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RESEARCH PAPER

Host range and seed borne nature of Pokkah boeng disease of maize caused by *Fusarium verticillioides*

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Abstract: Maize (*Zea mays* L.) is a globally significant crop cultivated for food, feed and industrial uses. However, its productivity is increasingly threatened by Pokkah boeng disease (PBD), an emerging disease caused by *Fusarium* species complex. Originally a sugarcane pathogen, *Fusarium* species have recently expanded their host range to maize and sorghum, causing notable losses in warm, humid regions of India. The present study investigated the host range and seed-borne nature of *F. verticillioides* associated with PBD of maize. Host range evaluation under field and glasshouse conditions revealed that sorghum and fodder maize exhibited the highest disease incidence (80%), while pearl millet showed the least (20%). Eight species were identified as susceptible hosts, whereas nine, including perennial sorghum, fodder sugarcane, and wheat, remained symptomless, indicating potential resistance. Seed pathology assays confirmed *F. verticillioides* infection through all standard detection methods, with maximum infection observed in the pin-prick (56.67%) and agar plate (53.33%) techniques. The pathogen was successfully transmitted from infected seeds to seedlings, confirming its seed-borne nature. These findings highlight *F. verticillioides* as a major threat to maize production, emphasizing the need for seed health surveillance, resistance breeding, and integrated management strategies to contain Pokkah boeng disease.

Key words: *Fusarium verticillioides*, Host range, Maize, Pokkah boeng disease, Seed transmission

Introduction

Maize (*Zea mays* L.), the "Queen of Cereals," is among the world's most important crops due to its high yield potential, wide adaptability and diverse uses. In 2023, global maize production was estimated at 1,241.56 million tonnes from 208.23 million ha, with an average productivity of 5.96 t/ha (Anon., 2023). In India, maize is widely cultivated in Karnataka, Madhya Pradesh, Bihar, Andhra Pradesh and Telangana. Karnataka alone accounts for 1.90 million ha, producing 6.16 million tonnes with an average yield of 3.24 t/ha (Anon., 2023a). Apart from being a staple food, maize serves as livestock feed and an industrial raw material, rich in carbohydrates, proteins, oils and essential micronutrients (Siyuan *et al.*, 2018; Luo *et al.*, 2023).

Despite its agronomic and economic significance, maize productivity is limited by several diseases caused by over 112 pathogens worldwide (Khokhar *et al.*, 2014). Among these, Pokkah boeng disease (PBD) has emerged as an important fungal threat, particularly under warm and humid conditions. Initially recognized as a sugarcane disease, PBD is now increasingly reported in maize and sorghum, reflecting a widening host range and growing economic impact. The disease is mainly associated with species of the *Fusarium* complex, including *F. verticillioides*, *F. proliferatum*, *F. fujikuroi*, *F. sacchari*, *F. subglutinans* and *F. oxysporum* (Hilton *et al.*, 2017). In India, maize PBD was first recorded in Belagavi district, Karnataka, during *kharif* 2018, caused by *F. verticillioides* (Harlapur *et al.*, 2023). Later studies reported *F. luffae*, *F. proliferatum*, *F. equiseti*, and *F. brachygibbosum* (Parime *et al.*, 2021; Supriya, 2024). In sorghum, *F. subglutinans* (Khambalkar *et al.*, 2014) and *F. acutatum* (Sajeev *et al.*, 2025) were implicated.

The increasing occurrence of PBD in maize and related cereals highlights the pathogen's adaptability and potential for cross-infection. However, information on its host range and seed-borne nature is limited. Since *Fusarium* spp. are known for seed transmission, understanding their dissemination through seed is vital for disease management and biosecurity. Therefore, the present study aimed to determine the host range and seed-borne potential of *Fusarium* species associated with Pokkah boeng disease of maize.

Material and methods

Host range studies of Pokkah boeng disease of maize

Host range studies were conducted under field and glasshouse conditions using various plant species, including grasses obtained from the Indian Grassland and Fodder Research Institute, Dharwad (Table 1). Plants were sprayed with *F. verticillioides* spore suspension (2×10^6 spores/ml) prepared from 10-day-old cultures. Ten plants per species were maintained and observed for Pokkah boeng symptoms such as chlorosis, wrinkling, twisting and top distortion. Disease incidence (%) was recorded for each inoculated species to determine host susceptibility.

$$\text{Disease incidence (DI)} = \frac{\text{Total number of plants infected}}{\text{Total number of plants observed}} \times 100$$

The disease severity was also recorded upon symptom expression, using a 0-5 scale as described by Elmer (2002).

$$\text{Percent Disease index} = \frac{\text{Sum of all the numerical ratings}}{\text{Total no of plants observed x Maximum rating scale observed}} \times 100$$

Disease rating scale

Disease ratings	Description
0	No symptoms
1	Chlorotic symptoms at the base of younger leaves, very few irregular reddish specks or stripes and slight wrinkling (<1%)
2	Distorted (wrinkling and twisting) leaves are narrow or shorter and reddish area sometimes develop into lens-shaped small holes, no definite pattern, or reddish tissues appearance, ladder like lesions (<10%)
3	Leaf sheath become chlorotic, irregular necrotic areas of reddish colour, infection in the spindle continue downward to the stalk and dark reddish streak may be formed that extended through several internodes, these lesions become cross depression that give them a ladder like appearance (11-25%)
4	The lesions break through the surface and cause curvature and distortion of the stalk. Overstated version of these depressions may look like knife-cuts in the stalk. In stem, the fungus causes dark brown discoloration of infected tissues (25-50%)
5	The top (growing point) of the plant dies and it is also referred to as top rot (>50%)

Seed borne nature of *Fusarium* spp.

Cobs and seeds from maize plants showing Pokkah boeng symptoms were collected to study the seed-borne nature of *Fusarium* spp. Five standard methods were employed: agar plate, blotter, rolled paper towel, pin-prick/seed dip and grow-out tests. Surface-sterilized seeds were incubated on Potato Dextrose Agar (PDA), blotter paper or moist towels at 25-28°C and examined under a microscope for fungal growth. In the pin-prick/seed dip method, wounded seeds were immersed in a *F. verticillioides* conidial suspension ($2x10^6$ spores/ml) before incubation. For the grow-out test, seeds from infected cobs were sown under controlled conditions and observed for Pokkah boeng symptoms. The percentage of infected seeds or diseased seedlings was calculated to determine seed infection levels.

Table 1. Host range studies of Pokkah boeng disease of maize on selected monocot crops

Host Preference	Common name	Scientific name
Hosts	Sugarcane (SNK 13374)	*Saccharum officinarum* L.
	Pearl millet (PFB 10)	*Pennisetum glaucum* (L.) R. Br.
	Brown top millet	*Urochloa ramose* (L.) T.Q. Nguyen
	Proso millet (DHPM-2769)	*Panicum miliaceum* L.
	Barnyard millet (DHBM 93-2)	*Echinochloa esculenta* (A.Braun) H.Scholz
	Little millet	*Panicum sumatrense* Roth ex Roem.& Schultes
	Sorghum (M 35-1)	*Sorghum bicolor* (L.)Moench
	Fodder maize (African Tall)	*Zea mays* L.
Non-Hosts		
	Perennial sorghum (COFS-29)	*Sorghum halepense* (L.) Pers.
	Fodder sugarcane	*Saccharum spontaneum* L.
	Guinea grass (Tall)	*Megathyrsus maximus*
	Guinea grass (D 44-1)	*Megathyrsus maximus*
	Hybrid Napier	(*Pennisetum purpureum* ×*Pennisetum typhoides*)
	Brachiaria grass	*Brachiaria plantaginea*
	Para grass	*Brachiaria mutica* (Forssk.) Stapf
	Rhodes grass	*Chloris gayana* Kunth
	Wheat (Bread wheat)	*Triticum aestivum* L.

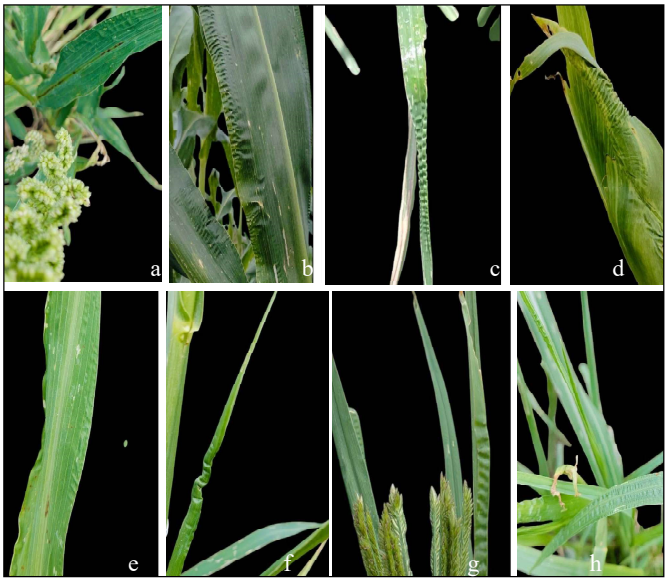

Plate 1. Crop species that showed susceptibility to Pokkah boeng disease of maize. a) Barnyard millet b) Fodder maize c) Browntop millet d) Sorghum e) Pearl millet f) Little millet g) Finger millet h) Proso millet

Results and discussions

Host range studies

The host range of *Fusarium* spp. associated with Pokkah boeng disease (PBD) of maize was assessed across several monocot crops. Disease incidence (DI) and per cent disease index (PDI) for each crop are presented in Table 2. Among the tested species, sorghum (*Sorghum bicolor*) and fodder maize (*Zea mays*) recorded the highest DI (80%), followed by sugarcane (*Saccharum officinarum* with 70% DI). Brown top millet (*Brachiaria ramosa*) exhibited moderate infection (40%), while proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa esculenta*), and little millet (*Panicum sumatrense*) showed lower DI (30%). Pearl millet (*Pennisetum glaucum*) displayed the least incidence (20%).

Disease severity, expressed as PDI, was highest (40%) in sugarcane, brown top millet, little millet, sorghum and fodder maize, indicating pronounced symptom expression. Pearl millet, proso millet and barnyard millet exhibited milder symptoms (20% PDI). Common symptoms included chlorosis, leaf wrinkling, twisting and malformed top, though less pronounced in the latter group (Plate 1).

Of the crops tested, eight were identified as hosts for *F. verticillioides* showing typical PBD-like symptoms, while nine

Table 2. Host range studies of Pokkah boeng disease of maize showing Disease Incidence (DI) and Per cent Disease index (PDI) on inoculated hosts by *F. verticillioides*

Host	Symptoms produced	DI (%)	PDI
Sugarcane (SNK 13374)	Wrinkling and twisting of leaves	70	40
Pearl millet (PFB 10)	Slight wrinkling of leaves	20	20
Brown top millet	Wrinkling and twisting of leaves	40	40
Proso millet (DHPM-2769)	Slight wrinkling of leaves	30	20
Barnyard millet (DHBM 93-2)	Slight wrinkling of leaves	30	20
Little millet	Wrinkling and twisting of leaves	30	40
Sorghum (M 35-1)	Wrinkling and twisting of leaves	80	40
Fodder maize (African Tall)	Wrinkling and twisting of leaves	80	40
Perennial sorghum (COFS-29)	-	-	-
Fodder sugarcane	-	-	-
Guinea grass (Tall)	-	-	-
Guinea grass (D 44-1)	-	-	-
Hybrid Napier	-	-	-
Brachiaria grass	-	-	-
Para grass	-	-	-
Rhodes grass	-	-	-
Wheat (Bread wheat)	-	-	-

Note: 1. DI= Disease Incidence 2. PDI= Per cent Disease Index

remained asymptomatic and were classified as non-hosts (Table 1 and 2). Non-host species included perennial sorghum (*Sorghum halepense*), fodder sugarcane (*Saccharum spontaneum*), guinea grass (tall and common), hybrid Napier, *Brachiaria* grass, para grass, Rhodes grass and wheat (*Triticum aestivum*). Their resistance likely results from stronger structural barriers or biochemical defences that restrict infection or colonization.

The contrast between susceptible cultivated species (*S. bicolor*, *S. officinarum*) and resistant fodder or wild relatives suggests loss of inherent resistance during domestication. The robust nature of hybrid Napier and Rhodes grass may contribute to their ability to suppress fungal establishment. Minor variations in host physiology and microenvironmental conditions might also influence differential symptom expression.

The findings corroborate earlier reports of the broad host range of *F. verticillioides*. Viswakarma *et al.* (2013) and Costa *et al.* (2019) documented its association with maize, sorghum, rice, sugarcane, and millets. The present study confirms this adaptability and newly identifies resistant species, such as perennial sorghum, fodder sugarcane and wheat, highlighting potential genetic resources for disease management and breeding programs.

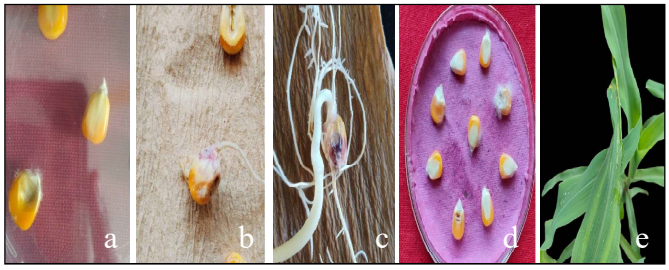

Plate 2. Detection of seed borne nature of *Fusarium* spp. causing Pokkah boeng disease of maize. a) Agar plate method, b) Paper towel method, c) Pin prick method, d) Blotter paper method, e) Grow out test

Seed-borne nature of *Fusarium* spp.

Cobs from PBD-infected maize plants were collected to evaluate the seed-borne nature of *Fusarium* spp. through agar plate, blotter, paper towel, pin-prick and grow-out tests (Table 3). All methods confirmed pathogen presence, verifying seed transmissibility (Plate 2).

In the agar plate method, surface-sterilized seeds produced white, cottony *Fusarium* mycelia after incubation on PDA. Microscopic observation showed hyaline septate hyphae and characteristic sickle-shaped conidia, confirming *F. verticillioides*. Infection rate was 53.33 per cent, demonstrating this method's high sensitivity.

The blotter method detected 20 per cent infection, while the paper towel assay recorded 26.67 per cent infection with reduced radicle length and seedling vigour, indicating detrimental effects on germination. The pin-prick method, which allowed easier pathogen entry, showed the highest infection (56.67%), reflecting the pathogen's capacity to invade through mechanical injuries.

In the grow-out test, 22.5 per cent of seedlings developed chlorosis and leaf wrinkling within 15-20 days, confirming seed-to-seedling transmission. These results clearly demonstrate that *F. verticillioides* survives and disseminates through infected seeds. Consistent detection across all techniques underscores the pathogen's persistence and the reliability of the employed assays.

The agar plate and pin-prick methods proved to be the most sensitive, while the grow-out test verified symptom expression and infectivity. The seed transmission of Pokkah boeng disease in sugarcane *via* infected seed setts has been previously documented by Poorniammal *et al.*(2024), and the present findings in maize are in alignment with those observations.

Overall, the study provides conclusive evidence that *F. verticillioides* associated with Pokkah boeng disease has a

Table 3. Per cent infection of Pokkah boeng disease of maize on seeds using various methods for proving seed borne nature

Method	Observations	Per cent infection
Agar plate method	White mycelial growth observed on PDA; spores confirmed under the microscope	53.33
Blotter paper method	Fungal growth visible on moistened blotter; typical conidiophores observed	20.00
Paper towel method	Infection visible on germinated seeds; reduced radicle length noted	26.67
Pin-prick method	High infection rate; visibly reduced germination	56.67
		Per cent disease incidence
Grow-Out Test	Leaf chlorosis and wrinkling observed on emerging seedlings	22.50

wide host range among cereals and is efficiently transmitted *via* maize seed. The identification of resistant host species offers valuable leads for resistance breeding, while the confirmation of seed-borne transmission highlights the need for stringent seed health testing and appropriate seed treatment to prevent the spread of Pokkah boeng in maize-growing regions.

Conclusion

The study evaluated the host range and seed-borne nature of *F. verticillioides* associated with Pokkah boeng disease (PBD) of maize. Among tested monocot crops, sorghum and fodder maize showed the highest disease incidence, followed by sugarcane, whereas pearl millet exhibited the lowest. Eight species were confirmed as hosts, while nine, including perennial sorghum, fodder sugarcane, and wheat, remained symptomless, indicating resistance. Seed health tests revealed the presence of *Fusarium* in all detection methods, with the pin-prick and agar plate techniques showing the highest infection. The pathogen was also transmitted from infected seed to seedlings. These results confirm that *F. verticillioides* possesses a broad host range and is seed-transmissible, posing a potential threat to cereal crops. The identification of resistant hosts provides a valuable basis for breeding and integrated management strategies against Pokkah boeng disease.

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