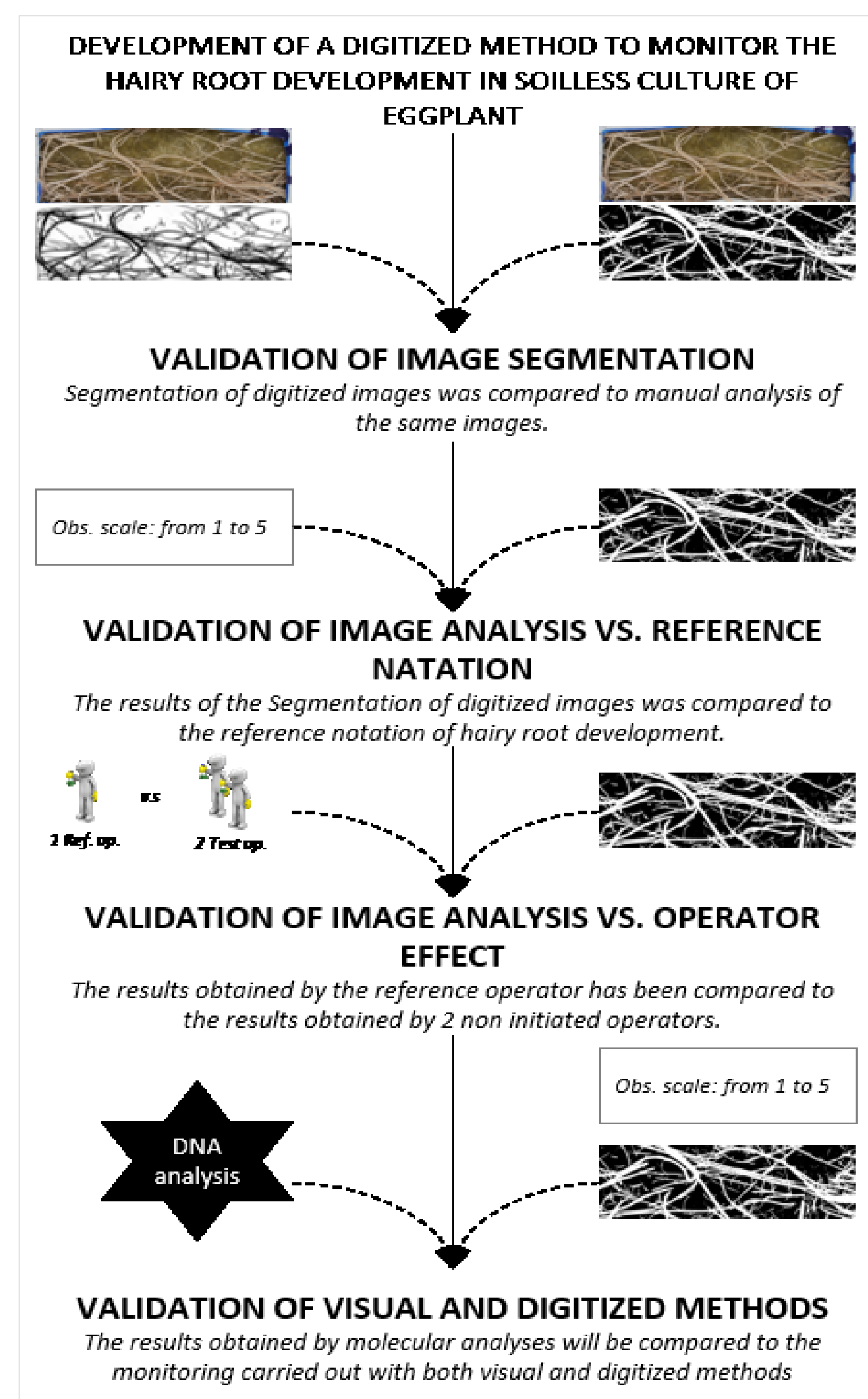


Fig. 1. Development steps of digital method to monitor the hairy root disease development.

## Three validation steps results

### -----IMAGE BINARIZATION-----

The first step was to compare image binarization by digitized method vs. manual method carried out by a reference operator who manually re-drew the roots on images (figure 1). Results of both methods were compared and a relation between the two methods was established at R<sup>2</sup>=0.81 (figure 2A).

### -----DIGITIZED VS. VISUAL METHOD-----

In a second step, the digitized method was compared to the visual method which consists in giving a score between 1 and 5 depending on the level of root occupancy in the slab windows. 3600 images and corresponding visual evaluations were collected in 2017. The strong correlation between methods has been obtained (R<sup>2</sup>=0.88)(figure 2B).

### -----DIGITIZED METHOD VS. EFFECT OF OPERATORS-----

In a third step, the effect of the operator on the practice of the digitized method was evaluated. Images were processed in digitized method by a reference operator and 2 test operators (figure 3A). A R<sup>2</sup>-value of 0.83 was calculated, meaning a good relationship between the reference operator and the two test operators.

## Application at large scale in greenhouse

- 2 years trials on Eggplant cultivated in soilless system in greenhouses.
- 8000 images and visual evaluations performed over two years trials.
- Molecular analyses confirmed infested vs. non-infested plants
- Digitized method allowed to monitor the infestation courses over the 2 seasons of trials, 2017 (figure 4) and 2018 (figure 5).

### -----VALIDATION STEPS-----

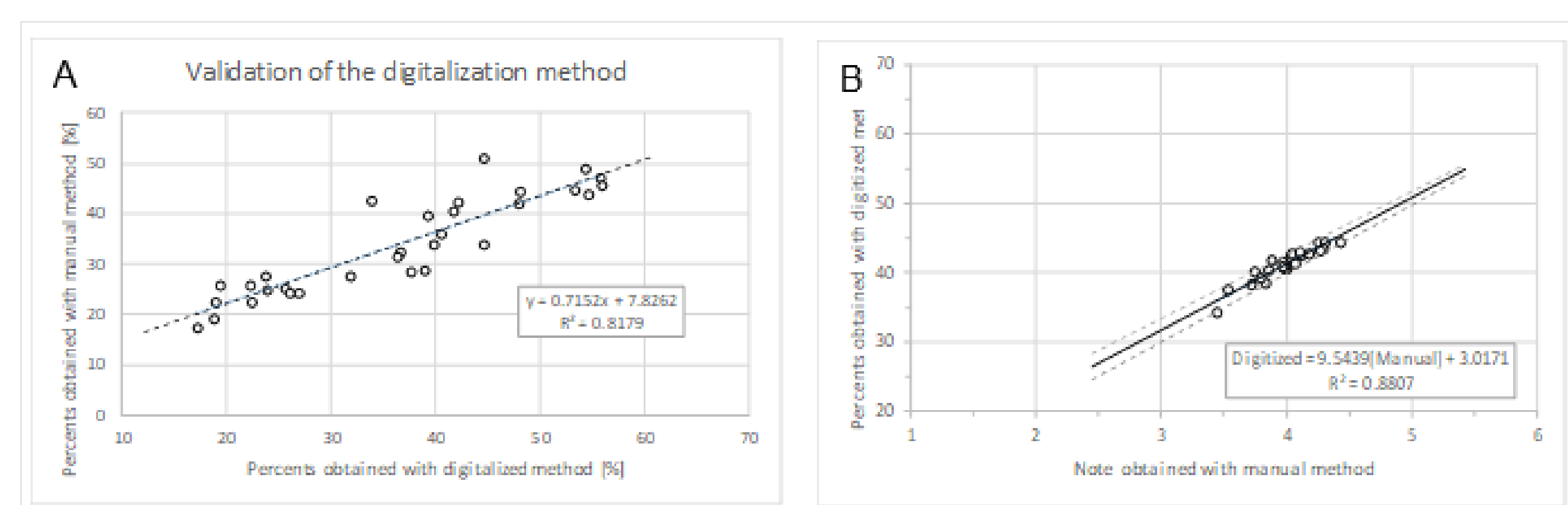


Fig. 2. Digitized vs. manually analyses of root pictures (A), Digitized analyses of root pictures vs. visual annotation (1 to 5) of roots proliferation.

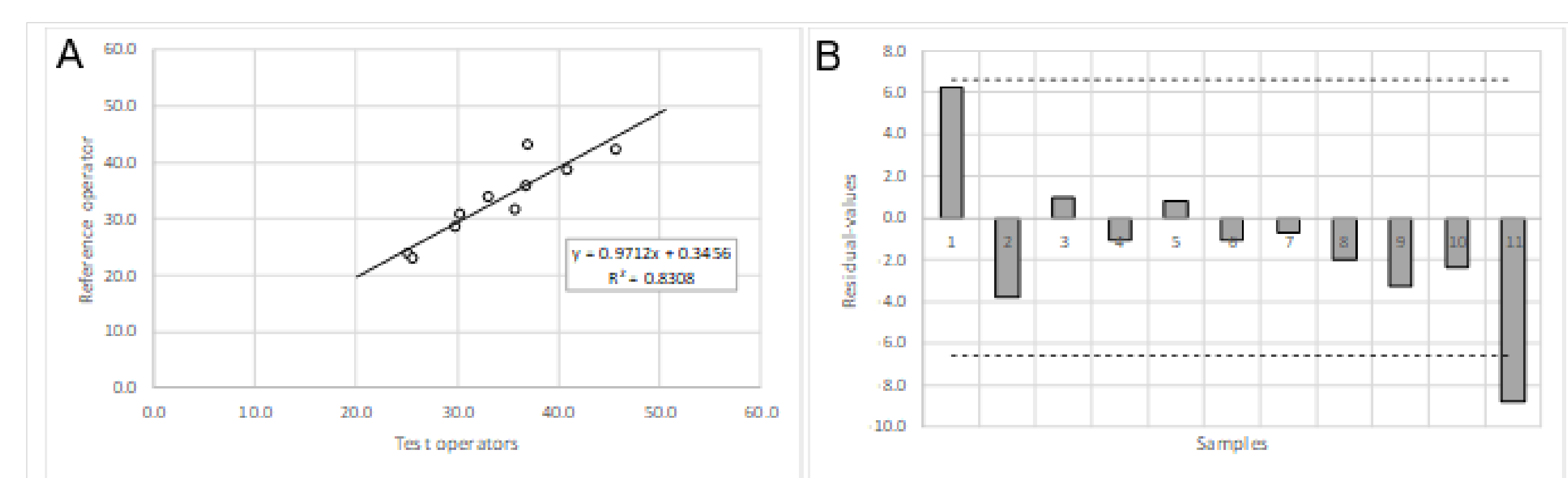


Fig. 3. Validation of the manual method by comparing the effect of 2 test operators vs. a reference operator on final result. Test operators results vs. reference operator results (A) and residual values calculated between reference and tests operators results (B).

### -----APPLICATION OVER 2 SEASONS-----

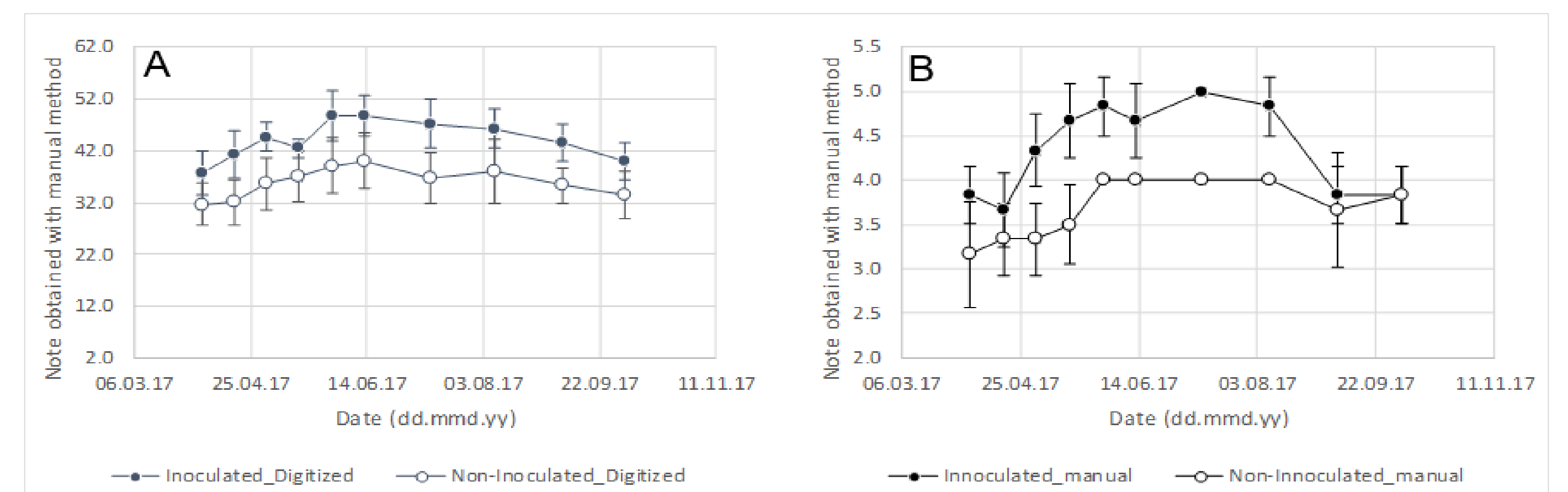


Fig. 4. Evolution of the percentage of roots with digitized (A) and visual (B) methods. Data from 2017. Error bars represent the confidence intervals at a threshold of 5%.

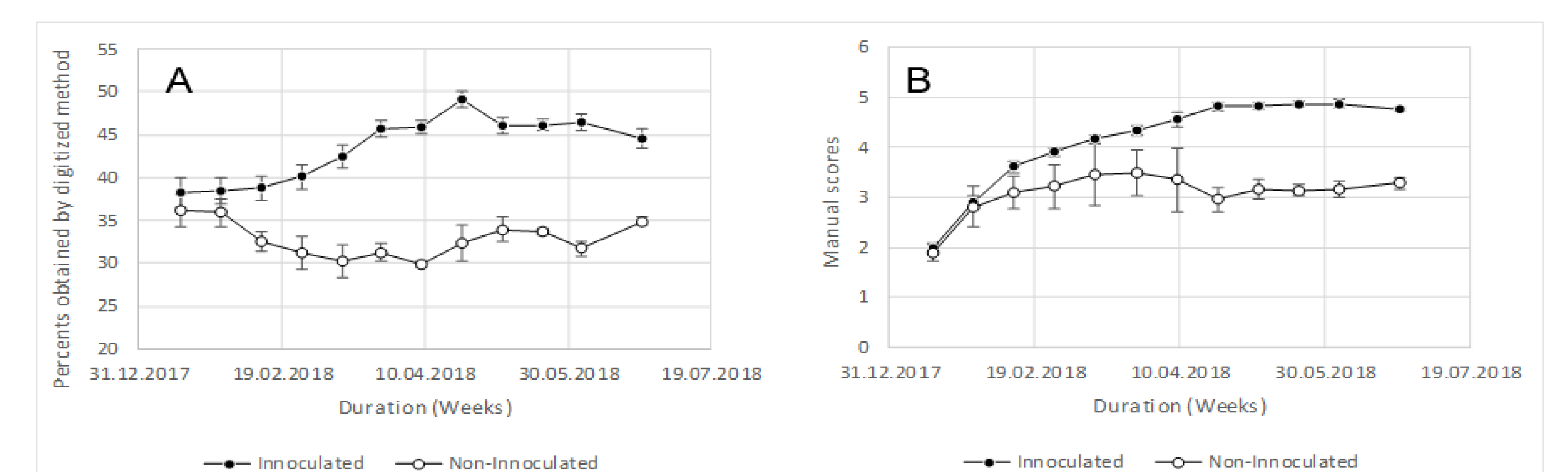


Fig. 5. Evolution of the percentage of roots with digitized (A) and visual (B) methods, Data from 2018. Error bars represent the confidence intervals at a threshold of 5%.

## Conclusions

A new and accurate method based on a simple image processing of root system has been developed to monitor the hairy root disease on soilless Eggplant culture in greenhouse. The present study has been carried out within a EU-C-IPM project in which several cropping systems have been compared to reduce the hairy roots disease. The new digitized method allowed us to work at a large scale by shooting a huge number of root systems (>8000) and thus, provide accurate information to research and further to maybe production.