GROWING STRAWBERRY FROM THE EQUATOR TO THE ARCTIC

Benefits of using silicon as a nutrient in sustainable strawberry production

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Introduction

- All plants grown in soil contain silicon (Si) in their tissues (e.g. leaf hairs), with concentrations that vary from 0.1% to 10% of their dry weight. Strawberry is a Si non-accumulator (<1% dry weight)
- A bio-available form of Si (H_4SiO_4) can be taken up by plants and deposited in the leaf epidermal surfaces (Fig. 1)[1]
- Si is referred to as "quasi-essential" for the growth of higher plants due to its important role in alleviating abiotic and biotic stresses[1,2]
- Previous work showed that strawberry plants treated with a bio-available Si nutrient had less severe strawberry powdery mildew (*Podosphaera aphanis*) ($P < 0.05$) and fewer two-spotted spider mites (*Tetranychus urtiae*) ($P < 0.001$) present on the leaves[3]. Si has also been reported to stimulate the plant biomass.

Aim: to investigate the efficacy of Si in reducing the severity of strawberry powdery mildew (2012-2018 field experiment), and effects of Si on the plant biomass (2018 glasshouse experiment).

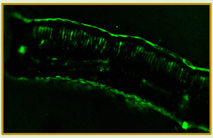

Figure 1 Si deposition in a strawberry leaf cross section, stained with LysoTracker™ dye, viewing under a LED fluorescent microscope

Materials and Methods

2012-2018 field experiment

- All field experiments (Table 1) were done in polythene tunnels on a commercial strawberry farm at Wisbech, Cambridgeshire, UK;
- The Si nutrient product used was Sirius® (main active ingredient: 70-80% tetraethyl silicate, OrionFT Ltd), applied via the fertigation system;
- Area Under the Disease Progress Curve (AUDPC) was calculated to assess the development of *P. aphanis*.

2018 Glasshouse experiment

- A hydroponic experiment was set up in the glasshouse in 5L plastic containers with aeration pumps providing an air supply.
- These contained Hoagland's solution[4], comprised of deionised water, macronutrients and micronutrients essential for plant growth (no Si).

Figure 2 Strawberry plants treated with and without Si in the 2018 Glasshouse experiment

Table 1 Details of Si field and glasshouse experiments between 2012 and 2018

	Year	Cultivation type	Treatment	Application interval	Assessment
Field experiment	2012, 2013	Open field	0.25% & 0.5% Si foliar spray, Untreated control	Weekly	Number of *P. aphanis* colonies per leaf
	2013	Tunnel	0.017% Si root application, 0.017% Si root application + commercial fungicide, Commercial fungicide only, Untreated control	Twice a week	
	2014, 2015	Tunnel		Weekly	% *P. aphanis* mycelium leaf coverage, Number of two-spotted spider mites per leaf
	2016, 2017-2018	Tunnel		Twice a week	% *P. aphanis* mycelium leaf coverage
Glasshouse experiment	2018	Glasshouse	50ml 0.017% Si, 50ml deionized water	Weekly	Number of leaves/fruits, Leaf chlorophyll content, Total biomass, Si localization using LysoTracker™ dye

Results & Discussion

Field experiment:

- Strawberry crops that received weekly Si application (with or without fungicide) had reduced severities of *P. aphanis* ($P < 0.05$) (2012-2016) and *T. urticae* (in 2014-2015) than the untreated control crops (Table 2);
- Si only treatment had lower disease level than untreated control (2012-2016);
- Si only treatment delayed the epidemic for two weeks compared to the no Si treatment (2013-2014).

Glasshouse experiment:

- The wet biomass of the Si treated plants was significantly higher than the untreated plants ($P < 0.05$) (Fig. 2 & Table 3);
- More leaves, higher chlorophyll content ($P < 0.05$) and a greater number of fruits ($P < 0.05$) in Si treated plants

Table 2 Analysis of disease severity (AUDPC) from Si field experiments 2012-2016

Treatment	2012 Spray	2013 Spray	2013 Root	2014 Root	2015 Root	2016 Root
	AUDPC value					
Untreated control	70	27	60.4	662	281	3,423
0.025% Si	51	26	-	-	-	-
0.5% Si	44	12	-	-	-	-
Commercial fungicide only	-	-	1.2	106	69	2,825
0.017% Si only	-	-	12.8	475	267	1,610
0.017% Si plus commercial fungicide	-	-	0.6	63	53	732

Table 3 Results from Si glasshouse hydroponic experiments in 2018

Treatment	Assessment criteria					
	Average number of leaves at the end of treatment	Average chlorophyll content of leaves (μmol m^{2-1})	Initial flowering date	Average number of fruits	Average Brix° content of fruit	Average total biomass (g)
Untreated control	20	665.1	22nd May	15	9	144
0.017% Si	29	813.5	15th May	32	17	169

Discussion

- Application of the Si nutrient in the field experiments improved crop resilience against disease and pests;
- It has also shown stimulatory effects on the biomass and crop quality (e.g. more leaves and fruits etc.) of strawberry plants;
- Good crop management can be achieved by a continuous supply of Si at a recommended rate via the roots

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