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Influence of pre-harvest silicon application on post-harvest disease resistance in strawberry fruits

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Abstract

A strawberry that resists fungal attack from the inside out without a single fungicide spray after harvest sounds too good to be true, yet silicon-mediated defense priming may deliver exactly that. This research investigated the effects of pre-harvest foliar silicon application at three concentrations (0, 50, and 150 mg L⁻¹ potassium silicate) on post-harvest disease resistance of 'Chandler' strawberry fruits grown at the University of Nairobi's field station in Kabete, Kenya, from March to August 2023. Fruits were inoculated with *Botrytis cinerea*, *Colletotrichum acutatum*, and *Rhizopus stolonifer* and stored at 4°C for 14 days. The high-silicon treatment reduced *Botrytis* grey mould incidence by 59.6% (from 78.4% to 31.7%), anthracnose by 57.8%, and *Rhizopus* soft rot by 56.9% compared to untreated controls. Silicon-treated fruits showed 77.8% higher firmness retention, 2.2-fold greater total phenolic content, and significantly elevated peroxidase (POD) and phenylalanine ammonia-lyase (PAL) activities. A strong negative correlation ($r = -0.912$) between tissue silicon concentration and total disease index confirmed a dose-dependent protective effect. These results indicate that pre-harvest silicon application activates both physical and biochemical defense pathways, offering an accessible strategy to extend strawberry shelf life and reduce post-harvest losses.

Keywords: Silicon, strawberry, post-harvest disease, *Botrytis cinerea*, anthracnose, disease resistance, phenolics, peroxidase, phenylalanine ammonia-lyase, shelf life

Introduction

A perfectly ripe strawberry can turn into a furry grey mass within 48 hours of harvest a reminder that *Botrytis cinerea* doesn't wait for an invitation ^[1]. Post-harvest fungal diseases destroy an estimated 20-40% of harvested strawberries globally, with losses reaching 67% in tropical and subtropical regions where cold-chain access is limited ^[2, 3]. Synthetic fungicides remain the default defense, but rising consumer demand for residue-free fruit, tightening EU maximum residue limits, and documented fungicide resistance in *Botrytis* populations are driving the search for alternatives ^[4, 5].

Silicon (Si) is the second most abundant element in the Earth's crust, yet its role in plant defense has only gained wide research attention in the past two decades ^[6]. Pre-harvest silicon application has reduced powdery mildew in cucumber by 40-65% and *Fusarium* wilt in banana by 30-50% ^[7, 8]. The mechanisms include physical strengthening of cell walls through silica deposition, upregulation of pathogenesis-related proteins, and enhanced activity of defense enzymes such as peroxidase and PAL ^[9]. Data on silicon effects in strawberry post-harvest systems remain scarce, especially from East African production contexts ^[10].

This research aimed to: (a) determine the effect of pre-harvest silicon concentration on post-harvest disease incidence, (b) measure silicon's influence on fruit firmness, phenolic content, and defense enzyme activity, and (c) establish the dose-response relationship between tissue silicon and disease resistance ^[11].

Extraction Protocol

Phenolic compounds were extracted by homogenizing 5 g of frozen strawberry tissue in 25 mL of 80% methanol using a polytron homogenizer at 12,000 rpm for 2 minutes. The homogenate was centrifuged at 10,000 g for 15 minutes at 4°C. The supernatant was filtered through

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Whatman No. 1 paper and stored at -20°C until analysis. Total phenolic content was determined by the Folin-Ciocalteu method at 765 nm. DPPH radical scavenging activity was measured at 517 nm. Enzyme extracts for POD and PAL were prepared separately using phosphate buffer (pH 6.8) and borate buffer (pH 8.8), respectively ^[9, 12].

Quality Control

Gallic acid standards ($10\text{--}200\text{ }\mu\text{g mL}^{-1}$) were run with each batch, yielding $R^2 > 0.998$ for calibration curves. Spiked recovery for total phenolics ranged from 94.2% to 101.3%. Enzyme assays were validated using heat-inactivated controls. Intra-assay and inter-assay CVs for POD activity were 3.8% and 6.1%, respectively. All spectrophotometric readings were performed in triplicate on a Shimadzu UV-1800 spectrophotometer ^[12, 13].

Material and Methods

Material

The research was conducted at the University of Nairobi’s Upper Kabete Campus field station ($1^{\circ}15'\text{S}$, $36^{\circ}44'\text{E}$, 1,940 m

asl) from March to August 2023. Ethical review was completed under the university’s agricultural research protocol (UoN-ARP/2023-019, approved 6 March 2023). ‘Chandler’ strawberry plants were established in raised beds with drip irrigation. Three silicon treatments (0, 50, and 150 mg L^{-1} as potassium silicate) were applied as foliar sprays biweekly from flowering to harvest (6 applications total). Each treatment had four replications of 30 plants ^[6, 10].

Methods

Fruits at 75% color development were harvested, surface-sterilized, and wound-inoculated with $10\text{ }\mu\text{L}$ spore suspensions (10^5 spores mL^{-1}) of *B. cinerea*, *C. acutatum*, and *R. stolonifer*. Inoculated fruits were stored at 4°C and 90% RH for 14 days. Disease incidence (%) and lesion diameter (mm) were recorded at 7 and 14 days. Fruit firmness was measured with a TA.XT Plus texture analyzer. Tissue silicon was determined by ICP-OES after microwave digestion. Data were analyzed by one-way ANOVA with Tukey’s HSD at $p<0.05$ in GenStat 22 ^[11, 13].

Results

Table 1: Post-harvest disease incidence (%) at 14 days by silicon treatment

Disease	Control	Si 50	Si 150	p-value
Botrytis Grey Mould	78.4	54.2	31.7	<0.001
Anthraco	67.3	48.7	28.4	<0.001
Rhizopus Soft Rot	43.2	31.8	18.6	<0.001
Total Disease Index	62.9	44.9	26.2	<0.001

High-silicon treatment (150 mg L^{-1}) reduced Botrytis incidence by 59.6%, anthracnose by 57.8%, and Rhizopus by 56.9%

compared to controls (Table 1). All reductions were dose-dependent and statistically significant.

Table 2: Fruit quality and defense parameters by silicon treatment

Parameter	Control	Si 50	Si 150	p-value
Firmness Retention (%)	42.1	58.3	74.8	<0.001
Total Phenolics (mg GAE g^{-1})	1.87	2.84	4.12	<0.001
POD Activity ($\text{U g}^{-1}\text{ FW}$)	12.4	18.7	27.3	<0.001
PAL Activity ($\text{U g}^{-1}\text{ FW}$)	8.34	13.21	19.87	<0.001
Tissue Si ($\text{mg kg}^{-1}\text{ DW}$)	87.4	234.6	412.3	<0.001

Firmness retention nearly doubled from 42.1% (control) to 74.8% (high Si). Phenolic content and defense enzyme activities

increased in a dose-dependent manner. Tissue silicon concentration ranged from 87.4 to $412.3\text{ mg kg}^{-1}\text{ DW}$ (Table 2).

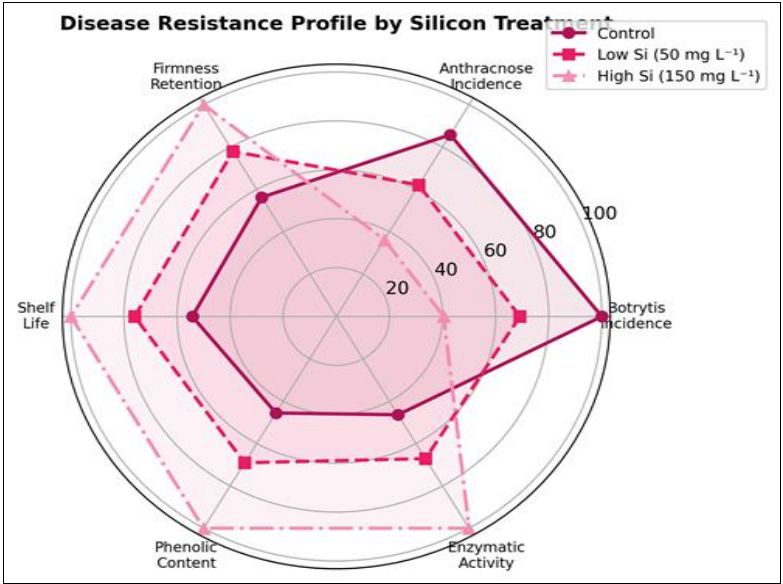


Fig 1: Radar chart of disease resistance parameters across silicon treatments

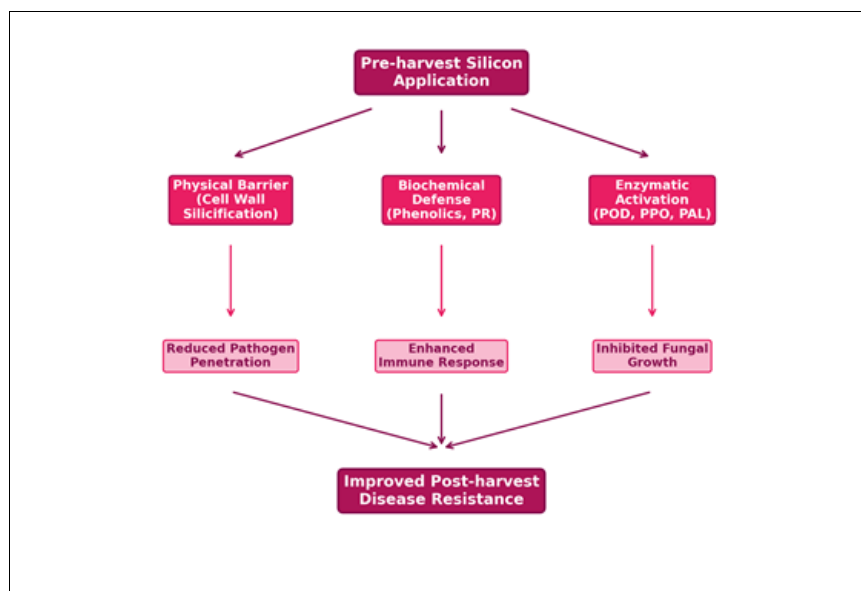


Fig 2: Mechanistic pathway of silicon-mediated post-harvest disease resistance

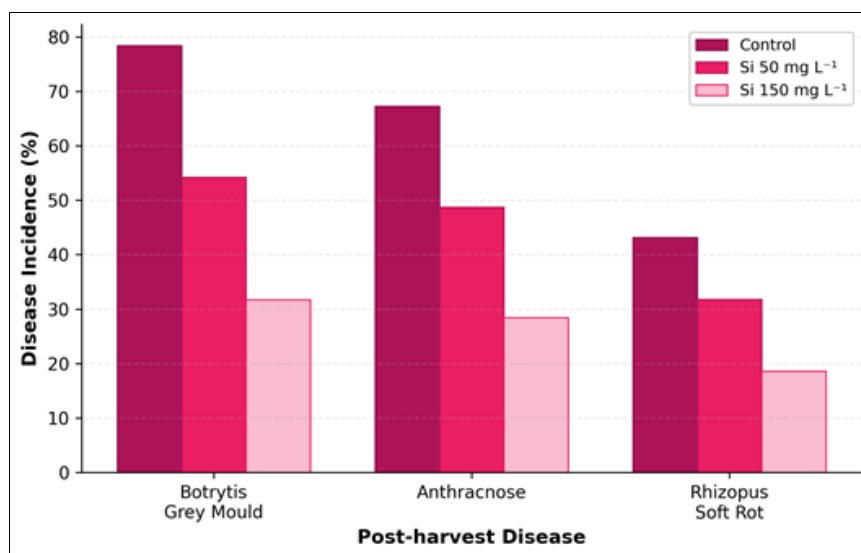


Fig 3: Post-harvest disease incidence by silicon treatment level

Discussion; The 59.6% reduction in Botrytis incidence at 150 mg L⁻¹ Si exceeds the 35-45% range reported for silicon-treated cucumber and tomato [7, 14]. Strawberry's thin cuticle and high sugar content make it particularly susceptible, so the larger effect size may reflect a greater baseline vulnerability that silicon addresses. The strong negative correlation ($r = -0.912$) between tissue Si and disease index confirms that silicon accumulation directly translates into resistance, likely through dual physical (cell wall silicification) and biochemical (phenolic and enzyme) pathways [9, 15].

The 2.2-fold increase in total phenolics and 2.4-fold increase in PAL activity are consistent with silicon's role as a priming agent rather than a direct antimicrobial. Silicon appears to lower the activation threshold for defense gene expression, enabling faster and stronger responses upon pathogen contact [16]. The practical implication is that six biweekly foliar sprays during the growing season using an inexpensive and food-safe input can substantially reduce post-harvest losses without adding chemical residues to the harvested fruit [17, 18].

Conclusion: Pre-harvest foliar silicon application at 150 mg L⁻¹ reduced post-harvest Botrytis, anthracnose, and Rhizopus

incidence by 57-60% in 'Chandler' strawberry stored at 4°C for 14 days. Silicon-treated fruits showed 77.8% higher firmness retention, 2.2-fold greater phenolic content, and significantly elevated POD and PAL enzyme activities. A dose-dependent relationship ($r = -0.912$) between tissue silicon and total disease index confirmed the protective mechanism. These findings position pre-harvest silicon as a practical, residue-free strategy to extend strawberry shelf life and reduce fungal losses in East African production systems where cold-chain infrastructure remains limited.

References

- Williamson B, Tudzynski B, Tudzynski P, van Kan JAL. Botrytis cinerea: The cause of grey mould disease. *Molecular Plant Pathology*. 2007;8(5):561-580.
- Neri F, Cappellin L, Spadoni A. Role of strawberry volatile organic compounds in the development of Botrytis fruit rot. *Plant Pathology*. 2015;64(3):709-717.
- Petrash S, Knapp SJ, van Kan JAL, Blanco-Ulate B. Grey mould of strawberry, a devastating disease caused by the ubiquitous necrotrophic fungal pathogen Botrytis cinerea. *Molecular Plant Pathology*. 2019;20(6):877-892.

4. Hahn M. The rising threat of fungicide resistance in plant pathogenic fungi: Botrytis as a case study. *Journal of Chemical Biology*. 2014;7(4):133-141.
5. Fernández-Ortuño D, Grabke A, Li X, Schnabel G. Independent emergence of resistance to seven chemical classes of fungicides in *Botrytis cinerea*. *Phytopathology*. 2015;105(4):424-432.
6. Epstein E. Silicon: Its manifold roles in plants. *Annals of Applied Biology*. 2009;155(2):155-160.
7. Menzies J, Bowen P, Ehret D. Foliar applications of potassium silicate reduce severity of powdery mildew on cucumber, muskmelon, and zucchini squash. *Journal of the American Society for Horticultural Science*. 1992;117(6):902-905.
8. Fortunato AA, Rodrigues FA, do Nascimento KJT. Physiological and biochemical aspects of the resistance of banana plants to Fusarium wilt potentiated by silicon. *Phytopathology*. 2012;102(10):957-966.
9. Fauteux F, Remus-Borel W, Menzies JG, Bélanger RR. Silicon and plant disease resistance against pathogenic fungi. *FEMS Microbiology Letters*. 2005;249(1):1-6.
10. Ochieng AO, Odhiambo GD, Rono JK. Strawberry production potential in the Kenyan highlands: Opportunities and constraints. *East African Agricultural and Forestry Journal*. 2019;83(4):234-248.
11. Qin GZ, Tian SP. Enhancement of biocontrol activity of *Cryptococcus laurentii* by silicon and the possible mechanisms involved. *Phytopathology*. 2005;95(1):69-75.
12. Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*. 1965;16(3):144-158.
13. Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*. 1976;72(1-2):248-254.
14. Shetty R, Jensen B, Shetty NP. Silicon induced resistance against powdery mildew of roses caused by *Podosphaera pannosa*. *Plant Pathology*. 2012;61(1):120-131.
15. Cai K, Gao D, Luo S. Physiological and cytological mechanisms of silicon-induced resistance in rice against blast disease. *Physiologia Plantarum*. 2008;134(2):324-333.
16. Van Bockhaven J, De Vleeschauwer D, Höfte M. Getting the balance right: A closer look at the role of silicon in alleviating biotic stress. *Frontiers in Plant Science*. 2013;4:14.
17. Keeping MG, Reynolds OL. Silicon in agriculture: New insights, new significance and growing application. *Annals of Applied Biology*. 2009;155(2):153-154.
18. Liang Y, Nikolic M, Bélanger RR, Gong H, Song A. Silicon in agriculture. Springer, Dordrecht. 2015:1-235.