DOI: https://doi.org/10.36719/2663-4619/119/65-68

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Evaluation of the Resistance of Almond Varieties to Major Pathogens Under Artificial Inoculation

Abstract

Almond production is increasingly threatened by fungal and bacterial diseases, exacerbated by intensive farming and climate variability. This study assesses the resistance of twelve almond (*Prunus dulcis*) cultivars to four significant pathogens: *Monilinia laxa* (brown rot), *Colletotrichum acutatum* (anthracnose), *Xanthomonas arboricola* pv. *pruni* (bacterial spot), and *Pseudomonas syringae* pv. *syringae* (bacterial canker). Using standardized artificial inoculation techniques in greenhouse and growth chamber environments, disease severity was quantitatively scored. Notable cultivar-level resistance differences were observed, with 'Guara' and 'Lauranne' exhibiting strong tolerance across multiple pathogens. These findings offer a foundation for breeding disease-resistant almonds and reducing reliance on chemical controls.

Keywords: *almond, cultivar resistance, pathogen screening, artificial inoculation, brown rot, bacterial spot, anthracnose, integrated disease management*

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Badam növlərinin əsas patogenlərə qarşı müqavimətinin qiymətləndirilməsi süni peyvənd altında

Xülasə

Badam istehsalı intensiv əkinçilik və iqlim dəyişkənliyi ilə daha da şiddətlənən göbələk və bakterial xəstəliklərlə getdikcə daha çox təhlükə altındadır. Bu tədqiqat on iki badam (Prunus dulcis) sortlarının dörd əhəmiyyətli patogenə qarşı müqavimətini qiymətləndirir: Monilinia laxa (qəhvəyi çürük), Colletotrichum acutatum (antraknoz), Xanthomonas arboricola pv. pruni (bakterial ləkə) və Pseudomonas syringae pv. syringae (bakterial xərçəng). İstixana və böyümə kamerası mühitlərində standartlaşdırılmış süni peyvənd üsullarından istifadə edərək xəstəliyin şiddəti kəmiyyətcə qiymətləndirilib. Sort səviyyəsində nəzərəçarpacaq müqavimət fərqləri müşahidə edildi, "Quara" və "Lauranne" çoxlu patogenlər arasında güclü tolerantlıq nümayiş etdirdi. Bu tapıntılar xəstəliyə davamlı badam yetişdirmək və kimyəvi nəzarətdən asılılığı azaltmaq üçün əsas təklif edir.

Açar sözlər: *badam, sort müqaviməti, patogen skrininq, süni peyvənd, qəhvəyi çürük, bakterial ləkə, antraknoz, inteqrasiya edilmiş xəstəliklərin idarə edilməsi*

Introduction

Almond orchards globally face recurring challenges from pathogens that threaten yield, tree longevity and fruit quality. Key diseases include brown rot, anthracnose, bacterial spot and bacterial canker, which impact flowers, fruit, leaves and woody tissues. Traditional control relies on fungicides and bactericides, raising sustainability and resistance concerns. Incorporating disease resistance through breeding and selection offers a long-term, eco-friendly strategy (Teviotdale et al., 2001; Gradziel et al., 2013; Fernández i Martí et al., 2021).

Research

This study focuses on evaluating the relative resistance of twelve widely grown or regionally important almond cultivars using artificial inoculation. This method ensures controlled pathogen exposure and reproducible results, critical for early-stage screening (De Cal et al., 2009; Duval et al., 2005).

2. Materials and Methods

2.1 Plant Material

Twelve cultivars were chosen to represent genetic and geographic diversity: 'Nonpareil', 'Carmel', 'Tuono', 'Ferragnès', 'Supernova', 'Guara', 'Texas', 'Sahand', 'Shokofeh', 'Mission', 'Marcona', and 'Lauranne'. All were propagated on uniform rootstocks and maintained under greenhouse conditions.

2.2 Pathogen Selection and Inoculum Preparation

Pathogens were selected based on their prevalence in almond-producing regions:

- *Monilinia laxa* (brown rot)
- *Colletotrichum acutatum* (anthracnose)
- *Xanthomonas arboricola* pv. *pruni* (bacterial spot)
- *Pseudomonas syringae* pv. *syringae* (bacterial canker)

Pathogen isolates were sourced from symptomatic plant material and cultured on PDA or NA media. Spore and cell suspensions were standardized to 10^5 (fungi) and 10^6 CFU/mL (bacteria).

2.3 Inoculation Protocols

Detached shoot and leaf assays were complemented by whole-plant inoculations. Wounding was applied where necessary to facilitate infection. Samples were incubated at 22–25°C with >90% humidity for 7–14 days (Phillips & Burkholder, 1983; Duval et al., 2005).

2.4 Disease Assessment and Scoring

Severity was rated on a 0–5 scale:

- 0: No symptoms
- 1: Trace lesions
- 2: Mild (1–25%)
- 3: Moderate (26–50%)
- 4: Severe (51–75%)
- 5: Very severe (>75% or tissue death)

Cultivars were categorized as:

- Resistant (R): <1.5
- Moderately Resistant (MR): 1.5–2.5
- Susceptible (S): >2.5

3. Results

3.1 Resistance to Fungal Pathogens

- *Monilinia laxa*: 'Guara', 'Lauranne', and 'Sahand' had minimal lesion development, indicating strong resistance. 'Nonpareil' and 'Carmel' were highly susceptible.
- *Colletotrichum acutatum*: 'Ferragnès' and 'Tuono' showed moderate resistance. 'Texas' and 'Mission' exhibited widespread necrosis.

3.2 Resistance to Bacterial Pathogens

- *X. arboricola* pv. *pruni*: 'Supernova' and 'Marcona' showed limited spotting. 'Shokofeh' and 'Nonpareil' were severely affected.
- *P. syringae* pv. *syringae*: 'Lauranne' and 'Guara' showed high tolerance. 'Texas' and 'Mission' were notably susceptible.

3.3 Overall Cultivar Ratings

Cultivar	Brown Rot	Anthracnose	Bacterial Spot	Bacterial Canker	Resistance Level
Guara	R	MR	R	R	High
Lauranne	R	MR	MR	R	High
Ferragnès	MR	R	MR	MR	Moderate–High
Tuono	MR	R	S	MR	Moderate
Supernova	MR	MR	R	MR	Moderate–High
Sahand	R	S	MR	MR	Moderate
Marcona	S	MR	R	S	Moderate
Shokofeh	MR	S	S	MR	Low–Moderate
Texas	S	S	MR	S	Low
Mission	S	S	MR	S	Low
Nonpareil	S	S	S	S	Very Low
Carmel	S	MR	S	MR	Low

4. Discussion

The data show considerable variation in cultivar resistance. 'Guara' and 'Lauranne' were consistently more tolerant across pathogen types, aligning with previous findings (López-Moral et al., 2019; Fernández i Martí et al., 2021). Their use in breeding programs could reduce disease pressure and chemical input.

Susceptibility of commercial standards like 'Nonpareil' suggests an urgent need for integrating resistance traits in high-value cultivars. Artificial inoculation provided effective early screening, although field validation remains essential (De Cal et al., 2009; Palou et al., 2002).

Conclusion

Artificial inoculation is a practical tool for screening almond disease resistance. 'Guara' and 'Lauranne' emerge as promising candidates for resistant orchard systems. Results support the inclusion of disease resistance as a key breeding objective in response to climate-induced disease dynamics.

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Received: 20.04.2025
Accepted: 01.07.2025