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Assessment of Two Pear Cultivars Against Scab Disease Caused by (*Venturia pirina*) and Determination of the Optimizing Time for Disease Controlling

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Abstract: Pear scab, caused by *Venturia pirina*, is a fungal disease of pear worldwide. This study evaluated two pear cultivars, cv. Bartlett and cv. Le Conte, under natural infection during 2024 and 2025 and assessed chemical control timing and efficacy. Cv. Bartlett was significantly more resistant than cv. Le Conte. Infection increased leaf proline content, peroxidase (PO) and polyphenol oxidase (PPO) activities, and phenolic compounds in both cultivars, with stronger responses generally observed in cv. Bartlett. Infected fruits of both cultivars showed significant reductions in total soluble solids (TSS) and total acidity (TA) compared with healthy fruits in both seasons. The reduction in TA was greater in cv. Le Conte. Fruit firmness remained stable in healthy fruits but increased after infection, with cv. Le Conte more affected than cv. Bartlett. All chemical treatments significantly reduced disease severity compared with the untreated control. The first application program provided the greatest protection. Captan Ultra 80% WG resulted in the lowest disease severity in cv. Bartlett and the highest single-program efficiency in cv. Le Conte; Bellis 38% WG was also effective. Potassium silicate was the least effective treatment, although it suppressed disease. Treatment efficacy declined and disease severity increased in the second and third programs, with efficacy lowest in the third program.

Key words: Pear, scab disease, optimizing time, disease control, fruit quality, Potassium silicate

1. Introduction

Among the variety of fruit trees, pears are very significant and are widely distributed throughout the nation (**Gradinaru and Istrate, 2009**). Pear farming is significant because of the fruit's nutritional, flavorful, and medicinal qualities. The fruits are highly valuable economically and possess unique technological characteristics (**Zlati and Gradinaru, 2010**). Consuming pears is advised to promote the

production of red blood cells and eliminate toxins; the leaves are used to treat diabetic, renal, and bladder problems (**Braniste and Parvan, 1986**). According to **Stanica and Branişte (2015)**, the pear cultures have been impacted by both biotic and abiotic destructive causes; however, the impacted surfaces have steadily decreased as a result of identification and countermeasures. Since the pathogenic agents should be avoided and eliminated, the protection activity is crucial (**Mateescu, 2007**).

In regions with mild climates, pears are among the most popular fruits. It is ranked fourth among all fruit harvests sold on the global market and third among deciduous fruits globally. The main crop grown in Egypt is the pear. However, throughout the past few decades, the total area under cultivation for pears has varied greatly due to the fire blight outbreak (**Pel *et al*., 2021**).

When the conditions are right, the aggressive fungus *Venturia pirina* can cause scab, one of the harmful diseases (**Lefter and Minoiu, 1990**). The ascomycete *V. pirina,* which causes scab on pears, is one of the most significant fruit-growing diseases because it can result in significant financial losses if control measures are not done. On fallen, infected leaves in the orchard, the fungus overwinters and produces pseudothecia. When the climatological parameters are met in the spring, ascospores are released.

Additionally, original lesions generate conidia, which, in the right circumstances, cause the disease to spread further and more locally. Unlike apple scab, pear scab causes twig lesions in addition to infecting fruits and leaves. Twig scab is a significant issue, particularly when cultivating organic pears, since fruit growers don't have adequate measurements to stop the disease. In early spring, twig lesions may serve as an extra source of inoculum for infections. It is still unknown how significant twig scab infections are in comparison to the springtime ascospore discharge. It is also unclear how exactly fruit, leaf, and twig diseases are related. Additionally, multiple *V. pirina* biotypes can be found in various orchards, geographies, cultivars, and plant sections. They are yet unknown in terms of their precise nature and potential variation in pathogenicity. The importance of secondary infections for pear scab is a second difference between growing apples and pears (**Stensvand *et al*., 1997**).

The proper management of pear scab (*Venturia pirina*) is crucial for both organic and conventional pear farming (**Trapman *et al*., 2013**). Similar to apple scab (*V. inaequalis*), pear scab can inflict harm on both leaves and fruit. Furthermore, pear scab can lead to twig scab, resulting in lesions on twigs that rupture and release conidia in early spring (**González-Domínguez *et al*., 2017**), just as the tender green parts begin to grow. It has been noted that part of the difficulty in managing pear scab arises from a lack of understanding regarding its infection biology (**Timmermans *et al*., 2010**).

Foliar applications of potassium silicate have been widely studied (**Laane, 2018**). Potassium silicate (K_2SiO_3) reduced powdery mildew severity in cucumber, muskmelon, zucchini, strawberry, wheat, and grapevine, generally with limited effects on growth and yield (**Guével *et al*., 2007**). However, control may be inadequate under severe disease pressure in grapevine (**Reynolds *et al*., 1996**). Silicic acid has also improved growth, yield, and fruit quality in several crops and reduced papaya smallpox, potato late blight, and tomato powdery mildew (**Soratto *et al*., 2012; Realpe and Laane, 2008**).

Fungicides that target ascospore infection are typically applied repeatedly to control scab disease. The time between fungicide treatments lengthens and may not always be required when the ascospore supply is exhausted in early summer **(Mac Hardy, 1996)**. In order to reduce the adverse effects of fungicide applications, effective management of scab disease depends on application timing. By applying fungicides at the appropriate time, the number of treatments could be lowered to three.

Gaining more insight for resistant cultivars and the best time for disease controlling can help to optimize pear scab disease control. The goal of this study was to set up assessment of two pear cultivars against scab disease caused by (*V. pirina*) and determination of the optimizing time for disease controlling.

2. Materials and Methods

1. Disease incidence and disease severity (%) under natural infection:

Field trials were conducted in 2024 and 2025 in a private orchard in Menofia governorate, Egypt, using 14-year-old cv. Bartlett and cv. Le Conte pear trees naturally exposed to *V. pirina*, the causal agent of pear scab. Each cultivar comprised three replicates of 30 trees. At the end of August, disease incidence and severity were assessed using the following formulas:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected leaves or fruits}}{\text{Total number of inspected leaves or fruits}} \times 100$$

Disease severity (%) was calculated using the following formula:

$$\text{DS (\%)} = \frac{\Sigma\, n \times v}{5N} \times 100$$

Where:

n = Number of infected leaves or fruits within each disease grade.

N = Total number of fruits examined.

5 = Highest disease severity grade.

v = Numerical score assigned to each grade:

0 = Fruit without symptoms.

1 = Scab affecting more than 1–10% of the leaf or fruit.

2 = Scab affecting more than 11–25% of the leaf or fruit.

3 = Scab affecting more than 26–50% of the leaf or fruit.

4 = Scab affecting more than 51–75% of the leaf or fruit.

5 = Scab affecting over 75% of the fruit.

2. *In vitro* Screening of two pear cultivars for scab response using a cell free fungal extract

A 5-mm mycelial dick of *Venturia pirina* was introduced into 100 ml of potato dextrose broth (PDB; pH 7.0) in a 250-ml flask and incubated for 21 days under suitable conditions, following by **You *et al*. (2016)**. The culture was passed through Whatman No. 1 filter paper and centrifuged at 5,000 rpm. The supernatant was then passed through a 0.22-µm membrane filter to obtain a cell free culture filtrate.

A new pear leaves cv. Bartlett and cv. Le Conte were exposed to the filtered extract in Petri plats. For each cultivar, a water control was included using sterile distilled water. The plats were maintained at 22°C under continuous illumination, and visible leaf necrosis was assessed after 24 and 48 h.

Disease severity was assessed visually using a Five-class scale (0–4): 0, no visible symptoms; 1, 1–5% of the leaf area affected; 2, 6–10%; 3, 11–15%; and 4, more than 15% necrosis or tissue collapse. Disease severity index (DS) can be expressed as:

$$\mathbf{DS\ (\%) = [\Sigma\ (n_i \times v_i) / (N \times V)] \times 100}$$

where n_i is the number of leaves assigned to score v_i, N is the total number of leaves assessed, and V is the maximum score (4).

3. Biochemical measurements

3.1. Proline content and accumulation:

Leaf proline was determined following **Bates *et al*. (1973)**. Fresh leaves (10 g) were homogenized in 10 mL of 3% sulfosalicylic acid and centrifuged at 5,000 rpm for 10 min. The supernatant (2 ml) was

mixed with 2 ml acid ninhydrin reagent and 2 ml glacial acetic acid, then heated at 100°C for 1 h and cooled in an ice bath. The reagent was prepared by dissolving 1.25 g ninhydrin in 30 ml glacial acetic acid and adding 20 mL of 6 M phosphoric acid. After adding 4 mL toluene and shaking, the toluene phase was separated and its absorbance measured at 520 nm against a toluene blank. Results were expressed as mg g^{-1} fresh weight.

The percentage increase in proline content was calculated as follows:

Increase (%) = {(Proline content in infected leaves − Proline content in healthy leaves) /Proline content in infected leaves} ×100.

3.2. Defense-related enzyme activities and total phenolic content

Fresh pear leaf tissue (0.5 g) from cv. Bartlett and cv. Le Conte was homogenized at 0–4°C in 3 mL of 50 mM Tris-HCl buffer (pH 7.8) containing 1 mM EDTA-Na_2 and 7.5% polyvinylpyrrolidone (PVP). Homogenates were centrifuged at 12,000 rpm for 20 min at 4°C, and supernatants were used for enzyme assays.

Peroxidase (PO) and polyphenol oxidase (PPO) activity

PO activity was determined according to **Hammerschmidt *et al*. (1982)**, and PPO activity according to **Malik and Singh (1980)**, using a UV-160A spectrophotometer at 25°C.

Total phenolic content:

TPC was measured following **Meighani *et al*. (2014)** and expressed as mg gallic acid equivalents (GAE) per 100 ml of pear leaf extract.

4. Fruit quality attributes

4.1. Total soluble solids (TSS)

Following **Mehaisen (1999)**, TSS was measured in fresh pear juice using a hand refractometer (BX-1; 0–32 °Brix).

The percentage reduction in TSS was calculated as follows:

Reduction (%) = {(Total soluble solids (%) in healthy fruits − Total soluble solids (%) in infected fruits)/ Total soluble solids (%) in healthy fruits} ×100.

4.2. Titratable Acidity (TA%):

Titratable acidity was determined by titrating 10 ml pear juice with 0.1 N NaOH using phenolphthalein. Acidity was expressed as tartaric acid according to **Mehaisen (1999)**.

The percentage reduction in titratable acidity was calculated as follows:

Reduction (%) = {(Total acidity (%) in healthy fruits − Total acidity (%) in infected fruits)/ Total acidity (%) in healthy fruits} ×100.

4.3. Fruit firmness (Ib/inch^2):

Fruit firmness was measured using a hand pressure tester and expressed in lb/inch^2 (**Abdel-Rahman *et al*., 2021**).

The percentage increase in fruit firmness was calculated as follows:

Increase (%) = {(Fruit firmness (Ib/inch^2) in infected fruits − Fruit firmness (Ib/inch^2) in healthy fruits) / Fruit firmness (Ib/inch^2) in infected fruits} ×100.

5. Disease control

Field trials were conducted in 2024 and 2025 in a private orchard in Menofia governorate, Egypt, using 14-year-old cv. Bartlett and cv. Le Conte pear trees. Three spray treatments (Table 1) were tested at different application times to identify an effective scab-control schedule and reduce fungicide use. Before the season, trees were pruned to remove dead tissues and overwintered leaves that could harbor inoculum. Applications began in the first week of February, the first week of March, or the first week of April. Control trees received water. Each treatment had three replicates of five trees and was applied three times at 15-day intervals. Trees were naturally infected, and disease severity was assessed at the end of August as described above.

Efficacy was calculated as follows: **Efficacy (%) = [(C − T)/C] × 100.**

Where:

C = Scab severity (%) in control trees.

T = Scab severity (%) in treated fruits.

Table (1). Trade names, active ingredients, and doses of the tested treatments per 100 L water

Trade name	Active ingredient	Dose/ 100 L water
Captan Ultra 80% WG	Captan	125g
Bellis 38% WG	25.2% Boscalid+ 12.8% Pyraclostrobin	30 g
Potassium silicate	K_2SiO_3	100g

Statistical analysis

Analysis of variance (ANOVA) was applied to analyze the data collected over the two growth seasons in accordance with **Snedecor and Cochran (1989)**. Duncan's Multiple Range Test (**Duncan, 1955**) was used to examine the differences between the treatment means.

3. Results

1. Disease incidence and disease severity (%) under natural infection

On fruits

Disease incidence and severity differed between the two pear cultivars under natural infection (Table 2 and Figures 1 and 2). Cv. Le Conte had the highest incidence, at 35% in 2024 and 36% in 2025, and severity values of 21.19% and 22.88%, respectively. Cv. Bartlett showed lower incidence (23% and 26%) and severity (14.33% and 16.66%) in the same seasons, indicating comparatively greater tolerance.

Table (2). Disease incidence and disease severity (%) under natural infected fruits

Cultivars	Disease incidence (%)		Disease severity (%)	
	2024	2025	2024	2025
Bartlett	23b	26b	14.33b	16.66b
Le Conte	35a	36a	21.19a	22.88a

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.



Fig. (1). Natural infection of pear fruits with scab: (A) cv. Le Conte, (B) cv. Bartlett.

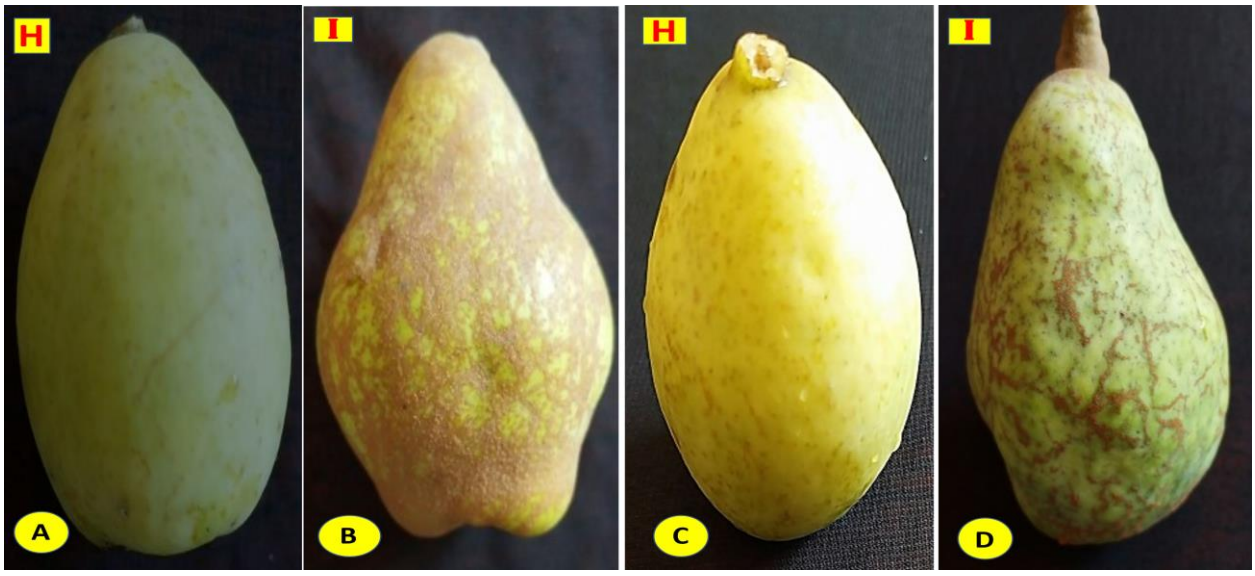


Fig. (2). Scab symptoms under naturally infected fruits: cv. Le Conte (A and B) and cv. Bartlett (C and D). H= healthy I = infected.

On leaves

Significant differences ($p < 0.05$) in disease characteristics across the cultivars under study were found by statistical analysis (Table 3 and Fig. 3). Cv. Bartlett showed the greatest tolerance, with a slight increase in disease severity from 6.40% to 7.00% and a consistent and lowest disease incidence (5.00%) during the 2024 and 2025 seasons. Cv. Le Conte, on the other hand, demonstrated a markedly greater disease incidence (9.00% in 2024 and 11.00% in 2025) and severity (12.00% in 2024 and 15.00% in 2025).

Table (3). Disease incidence and disease severity (%) under natural infected leaves.

Cultivars	Disease incidence (%)		Disease severity (%)	
	2024	2025	2024	2025
Bartlett	5.00 b	5.00 b	6.40b	7.00b
Le Conte	9.00 a	11.00 a	12.00a	15.00a

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

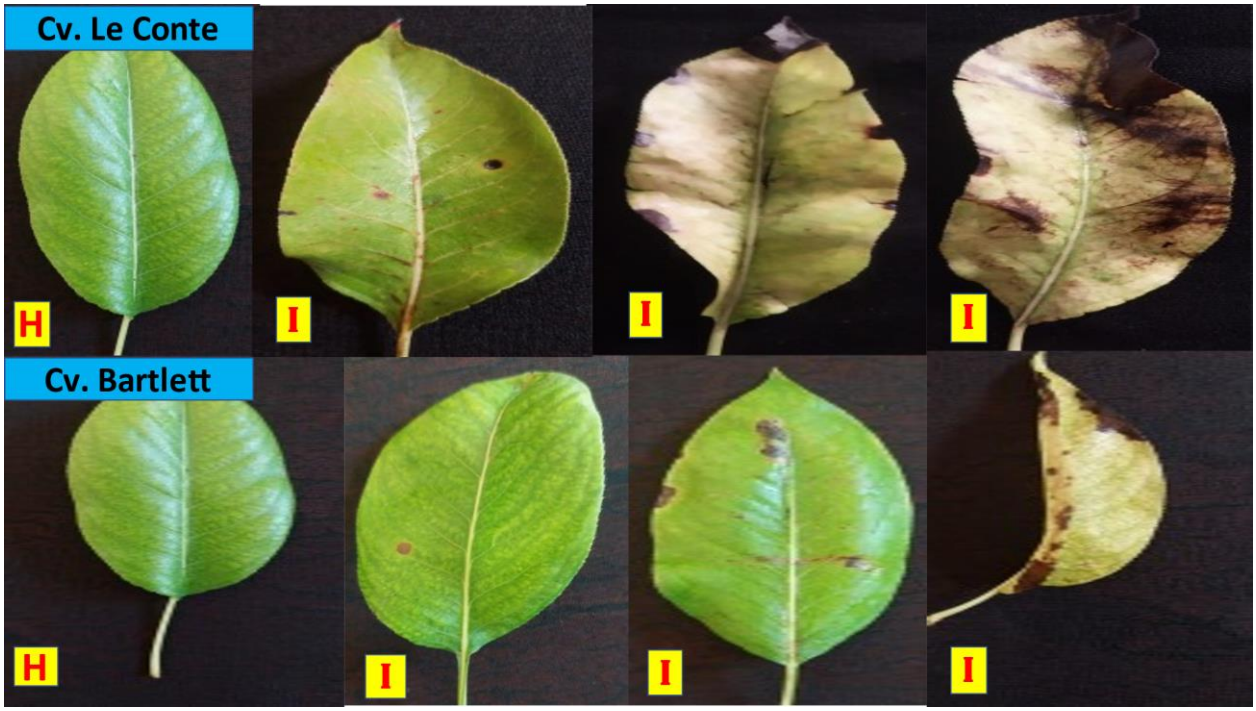


Fig. (3). Scab symptoms under naturally infected leaves: cv. Le Conte and cv. Bartlett. H= healthy; I = infected.

2. *In vitro* screening of two pear cultivars for scab response using a cell free fungal extract.

The cell free *V. pirina* extract produced different levels of visible injury in the two pear cultivars (Table 4 and Figures 4 and 5), and the recorded severity increased between 24 and 48 h in both cases. In cv. Bartlett, severity increased from 7.50% at 24 h to 22.50% at 48 h, a rise of 15.00 percentage points. In cv. Le Conte, severity increased from 45.00% to 68.75%, a rise of 23.75 percentage points. At 48 h, the value recorded for cv. Le Conte was 46.25 percentage points higher than that for cv. Bartlett. Both water controls recorded 0.00% severity at 48 h.

Table (4). *In vitro* screening of two pear cultivars for scab response using a cell free fungal extract.

Cultivars / treatment	Incubation time	Visual (Disease severity %)
Bartlett	24h	7.50
	48h	22.50
Control (water)	48h	0.00
Le Conte	24h	45.00
	48h	68.75
Control (water)	48h	0.00



Fig (4). Five-class scale (0–4): 0, no visible symptoms; 1, 1–5% of the leaf area affected; 2, 6–10%; 3, 11–15%; and 4, more than 15% necrosis or tissue collapse (Cv. Le Conte).

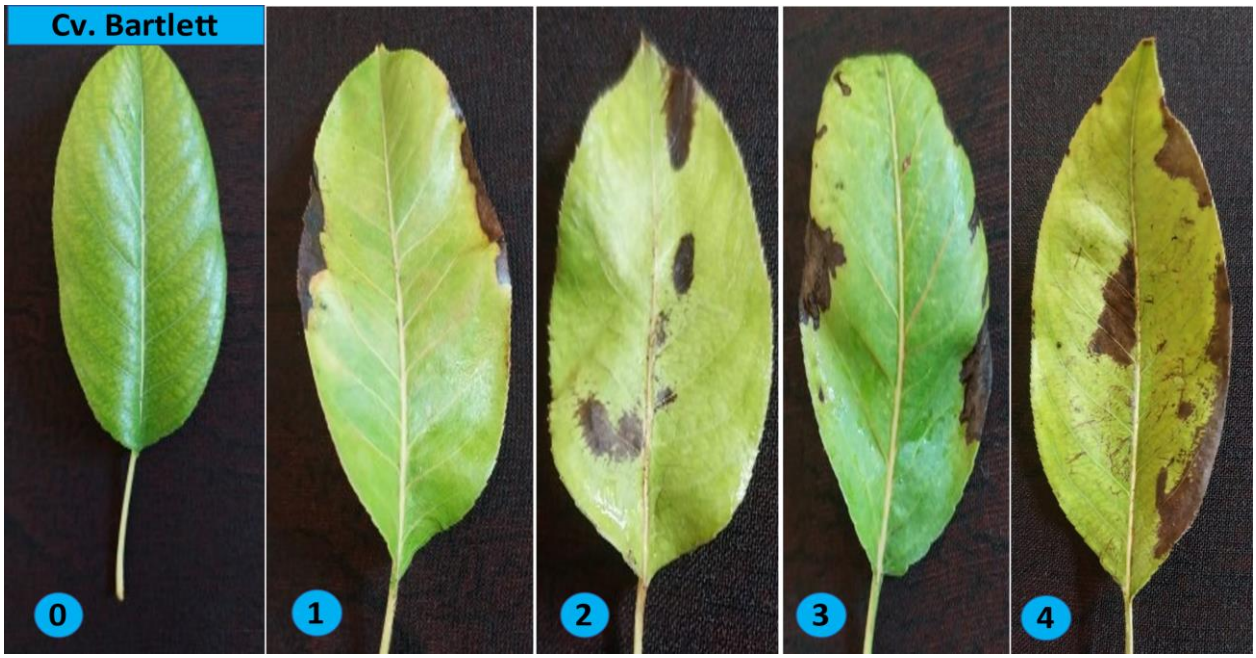


Fig (5). Five-class scale (0–4): 0, no visible symptoms; 1, 1–5% of the leaf area affected; 2, 6–10%; 3, 11–15%; and 4, more than 15% necrosis or tissue collapse (Cv. Bartlett)

3. Biochemical measurements

3.1. Proline content and accumulation

Pear scab infection increased leaf proline content in both cultivars, although the response was stronger in cv. Bartlett (Table 5). In cv. Bartlett, proline increased from 0.53 to 0.66 mg g^{-1} fresh weight in 2024 and to 0.69 mg g^{-1} in 2025; the reported increases were 19.69% and 23.18%, respectively. In cv. Le Conte, values increased from 0.58 to 0.61 mg g^{-1} in both seasons, with a reported increase of 4.91%.

Table (5). Leaf proline content in healthy and scab-infected Bartlett and Le Conte pear cultivars during the 2024 and 2025 seasons

Cultivars	Proline (mg/g^{-1} fresh wt.)					
	Season 2024			Season 2025		
	Healthy	Infected	Increasing (%)	Healthy	Infected	Increasing (%)
Bartlett	0.53b	0.66a	19.69	0.53b	0.69a	23.18
Le Conte	0.58a	0.61b	4.91	0.58a	0.61b	4.91

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

3.2. Defense-related enzyme activities and total phenolic content

Table 6 compares peroxidase (PO), polyphenol oxidase (PPO), and total phenolic content (TPC) in healthy and infected Bartlett and Le Conte pear cultivars over two seasons.

Infection increased PO activity in both cultivars. Cv. Bartlett values increased from 0.67 to 0.98 in both seasons, while cv. Le Conte increased from 0.67 to 0.88 in 2024 and from 0.66 to 0.88 in 2025. PPO also increased after infection: in cv. Bartlett, from 0.19 to 0.23 in 2024 and from 0.21 to 0.24 in 2025; in cv. Le Conte, from 0.19 to 0.20 and from 0.20 to 0.22, respectively.

Total phenolic content (TPC):

TPC increased following infection in both cultivars. Cv. Bartlett increased from 0.57 to 0.63 in each season, whereas Le Conte showed smaller changes, from 0.57 to 0.58 in 2024 and from 0.55 to 0.56 in 2025.

Table (6). Enzyme activities and total phenolic content in healthy and scab-infected Bartlett and Le conte pear cultivars

Enzyme & phenol	Enzyme activities and phenolic content							
	Season 2024				Season 2025			
	Bartlett		Le Conte		Bartlett		Le Conte	
	Healthy	Infected	Healthy	Infected	Healthy	Infected	Healthy	Infected
PO	0.67a	0.98a	0.67a	0.88a	0.67a	0.98a	0.66a	0.88a
PPO	0.19c	0.23c	0,19c	0.20c	0.21c	0.24c	0,20c	0.22c
TPC	0.57b	0.63b	0.57b	0.58b	0.57b	0.63b	0.55b	0.56b

Within each column, values sharing the same letter are not significantly different at $p < 0.05$. PO = peroxidase; PPO = polyphenol oxidase; TPC = total phenolic content.

4. Fruit quality

4.1. Total soluble solids (TSS)

Total soluble solids (TSS) were lower in infected than in healthy fruits of both cultivars in 2024 and 2025 (Table 7). In 2024, TSS in cv. Bartlett declined from 13.55% in healthy fruit to 12.28% in infected fruit, a reported reduction of 9.37%. In cv. Le Conte, values fell from 13.30% to 12.00%, corresponding to a 9.77% reduction. The same pattern occurred in 2025, cv. Bartlett TSS decreased from 13.60% to 12.80% (5.88%), while cv. Le Conte declined from 13.50% to 12.15% (10.00%).

Table (7). Total soluble solids (TSS) in healthy and scab-infected in two pear cultivars during 2024 and 2025.

Cultivars	Total soluble solids (%)					
	Season 2024			Season 2025		
	Healthy	Infected	Reduction (%)	Healthy	Infected	Reduction (%)
Bartlett	13.55a	12.28a	9.37	13.60a	12.80a	5.88
Le Conte	13.30b	12.00b	9.77	13.50b	12.15b	10.00

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

4.2. Titratable Acidity (TA%)

In both seasons, infection was associated with lower titratable acidity (TA) in both cultivars, with larger reported reductions in cv. Le Conte (Table 8). In 2024, cv. Bartlett TA decreased from 0.54% to 0.50% (7.40%), while cv. Le Conte declined from 0.50% to 0.43% (14.00%). For 2025, the table reports a 10.34% reduction in cv. Bartlett and a 17.30% reduction in cv. Le Conte; the latter had an infected fruit value of 0.43% compared with 0.58% in healthy fruit.

Table (8). Total acidity (TA) in healthy and scab-infected in two pear cultivars during 2024 and 2025

Cultivars	TA = Total acidity					
	Season 2024			Season 2025		
	Healthy	Infected	Reduction (%)	Healthy	Infected	Reduction (%)
Bartlett	0.54a	0.50a	7.40	0.52b	0.52a	10.34
Le Conte	0.50b	0.43b	14.00	0.58a	0.43b	17.30

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

4.3. Fruit firmness (Ib/inch^2)

Table 9 shows that fruit firmness increased after infection in both cultivars. Cv. Bartlett increased from 13.50 lb/in.^{2} in healthy fruit to 14.60 in 2024 (7.53%) and 14.80 in 2025 (8.78%). Cv. Le Conte increased from 12.40 lb/in.^{2} to 15.50 (20.00%) and 15.90 (22.01%) in the respective seasons.

The reported firmness increase was greater in cv. Le Conte (>20%) than in cv. Bartlett (<9%). Healthy fruit firmness remained constant across seasons for both cultivars, while infected fruit values were slightly higher in 2025 than in 2024. These observations describe the measured firmness differences; they do not by themselves establish whether disease severity or environmental conditions caused the seasonal change.

Table (9). Fruit firmness (lb/in.^{2}) in healthy and scab-infected in two pear cultivars during 2024 and 2025

Cultivars	Fruit firmness (Ib/inch^2)					
	Season 2024			Season 2025		
	Healthy	Infected	Increasing (%)	Healthy	Infected	Increasing (%)
Bartlett	13.50	14.60	7.53	13.50	14.80	8.78
Le Conte	12.40	15.50	20.00	12.40	15.90	22.01

Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

5. Disease control

All three fungicide treatments reduced scab severity relative to the untreated control (Tables 10 and 11). The first application program gave the lowest severity and highest efficacy overall. Captan Ultra 80% WG performed best, with severity values of 4.50 and 4.80% for cv. Bartlett and 6.50 and 7.66% for cv. Le Conte in 2024 and 2025, respectively. Bellis 38% WG was generally the next most effective, whereas Potassium silicate showed the lowest efficacy among the fungicides. Across the second and third programs, disease severity generally increased and efficacy declined, with the lowest efficacy observed in the third program.

Table (10). Efficacy of different application times of three treatments against pear scab disease severity in cv. Bartlett during 2024 and 2025

Treatment	Application programs 2024						Mean Eff %
	First programs		Second programs		Third programs		
	DS%	Eff%	DS%	Eff%	DS%	Eff%	
Captan Ultra 80% WG	4.50d	68.59	8.60d	39.98	9.50d	33.70	47.42
Potassium silicate	5.35b	62.66	8.90b	37.37	10.00b	30.21	43.41
Bellis 38% WG	4.68c	67.34	8.80c	38.59	9.70c	32.30	46.07
Control	14.33a	--	14.33a	--	14.33a	--	--
Application programs 2025							
Captan Ultra 80% WG	4.80d	71.18	8.95d	46.27	11.50d	30.97	49.47
Potassium silicate	5.30b	68.18	9.90b	40.57	12.66b	24.00	44.25
Bellis 38% WG	4.99c	70.04	9.25c	44.47	11.90c	28.57	47.69
Control	16.66a	--	16.66a	--	16.66a	--	--

DS% = disease severity; Eff% = efficacy (%).
Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

Table (11). Efficacy of different application times of three treatments against pear scab disease severity in cv. Le Conte during 2024 and 2025

Treatment	Application programs 2024						Mean Eff %
	First programs		Second programs		Third programs		
	DS%	Eff%	DS%	Eff%	DS%	Eff%	
Captan Ultra 80% WG	6.50d	69.32	10.66d	49.69	11.55d	45.49	54.83
Potassium silicate	8.30b	60.83	10.95b	48.32	12.55b	40.77	49.97
Bellis 38% WG	7.60c	64.13	10.85c	48.79	11.80c	44.31	52.41
Control	21.19a	--	21.19a	--	21.19a	--	--
Application programs 2025							
Captan Ultra 80% WG	7.66d	66.52	11.55d	49.51	12.50d	45.36	53.79
Potassium silicate	8.30b	63.72	12.90b	43.61	14.66b	35.92	47.75
Bellis 38% WG	7.90c	65.47	11.80c	48.42	12.95c	43.40	52.43
Control	22.88a	--	22.88a	--	22.88a	--	--

DS% = disease severity; Eff% = efficacy (%).
Within each column, values sharing the same letter are not significantly different at $p < 0.05$.

4. Discussion

Le Conte is one of the most widely cultivated pear varieties in Egypt (**Khedr, 2018**). Yield varies among orchards and seasons, potentially because of rootstock, fire blight, chilling requirements, pollination, and fertilization (**Khamis *et al*., 2018**). Fruit rot losses during storage may be limited to about 1% under suitable conditions but can reach 50% or more under poor storage conditions (**Monroe, 2009**).

Pear scab generally does not kill the tree, but it can cause leaf and fruit loss. Early fruit infection may result in deformation and premature drop, whereas infections occurring late in summer or near harvest may produce small, circular, black lesions (0.1- 4 mm) known as pin-point scab during storage. Fruit susceptibility has been reported to be greatest early in the season (**Van Hemelrijck *et al*., 2015**).

In the present study, the differences observed between the cultivars under natural infection suggest that genetic background contributes to scab response. Cv. Bartlett had significantly lower disease incidence and severity, indicating greater field tolerance and/or more effective structural or biochemical defenses than cv. Le Conte. Under the conditions of this study, Le Conte was highly susceptible. Both cultivars showed a slight increase in disease incidence and severity in 2025 compared with 2024.

The cell free *V. pirina* extract produced different levels of visible injury in the two pear cultivars, and the recorded severity increased between 24 and 48 h in both cases. The observed cultivar contrast is consistent with published work showing that pear genotypes can differ substantially in their responses to *V. pirina*. **Sokolova and Moročko-Bičevska (2021),** using detached-leaf and immature-fruit inoculations, reported variation among pear cultivars and among fungal strains, highlighting that host response may depend on the particular cultivar–isolate combination. Field screening has likewise identified broad differences in scab susceptibility among European pear genotypes (**Benedek *et al*., 2016**).

Proline increased markedly in infected cv. Bartlett fruit, suggesting a pronounced physiological response and activation of metabolic defenses against scab. Healthy cv. Le Conte fruit had a higher baseline proline concentration (0.58 mg g^{-1}) than cv. Bartlett (0.53 mg g^{-1}), but showed little change after infection. This pattern may reflect differences in constitutive tolerance or in the responsiveness of proline metabolism to the pathogen. Proline contributes to plant stress responses by supporting osmotic adjustment and cellular stability (**Kishor *et al*., 2005**).

Following infection, cv. Bartlett showed a significantly greater increase in PO, PPO, and TPC than cv. Le Conte, indicating a stronger induced biochemical response. This response may contribute to more effective defense against scab. Polyphenol oxidase activity varies with cultivar, developmental stage, and environmental conditions (**Sapis *et al*., 1983**). Peroxidase and polyphenol oxidase are also associated with induced resistance, and increased activity of these enzymes has been reported in crops treated with elicitors or fungicides (**Martinez *et al*., 2004; Monir *et al*., 2021; Hassan *et al*., 2024**).

Total soluble solids (TSS) and firmness are key pear quality traits that affect consumer choice (**Nicolaï *et al*., 2008**). Firmness is also a useful indicator of ripeness and should be assessed during shipping and retail (**Paz *et al*., 2009**). The lower TSS in infected fruit may be related to pathogen activity, as infection can increase the use of soluble sugars and organic acids for microbial growth and energy metabolism.

Cv. Le Conte showed greater variation in acidity and the strongest declines during 2024, suggesting that infection had a greater effect on its fruit metabolism. In contrast, cv. Bartlett maintained acid concentrations that were higher or more stable than those of its healthy controls. This pattern may indicate stronger metabolic stability or defense responses that limit infection associated changes in organic acid pools.

The smaller increase in firmness in cv. Bartlett may reflect a different physiological response or greater tolerance than in cv. Le Conte. The 20–22% increase recorded in cv. Le Conte may indicate a stronger stress response or infection associated tissue changes and water loss. Firmness is an important determinant of marketability and postharvest life, and it is influenced by cultivar and cultural practices (**Ehlenfeldt and Martin, 2002; Stückrath *et al*., 2008**).

Our results highlight the importance of well-timed fungicide programs for pear-scab management. all chemical treatments significantly reduced pear scab disease severity compared to the untreated control. First program achieved the lowest disease severity levels across both years. Captan Ultra 80% WG performed best overall, potentially because of its broad-spectrum, multi-site contact activity. Bellis 38% WG (Boscalid + Pyraclostrobin) provided intermediate suppression through its combined modes of action and preventive activity. Potassium silicate had the lowest overall mean efficacy in this study.

Pear-scab control often relies on repeated fungicide applications, increasing production costs and the risk of resistance, environmental contamination, fruit residues, and exposure risks for workers and consumers. Optimizing spray timing and frequency is therefore important for reducing fungicide use while maintaining fruit quality. Frequent seasonal sprays have also been reported for apple scab, with the number depending on climate, disease pressure, and cultivar susceptibility (**Buhler and Gessler, 1994; Holb *et al*., 2003; Jamar *et al*., 2007; Aleksic *et al*., 2012**). Application timing can also affect fungicide performance against other diseases; **Hassan (2015)**, for example, reported differences in mango dieback control among application periods. **Funt *et al*. (1990)** found that post-infection programs could reduce the number of sprays needed for scab control.

Silicon can strengthen plant tissues by reinforcing cell walls and cuticles, thereby limiting pathogen penetration and enzymatic degradation (**Epstein, 2001; Van Bockhaven, 2013; Sousa *et al*., 2013**). It may also enhance defense responses through the accumulation of phenolics and flavonoid phytoalexins, increased activity of chitinases, peroxidases, and polyphenol oxidases, and production of antimicrobial compounds (**Fortunato *et al*., 2012**). In addition, silicon activates defense-signaling pathways involving ethylene, salicylic acid, and jasmonic acid (**Ghareeb *et al*., 2011**).

5. Conclusions

Under the environmental conditions of this study, cv. Bartlett was significantly more resistant to natural scab infection than cv. Le Conte. These findings can inform cultivar selection and disease-management decisions. Captan Ultra 80% WG may be considered for early-season protection, while treatments with different modes of action, the fungicide including Bellis 38% WG or Potassium silicate, should be rotated in accordance with label directions and resistance-management guidance.

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Conflict of interests

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