Silicon enhances the constitutive defence pathway in strawberries against strawberry powdery mildew and two-spotted spider mites

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Introduction

Strawberry powdery mildew (*Podosphaera aphanis*) is a major fungal disease affecting strawberry production worldwide and can result in great yield losses. Work at University of Hertfordshire has shown that the use of a silicon (Si) nutrient 'Sirius®' (OrionFT) contributed to enhanced constitutive (passive) defence pathway (i.e. morphological changes in the leaf structure) in strawberry plants. The work reported here assessed the use of this silicon nutrient applied via the fertigation tubes in contributing to delayed *P. aphanis* epidemic build-up and reduced number of two-spotted spider mites (*Tetranychus urticae*) in commercial strawberry tunnels, as a result of such enhanced passive defence pathway.

Aims

To investigate the effects of the silicon nutrient in enhancing the constitutive defence pathway in strawberries, and how did these changes contributed to reduced severity of *P. aphanis* and *T. urticae* on strawberry leaves.

Materials and Methods

The experiments were carried out in polythene tunnels at a commercial strawberry farm in Wisbech, UK in 2014 and 2015. In the 2014 experiment, the silicon nutrient was applied once a week at a concentration of 0.017% (volume/volume) in the fertigation system. Four treatments were undertaken, which were: untreated control, commercial fungicide only, 0.017% Si only and 0.017% Si plus commercial fungicide. 75 leaf samples (15 leaves x 5 replicates) were taken per treatment fortnightly for leaf mycelium and spider mite assessment. In the 2015 experiment, two more treatments (0.017% Si double dosage only and 0.017% Si double dosage plus commercial fungicide) were added based on the 2014 treatments. Sampling and assessment methods were consistent with the 2014 experiment. Strawberry crops received commercial fungicide applications according to the farm normal spray programme. Area Under the Disease Progress Curve (AUDPC) was calculated for each treatment.

Fig. Strawberry powdery mildew infected leaf (a) peduncles (b) and fruit (c)

Results

The strawberry plants that received silicon were significantly less infected by *P. aphanis* ($P<0.05$) for the period of 2014-2015 (Fig.1A(2014) & Fig.1B(2015)). 0.017% Silicon nutrient plus commercial fungicide treatment had the smallest disease score (AUDPC=63 in 2014, and 53 in 2015) among all treatments in both years. Crops from the 0.017% Silicon nutrient alone treatment also showed a smaller disease severity (AUDPC=475 in 2014 and 267 in 2015) than untreated control (AUDPC=662 in 2014 and 281 in 2015). Plants showed a delayed epidemic build-up for approximately two weeks compared to untreated control in 2014 (Fig.1A).

Plants from silicon treatments were also less infested by *T. urticae* ($P<0.001$) for the period of 2014-2015 (Fig.2A(2014) & Fig.2B(2015)). In 2014, two silicon treatments had smaller numbers of *T. urticae* per strawberry leaf than untreated control. Similarly, in the 2015 experiment, 0.017% silicon nutrient only and 0.017% silicon nutrient plus commercial fungicide treatments had an average of 2 *T. urticae* per leaf compared to 9 in the untreated control.

Silicon treated plants had thicker leaf cuticle (Fig 3A&B) and denser layer of leaf wax (Fig 3C&D), and silicon was mainly deposited in leaf epidermis and palisade layers (Fig. 4B).

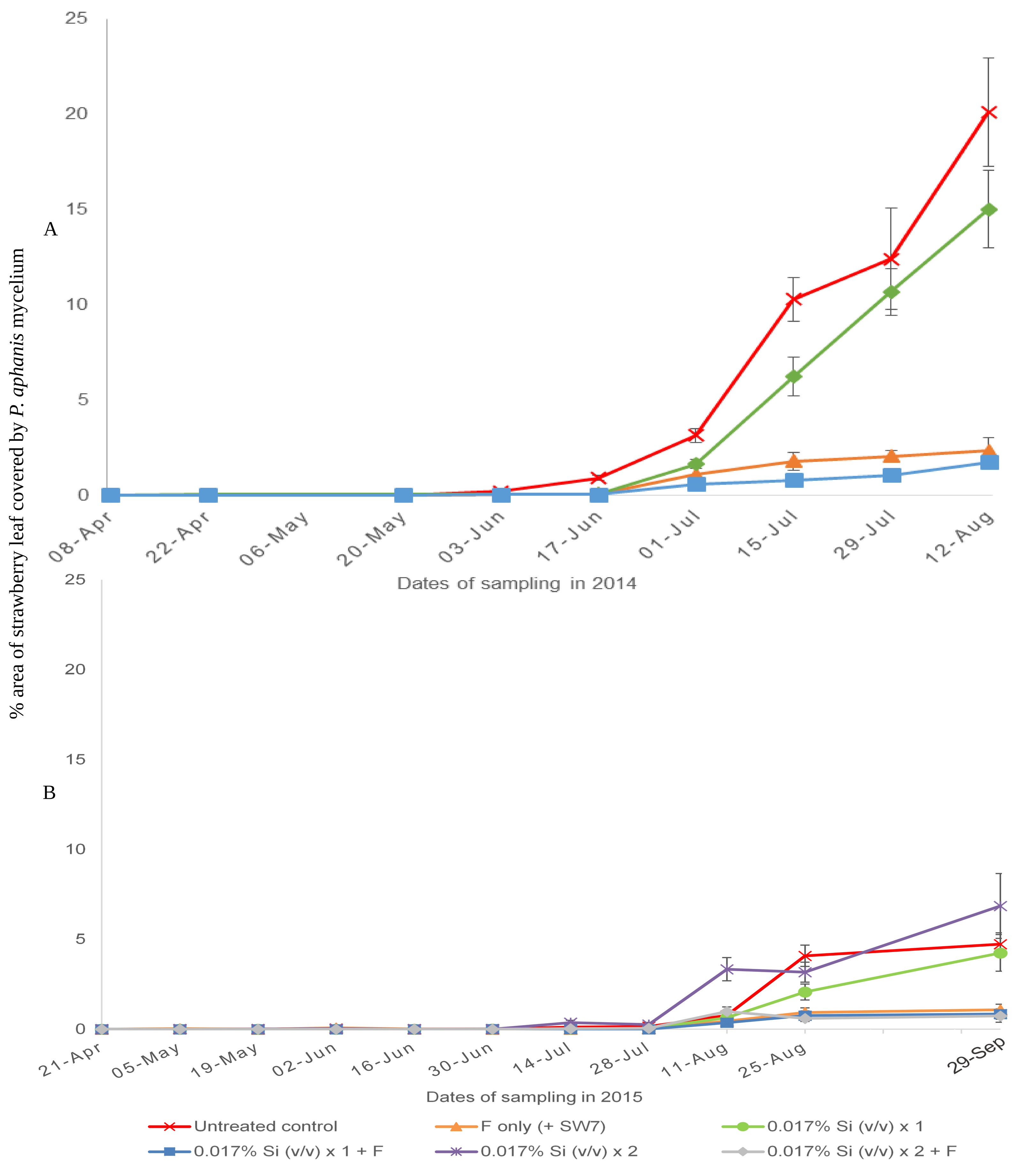

Fig. 1 % area of strawberry leaf covered by *P. aphanis* mycelium from 2014 (A) and 2015 (B) Si fertigation trials. Treatments were: untreated control (2014 & 2015), commercial fungicide only (2014 & 2015), 0.017% Silicon only (2014 & 2015), 0.017% Silicon plus commercial fungicide (2014 & 2015), 0.017% Silicon double dosage only (2015), 0.017% Silicon double dosage plus commercial fungicide (2015).

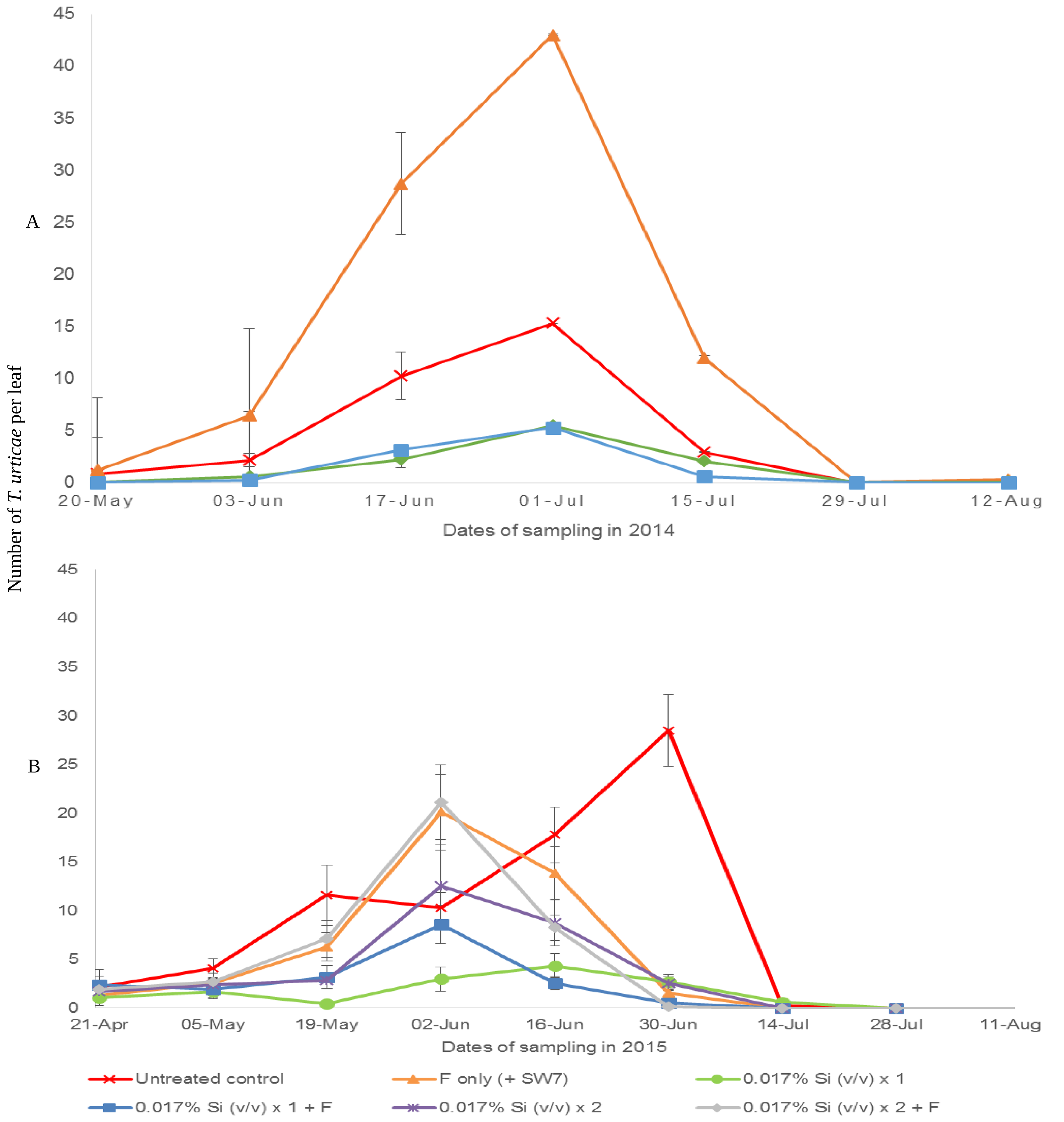

Fig. 2 Number of *T. urticae* per strawberry leaf from 2014 (A) and 2015 (B) Si fertigation trials. Treatments were: untreated control (2014 & 2015), commercial fungicide only (2014 & 2015), 0.017% Silicon only (2014 & 2015), 0.017% Silicon plus commercial fungicide (2014 & 2015), 0.017% Silicon double dosage only (2015), 0.017% Silicon double dosage plus commercial fungicide (2015).

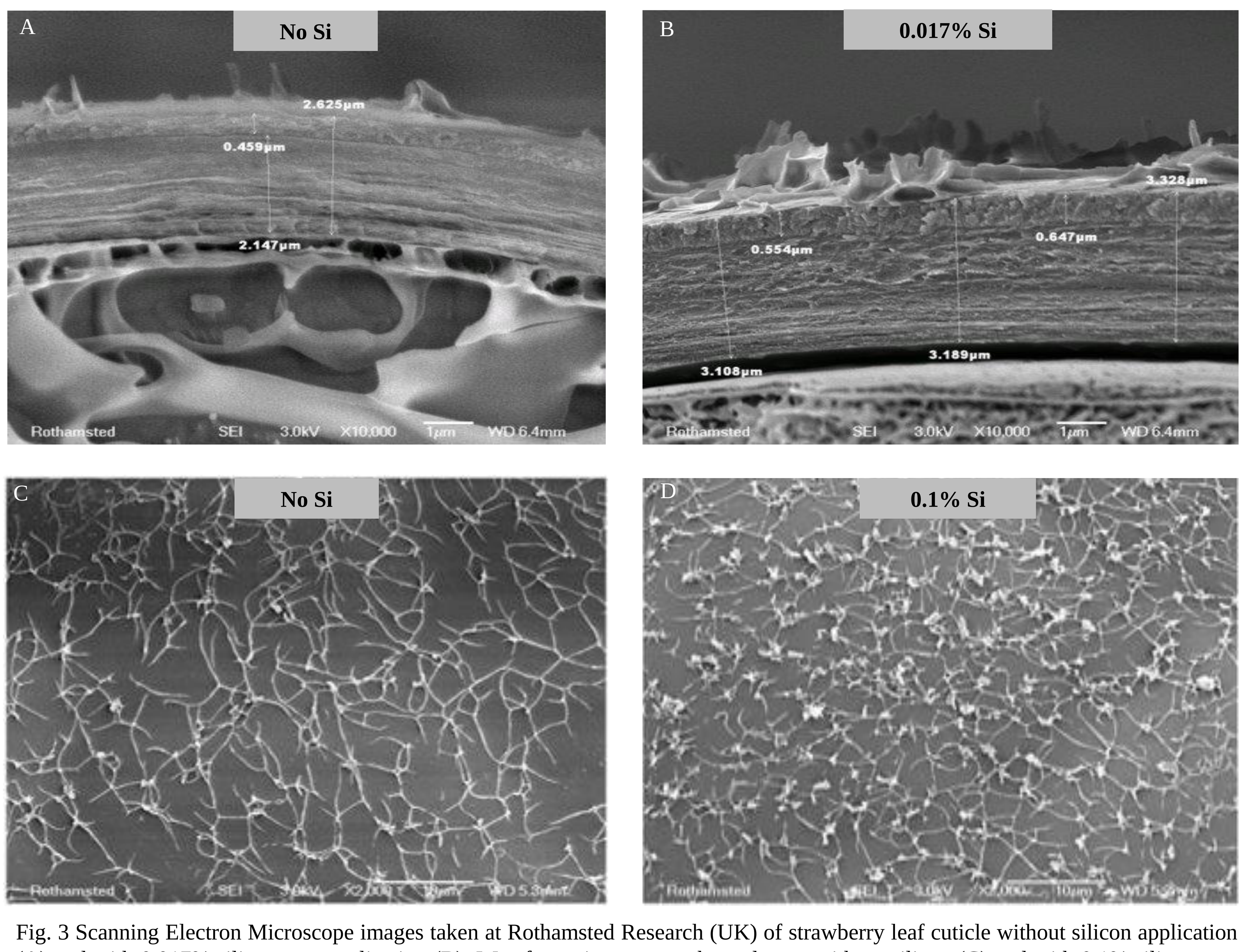

Fig. 3 Scanning Electron Microscope images taken at Rothamsted Research (UK) of strawberry leaf cuticle without silicon application (A) and with 0.017% silicon root application (B); Wax formation on strawberry leaves without silicon (C) and with 0.1% silicon root application (D). (Jin, 2016)

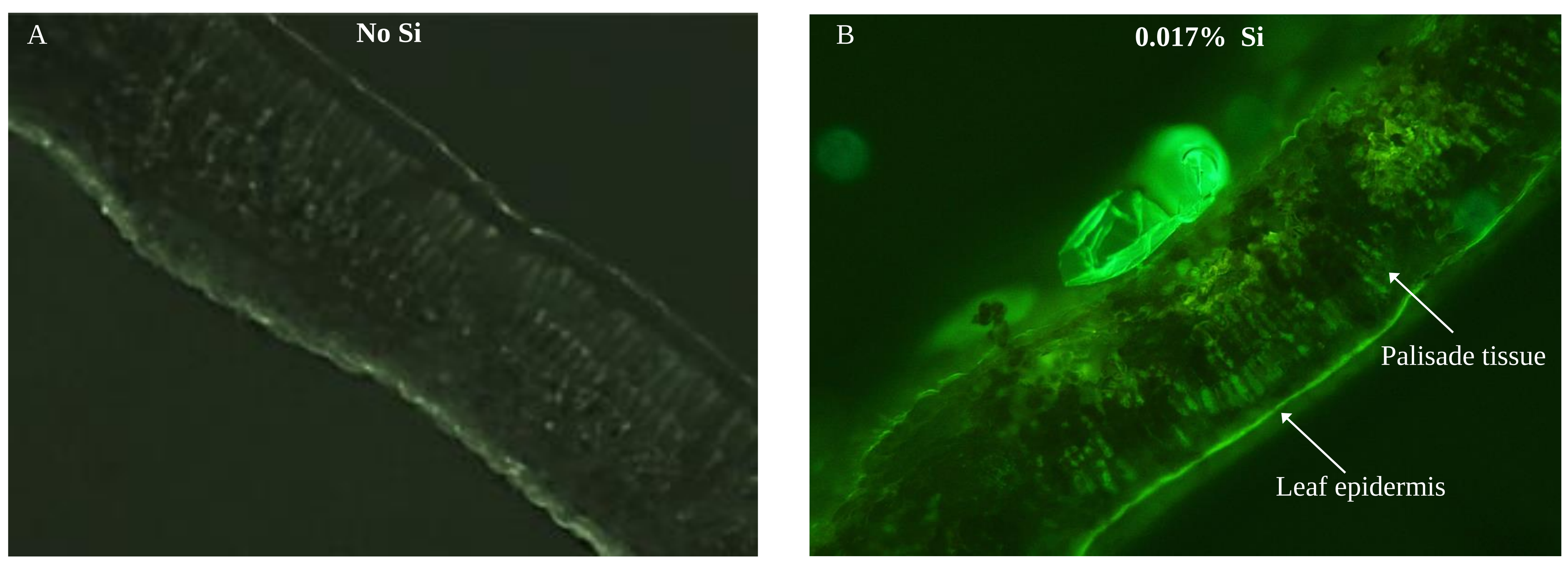

Fig. 4 Cross section of strawberry leaves from control (A) and 0.017% silicon root application (B) treatments stained with molecular tracker dye observed under the Confocal microscope. Silicon was mainly deposited (areas showing fluorescence) in leaf epidermis and palisade layers (B) (Asiana, unpublished)

Conclusion & Discussion

The results indicated that silicon nutrient enhanced the constitutive defence pathway of strawberry plants, resulted in increased leaf cuticle thickness and wax density, which contributed to the reduction of strawberry powdery mildew and two-spotted spider mites. Silicon was found mainly deposited in leaf epidermis and palisade layers, and have other beneficial effects on strawberries, e.g. increased pollen viability, increased °Brix level in the fruits etc., which all worth to be further investigated. The questions lay ahead will be find out how much silicon a plant can take in order to benefit its growth therefore to work out the most suitable application rate for commercial growing.

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