

# Review: Occurrence, Spread, and Management Possibilities of Citrus Bacterial Canker (*Xanthomonas citri* subsp. *citri*) in Sudan

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## Introduction & aims

Bacterial citrus canker disease (BCCD), caused by *Xanthomonas citri* subsp. *citri* (*Xcc*) is considered one of the most damaging factors to the citrus industry worldwide. Recently, based on the host range and pathogen interactions, five different pathovars of the BCCD have been extensively investigated, in which pathotype A (the Asiatic form of *X. citri* subsp. *citri*) being the most devastating and widespread among almost all citrus varieties and their relative. The disease causative agent (*Xcc*) induces varying symptoms depending on the citrus species, plant part, age, geographical area, and climate conditions.. Based on all published articles about BCCD in Sudan from the first detection in 2013 to date, the current study aimed to highlight the starting point of BCCD in a specific region in eastern Sudan, the path of spread to cover almost all citrus-producing areas in Sudan, Symptomatology, *Xcc* identity, ecology, and assessing the efficacy of various chemical compounds and plant extracts against *Xcc* through both *in vivo* and *in vitro* examinations to establish an effective strategy to manage this disease.

## Symptomatology and Host Range

The disease is characterized by the occurrence of raised necrotic lesions that develop on leaves, twigs and fruits. On leaves, first appearance is as oily looking, 2-10 mm circular spots, usually on the abaxial surface (reflecting stomatal entry following rain dispersal). Lesions are often similarly sized. Later, both epidermal surfaces may become ruptured by tissue hyperplasia induced by the pathogen.. Severe infection results in defoliation, die-back, deformation of fruit and premature fruit drop (Rossetti, 1977; Civerolo, 1981; Chand and Pal, 1982; Stall and Seymour, 1983).

The Asiatic type of citrus canker (Pathotype A), caused by the *Xanthomonas citri* pv. *citri* (*Xcc*) is considered the most widespread and severe form of the disease. This is the strain that causes the disease most often referred to as citrus canker (Stall and Civerolo, 1991). Cancrosis B caused by the *Xanthomonas citri* pv. *aurantifolia* is a minor canker disease of diminishing importance on lemons in Argentina, Paraguay, and Uruguay. Mexican lime, sour orange and pummelo are also susceptible (Civerolo, 1984). Cancrosis C also caused by *Xanthomonas citri* pv. *aurantifolia* that can only infect Mexican lime in Brazil (Schubert *et al.*, 2001).



Fig 1.(A):canker lesions with crater-like centers on lime fruits, (B): necrotic lesions on branches, and(C): severe canker symptoms on leaves.

## Occurrence and Epidemiology of CBCD in Sudan

According to Abubaker *et al.* (2016), CBCD was surveyed and detected for the first time in 2013/2024 in main citrus orchards and nurseries of Gadaref State (eastern Sudan). Incidence of 65.35% and 8.68 were recorded in Gadaref and Mafaza locality respectively (fig.2 and 3). the spread of canker bacteria may have occurred during strong wind-driven rains coming from Gadaref State or across the borders from Ethiopia (D-

erso *et al.*, 2009). The fact that CBCD was first detected in some Gadaref localities only a year before it appeared in Kassala, would indicate that the path of the disease was most likely: Ethiopia- Gadaref - Kassala and Khartoum. This could be substantiated by the discovery of the disease several years ago in Ethiopia (Derso *et al.*, 2009) and only recently in commercial citrus orchards and nurseries of Gadaref State (Abubaker *et al.*, 2016). The bacterial inoculum might have been present in Kassala in the same year of the discovery of CBCD in Gadaref, but it has been overlooked since the pathogen is known to survive epiphytically at low population levels on citrus hosts without symptoms development, and in association with other weeds and grass hosts (Mohr, 1984).

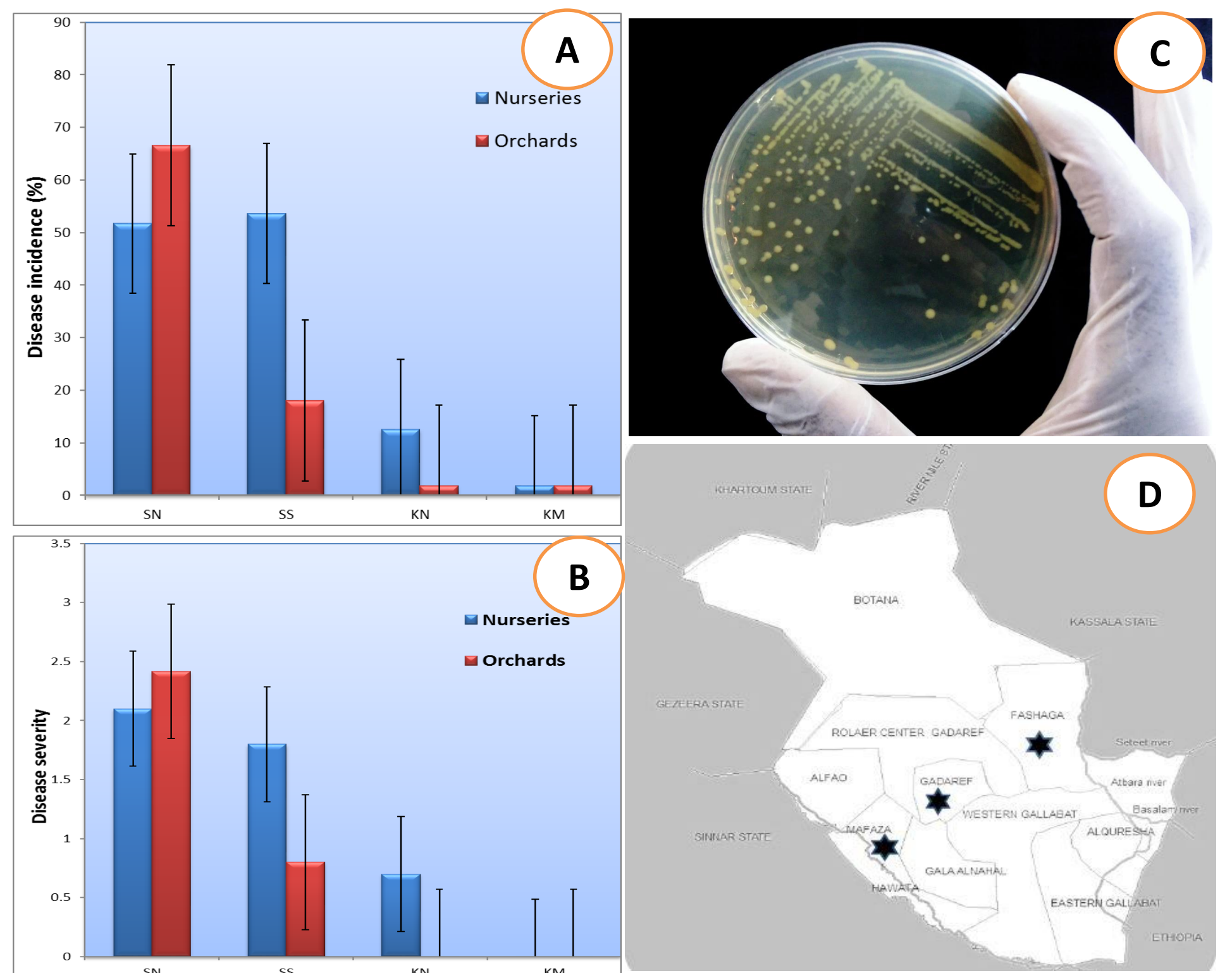


Figure 2. A and B: Incidence and Severity of citrus bacterial canker disease at two locations in each of Kassala and Khartoum states (January 2015). SN: Sawagi North; SS: Sawagi South, KN: Khartoum North; KM: Khartoum. C: phenotypic analysis of CBCD. D: map of Gadaref state showing the surveyed area, source (Abubaker, et al 2016)

## Management Possibilities

Elshafia *et al.* (2020), *Hibiscus subdariffa* and *Azadirachta indica* demonstrated some positive inhibitory effect against the citrus canker bacterial isolate under study, but not diffusates from Cinnamon and Clove. The diffusates from selected plant species needs further investigation to be considered as a promising option or an essential IPM component to curtail the spread of CBCD.

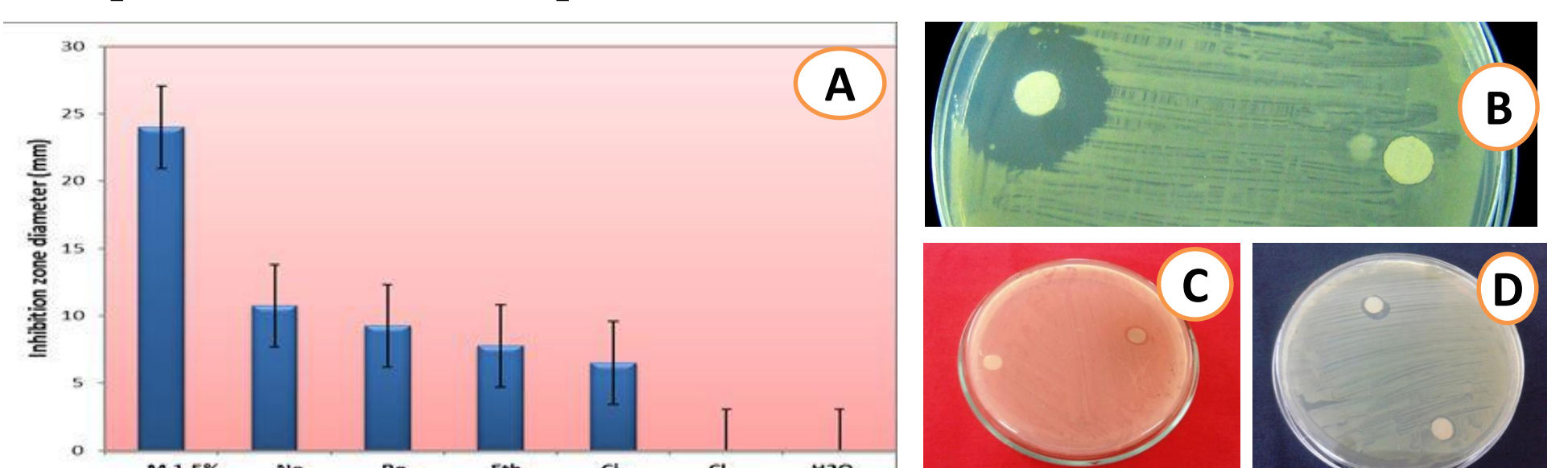


Fig.3. Efficacy of different plant extracts against *Xcc* multiplication. M 1.5%: Mancozeb (1.5%) used as positive control; Ne30%: neem extract (30% neem extract+70% ethanol); Ro: Roselle; Eth.: Ethanol 70%; Ci: Cinnamon; Cl: Clove; H<sub>2</sub>O: Negative control.

## Conclusion

Since the first discovery of CBCD in Gadaref- Sudan was in 2014, the disease appeared to have attained an epidemic level in Kassala. The disease was restricted to lime and it appears to belong to the pathotype (*Xcc*- A\*).