



RESEARCH ARTICLE

# Management of pokkah boeng disease of maize caused by *Fusarium verticillioides*

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## Abstract

Pokkah boeng, caused by *Fusarium verticillioides*, is a major constraint in maize production. Field experiments were conducted during kharif and rabi 2024 at the Main Agricultural Research Station (MARS), Dharwad and during kharif 2024 at the Agricultural Research Station (ARS), Sankeshwar, to evaluate fifteen fungicidal treatments for disease management and yield improvement. Disease incidence, severity and yield traits were recorded and data were arc-sine transformed before statistical analysis. Significant differences were observed among treatments across locations. The combination fungicide (Carbendazim 12 % + Mancozeb 63 % WP) (SAAF) consistently recorded the lowest pooled disease incidence (19.65 %) and severity (13.53 %) and the highest grain yield (64.17 q/ha), outperforming the untreated check (34.82 % and 33.90 %; 50.32 q/ha). Carbendazim 50 % WP ranked second in efficacy, with incidence of 21.12 %, severity of 16.58 % and yield of 62.82 q/ha. Yield-contributing traits, including 100-seed weight, cob length, cob girth and shelling percentage, were significantly improved in the superior treatments. Consistent trends across locations and pooled analysis confirmed the stability of these treatments. The results indicate that (Carbendazim 12 % + Mancozeb 63 % WP) and Carbendazim 50 % WP are effective and reliable options for managing pokkah boeng disease under northern Karnataka conditions.

**Keywords:** disease management; fungicides; *Fusarium*; maize; pokkah boeng; yield

## Introduction

Maize (*Zea mays* L.), a member of the *Poaceae* family, is a C<sub>4</sub> plant, alongside other grasses like sorghum and sugarcane, which exhibits an efficient photosynthetic pathway that enhances productivity in high temperatures and intense solar radiation. Introduced to India by the Portuguese in the 17<sup>th</sup> century, maize has become integral to Indian agriculture, cultivated for grain, fodder, green cobs, sweet corn, baby corn, popcorn and industrial products like ethanol (1). Globally recognised as the queen of cereals due to its high genetic yield potential and adaptability to varied environmental conditions, maize is grown across a wide range of agroecological zones (2). Its photothermo-insensitive nature allows it to thrive in diverse climates, making it a critical crop in both tropical and temperate regions. In 2023, global maize production reached approximately 1241.56 MT from 208.23 M ha, with an average yield of 5.96 t/ha (3). The United States leads as the largest producer, followed by China, Brazil, Argentina, Ukraine, Mexico, India, France and Indonesia. Global maize productivity has significantly increased over the past quarter-century, with production more than

doubling from 521 million tonnes to 1137 million tonnes due to a 50 % yield rise (from 3.9 to 5.8 t/ha) and 46 % area expansion, positioning it as the leading cereal crop by volume. As a versatile multi-purpose crop, maize serves primarily as livestock feed worldwide, driving demand with rising animal source food consumption, while playing a crucial role in human food security and livelihoods in regions like sub-Saharan Africa and Latin America, where it contributes over 20 % of food calories (4). In India, maize is predominantly a kharif crop, occupying 85 % of the cultivated area, with 90 % of this area planted with hybrids. India ranks fourth globally in terms of maize cultivation area, accounting for approximately 4 % of the total and stands seventh in production, contributing around 2 % to the global output. In 2023, India cultivated maize on 10.72 M ha, producing 38.09 MT with an average yield of 3.54 t/ha. Key maize-growing states include Karnataka, Madhya Pradesh, Bihar, Andhra Pradesh and Telangana, with Karnataka alone cultivating 1.90 M ha, yielding 6.16 MT at an average productivity of 3.24 t/ha (5). The major maize-producing districts of the state, in terms of area, include Haveri, Belagavi, Vijayanagara, Davangere, Chitradurga and Koppal.

Globally, maize is vulnerable to approximately 112 diseases, which collectively limit its productivity (6, 7). Major diseases include *Turicum* leaf blight (*Exserohilum turcicum*), Maydis leaf blight (*Drechslera maydis*), banded leaf and sheath blight (*Rhizoctonia solani* f. sp. *sasakii*), bacterial stalk rot (*Erwinia chrysanthemi* pv. *zeae*), post-flowering stalk rots (*Fusarium verticillioides*, *Macrophomina phaseolina*) and *Curvularia* leaf spot (*Curvularia lunata*). Among these, pokkah boeng disease (PBD) has emerged as a significant threat to maize production, particularly in regions like Karnataka, India. The *Fusarium* species complex, including *F. verticillioides*, *F. sacchari*, *F. fujikuroi*, *F. proliferatum*, *F. oxysporum* and *F. subglutinans* are the primary causal agent of Pokkah boeng worldwide (8). Additionally, *Fusarium subglutinans* and *Fusarium acutatum* were reported to be the causal agents of PBD in sorghum (9, 10). The disease's emergence in maize is relatively recent, with the first report in India from Belagavi district, Karnataka, during the kharif season of 2018, caused by *Fusarium verticillioides* (11). Subsequent studies identified *Fusarium luffae* as a causal agent in maize during kharif 2019, with additional reports implicating *Fusarium proliferatum*, *Fusarium equiseti*, *Fusarium brachygibbosum*, *Fusarium incarnatum*, *Fusarium equiseti* and *Fusarium sulawesiense* (12–14).

In maize, PBD symptoms include leaf chlorosis, malformation, twisting, curling of leaves and top rot, which can lead to significant yield reductions, as shown in Fig. 1 (14). Also, the disease was more prevalent in irrigated conditions and black soils and the vegetative stage was more prone to the disease. In Karnataka, the highest disease incidence was found in Belagavi (37.67 %), whereas Davangere recorded the lowest disease incidence (17.68 %) (14, 15). The crop loss in the state varied significantly from genotype to genotype, with grain yield loss ranging from 2.42 to 13.56 % (13). Recent studies have expanded the known host range of PBD to include pearl millet, proso millet, finger millet, browntop millet, barnyard millet, little millet and fodder maize, in addition to sorghum and sugarcane. The disease has also been reported to be seed-borne (16). Effective management of PBD also depends on identifying suitable chemical fungicides. While cultural and biological methods are valuable, chemical methods remain a practical solution for immediate disease management, particularly

in high-value crops like maize. Evaluating the efficacy of fungicides against *Fusarium* species causing PBD will provide farmers with actionable tools to mitigate yield losses. Given the emerging threat of PBD to maize production and its potential to affect food security, a systematic and multifaceted study is essential.

## Materials and Methods

Field experiments for the management of PBD of maize were conducted at the Main Agricultural Research Station, Dharwad, during the kharif and rabi seasons of 2024 and at the Agricultural Research Station, Sankeshwar, during the kharif 2024 season. The plants under study were artificially inoculated with the spore suspension of *Fusarium verticillioides* ( $2 \times 10^6$  spores/mL), prepared from a 7-day-old culture in sterile distilled water. The details of the treatments implemented are presented in Table 1 and 2.

Observations on disease incidence, CODEX and percent disease index were recorded before the flowering stage of maize, with the final assessment taken at 60–70 days after sowing (DAS). The disease incidence and CODEX were calculated using the following formula (17):

$$\text{Disease Incidence (DI)} = \frac{\text{Total number of plants infected}}{\text{Total number of plants observed}} \times 100 \quad (\text{Eqn. 1})$$

$$\text{CODEX} = \frac{\text{Disease incidence} \times \% \text{ disease index}}{100} \quad (\text{Eqn. 2})$$

The disease severity was calculated by using 1–5 disease rating scale (18)

$$\% \text{ disease index (PDI)} = \frac{\text{Sum of all the numerical ratings}}{\text{Total number of plants observed} \times \text{Maximum rating scale observed}} \times 100 \quad (\text{Eqn. 3})$$

**Table 1.** Experimental details of the field trial

| Location                     | MARS, UAS, Dharwad (kharif and rabi, 2024) and ARS, Sankeshwar (kharif, 2024)               |
|------------------------------|---------------------------------------------------------------------------------------------|
| Season                       | Kharif and rabi 2024                                                                        |
| Design                       | Randomised block design (RBD)                                                               |
| Treatments                   | 15                                                                                          |
| Replications                 | 3                                                                                           |
| Hybrid                       | DKC-9126                                                                                    |
| Spacing                      | 60 × 20 cm                                                                                  |
| Plot size                    | 7.2 m <sup>2</sup>                                                                          |
| No. of sprays and time (DAS) | Two sprays at an interval of 15 days starting from the onset of disease (30 DAS and 45 DAS) |

**Table 2.** Details of fungicide treatments and dosages evaluated for efficacy against pokkah boeng disease of maize

| Treatment       | Details                                                   | Trade name                         | Dosage      |
|-----------------|-----------------------------------------------------------|------------------------------------|-------------|
| T <sub>1</sub>  | Carbendazim 50 % WP                                       | Bavistin (Crystal Crop Protection) | 1 g/L       |
| T <sub>2</sub>  | Hexaconazole 5 % SC                                       | Contaf Plus (Rallis India-TATA)    | 1 mL/L      |
| T <sub>3</sub>  | Propiconazole 25 % EC                                     | Tilt (Crystal Crop Protection)     | 1 mL/L      |
| T <sub>4</sub>  | Tebuconazole 25.9 % EC                                    | Folicur (Bayer India)              | 1 mL/L      |
| T <sub>5</sub>  | (Carbendazim 12 % + Mancozeb 63 % WP)                     | SAAF (UPL)                         | 2 g/L       |
| T <sub>6</sub>  | (Azoxytrobilin 18.2 % + Difenoconazole 11.4 % SC)         | Amistar Top (Syngenta)             | 1 mL/L      |
| T <sub>7</sub>  | (Tebuconazole 50 % + Trifloxystrobin 25 % WG)             | Nativo (Bayer)                     | 1 g/L       |
| T <sub>8</sub>  | (Hexaconazole 5 % + Captan 70 % WP)                       | Taqat (Rallis India- TATA)         | 2 g/L       |
| T <sub>9</sub>  | (Tricyclazole 18 % + Mancozeb 62 % WP)                    | Merger (Indofil)                   | 2 g/L       |
| T <sub>10</sub> | (Hexaconazole 5 % + Validamycin 2.5 % SC 10)              | Valxtra (Willowood Crop Science)   | 2 mL/L      |
| T <sub>11</sub> | (Metiram 55 % + Pyraclostrobin 5 % WG)                    | Cabrio top (BASF)                  | 2 g/L       |
| T <sub>12</sub> | Mancozeb 75 % WP                                          | Dhanuka-M-45 (Dhanuka Agritech)    | 2.5 g/L     |
| T <sub>13</sub> | Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS) | Sprint (Indofil)                   | 2 g/kg seed |
| T <sub>14</sub> | (Hexaconazole 4 % + Zineb 68 % WP)                        | Avatar                             | 2 g/L       |
| T <sub>15</sub> | Untreated check                                           |                                    |             |



**Fig. 1.** Characteristic symptoms of pokkah boeng disease of maize. A) Development of small streaks on leaves; B) Chlorosis of leaf; C) Wrinkling of leaves; D) Twisting of leaf; E) Rolling of the leaf; F) Top rot symptom; G) Stunted growth of the plant

Postharvest data on test weight, cob length, cob girth, shelling percentage and grain yield were recorded. The collected data were subjected to statistical analysis using randomised block design (RBD) for field studies (19). Percentage data were arc-sine transformed before analysis. The data were analysed using Fisher's method of analysis of variance (ANOVA) (20, 21). Additionally, statistical tools such as the OPSTAT online statistical analysis software developed by CCS Haryana Agricultural University and Microsoft Excel were employed for data processing and interpretation.

## Results and Discussion

Field experiments conducted during kharif and rabi 2024 at MARS, Dharwad and during kharif 2024 at ARS, Sankeshwar, revealed significant differences among fungicidal treatments in the management of PBD of maize. Disease incidence, severity and CODEX index varied considerably across locations and seasons, with several treatments providing substantial disease reduction compared to the untreated control (Table 3). Improved disease suppression was directly associated with enhanced grain yield and yield attributes such as 100-seed weight, cob length, cob girth and shelling percentage. Economic analysis also demonstrated wide variation among treatments, indicating the influence of effective disease management on net profitability. The key findings from individual environments and pooled analyses are presented below.

### Main Agricultural Research Station , Dharwad (kharif 2024)

Significant differences were observed among treatments for disease incidence, disease severity and CODEX. The treatment T<sub>5</sub> [(Carbendazim 12 % + Mancozeb 63 % WP) at 2 g/L] recorded the lowest disease incidence (19.65 %) and PDI (13.53 %), which was statistically superior to all other treatments and the untreated control (DI- 34.82 %; PDI- 24.73 %).

T<sub>1</sub> (Carbendazim 50 % WP at 1 g/L) and T<sub>13</sub> (Seed treatment with Carbendazim 25 % + Mancozeb 50 % WS) formed the next best group with reduced disease levels. Treatments such as T<sub>14</sub> (Hexaconazole 4 % + Zineb 68 % WP) showed moderate suppression, while the untreated control (T<sub>15</sub>) and T<sub>12</sub> (Mancozeb 75 % WP) recorded the maximum disease expression. Yield attributes such as cob length, cob girth, shelling percentage and 100-seed weight differed significantly among treatments. T<sub>5</sub> resulted in maximum cob length (19.9 cm), cob girth (4.76 cm) and 100-seed weight (36.19 g), closely followed by T<sub>1</sub> and T<sub>13</sub>. Minimum values were recorded in T<sub>15</sub> (untreated control). The highest grain yield was obtained with T<sub>5</sub> (64.17 q/ha), yielding more than the control (47.81 q/ha). This treatment also recorded the maximum benefit-cost ratio (2.19), confirming its commercial suitability, while T<sub>1</sub> and T<sub>13</sub> also showed substantial economic gain (Fig. 2–3 and Table 3–5).

### Main Agricultural Research Station , Dharwad (rabi 2024)

A similar trend was observed during the rabi 2024 season in Dharwad, where the disease incidence was found to be higher in treatment T<sub>12</sub> (26.83 %) next to untreated control (31.83 %). The treatment T<sub>5</sub> recorded the lowest disease incidence (16.00 %) and PDI (25.70 %), which was statistically superior to all other treatments and the untreated control. T<sub>1</sub> and T<sub>13</sub> formed the next best group with reduced disease levels. Treatments such as T<sub>14</sub> showed moderate suppression, while the untreated control (T<sub>15</sub>)

and T<sub>12</sub> recorded the maximum disease expression. Yield attributes such as cob length, cob girth, shelling percentage and 100-seed weight differed significantly among treatments (Fig. 2, 3 and Table 3–5).

T<sub>5</sub> resulted in maximum cob length (17.27 cm), cob girth (4.68 cm) and 100-seed weight (35.67 g), closely followed by T<sub>1</sub> and T<sub>13</sub>. Minimum values were recorded in T<sub>15</sub>. The highest grain yield was obtained with T<sub>5</sub> (76.34 q/ha), yielding more than the control (44.30 q/ha). This treatment also recorded the maximum benefit-cost ratio (2.61), confirming its commercial suitability, while T<sub>1</sub> and T<sub>13</sub> also showed substantial economic gain.

### Agricultural Research Station , Sankeshwar (kharif 2024)

Fungicidal treatments had a significant effect on disease incidence, disease severity and CODEX. The treatment T<sub>5</sub> consistently recorded the lowest disease incidence (19.85 %) and PDI (19.97 %), which was statistically superior to all other treatments and the untreated control (DI- 35.76 %; PDI- 32.87 %). T<sub>1</sub> and T<sub>13</sub> formed the next best group with reduced disease levels. Treatments such as T<sub>14</sub> showed moderate suppression, while the untreated control (T<sub>15</sub>) and T<sub>12</sub> recorded the maximum disease expression. Yield attributes such as cob length, cob girth, shelling percentage and 100-seed weight differed significantly among treatments (Table 3–5).

T<sub>5</sub> resulted in maximum cob length (17.25 cm), cob girth (4.69 cm) and 100-seed weight (35.12 g), closely followed by T<sub>1</sub> and T<sub>13</sub>. Minimum values were recorded in T<sub>15</sub> (untreated control). The highest grain yield was obtained with T<sub>5</sub> (63.91 q/ha), yielding more than the control (48.12 q/ha). This treatment also recorded the maximum benefit-cost ratio (2.18), confirming its commercial suitability, while T<sub>1</sub> and T<sub>13</sub> also showed substantial economic gain.

### Pooled data of 2024

The data obtained from two locations and two seasons were pooled and analysed statistically to determine the best treatment. The data presented depict the significant difference among the treatments concerning disease incidence, % disease severity, CODEX, 100 seed weight and grain yield (Table 3). From both seasons, it was observed that the treatment T<sub>5</sub> remained consistently superior across all locations and seasons, followed by T<sub>1</sub> and T<sub>13</sub> (Fig. 2–3 and Table 3–5).

In China, Carbendazim was widely used to manage PBD of sugarcane until the emergence of the *Fusarium* species complex (22). Research evaluated nine fungicides against sugarcane PBD, where the highest disease control was observed when treated with Carbendazim, followed by (Carbendazim + Mancozeb) (23). The results of the presented study are consistent with earlier findings, where timely application of highly effective fungicides or fungicide combinations provided substantial reductions in Pokkah boeng severity and enhanced yield (13). The strong performance of (Carbendazim 12 % + Mancozeb 63 % WP) and Carbendazim 50 % WP may be attributed to their dual preventive and curative action against *Fusarium verticillioides*, effectively limiting pathogen establishment and spread. Maintaining healthy foliage and stalk integrity likely enabled more efficient translocation of photosynthates to the developing cobs, thereby improving grain yield and quality (Fig. 1).

The differences in efficacy among treatments could also be influenced by the prevailing warm and humid conditions during the early crop growth stage, which favoured disease development. Under such conditions, treatments with insufficient systemic or

**Table 3.** Pooled data on DI, DSI and CODEX under the management of pokkah boeng disease at Dharwad and Sankeshwar during 2024

| Treatment       | DI                |                  |                  | PDI              |                  |                  | CODEX      |            |          |
|-----------------|-------------------|------------------|------------------|------------------|------------------|------------------|------------|------------|----------|
|                 | Kharif (D)        | Kharif (S)       | Rabi (D)         | Kharif (D)       | Kharif (S)       | Rabi (D)         | Kharif (D) | Kharif (S) | Rabi (D) |
| T <sub>1</sub>  | 21.12<br>(27.36)* | 20.34<br>(26.81) | 16.33<br>(23.84) | 16.58<br>(24.03) | 24.37<br>(29.58) | 20.07<br>(26.61) | 3.50       | 4.96       | 3.28     |
| T <sub>2</sub>  | 27.48<br>(31.61)  | 27.63<br>(31.71) | 23.63<br>(29.09) | 27.67<br>(31.73) | 28.90<br>(32.52) | 24.53<br>(29.69) | 7.60       | 7.99       | 5.80     |
| T <sub>3</sub>  | 25.12<br>(30.08)  | 25.70<br>(30.46) | 21.67<br>(27.74) | 24.09<br>(29.39) | 24.60<br>(29.73) | 23.10<br>(28.73) | 6.05       | 6.32       | 5.01     |
| T <sub>4</sub>  | 24.92<br>(29.95)  | 24.34<br>(29.56) | 20.33<br>(26.80) | 23.93<br>(29.29) | 24.67<br>(29.78) | 22.03<br>(28.00) | 5.96       | 6.00       | 4.48     |
| T <sub>5</sub>  | 19.65<br>(26.31)  | 19.85<br>(26.46) | 16.00<br>(23.58) | 13.53<br>(21.58) | 19.97<br>(26.54) | 15.50<br>(23.18) | 2.66       | 3.96       | 2.48     |
| T <sub>6</sub>  | 27.83<br>(31.84)  | 28.48<br>(32.26) | 24.50<br>(29.67) | 27.92<br>(31.89) | 28.63<br>(32.35) | 25.70<br>(30.46) | 7.77       | 8.16       | 6.30     |
| T <sub>7</sub>  | 24.59<br>(29.73)  | 23.96<br>(29.31) | 20.00<br>(26.57) | 23.87<br>(29.25) | 22.67<br>(28.43) | 21.60<br>(27.69) | 5.87       | 5.43       | 4.32     |
| T <sub>8</sub>  | 22.94<br>(28.62)  | 23.36<br>(28.90) | 19.33<br>(26.08) | 22.12<br>(28.06) | 23.30<br>(28.86) | 21.40<br>(27.56) | 5.07       | 5.44       | 4.14     |
| T <sub>9</sub>  | 27.85<br>(31.85)  | 28.50<br>(32.27) | 24.50<br>(29.67) | 28.16<br>(32.05) | 31.57<br>(34.18) | 26.49<br>(30.98) | 7.84       | 9.00       | 6.49     |
| T <sub>10</sub> | 26.34<br>(30.88)  | 25.84<br>(30.55) | 21.83<br>(27.86) | 25.18<br>(30.12) | 24.30<br>(29.53) | 23.13<br>(28.75) | 6.63       | 6.28       | 5.05     |
| T <sub>11</sub> | 26.75<br>(31.15)  | 26.71<br>(31.12) | 22.83<br>(28.54) | 26.99<br>(31.30) | 26.63<br>(31.07) | 24.43<br>(29.62) | 7.22       | 7.11       | 5.58     |
| T <sub>12</sub> | 30.56<br>(33.56)  | 30.92<br>(33.78) | 26.83<br>(31.20) | 28.46<br>(32.24) | 32.87<br>(34.98) | 27.13<br>(31.39) | 8.70       | 10.16      | 7.28     |
| T <sub>13</sub> | 22.85<br>(28.56)  | 21.97<br>(27.95) | 18.00<br>(25.10) | 20.18<br>(26.69) | 18.63<br>(25.57) | 21.17<br>(27.39) | 4.61       | 4.09       | 3.81     |
| T <sub>14</sub> | 29.21<br>(32.71)  | 29.71<br>(33.03) | 20.16<br>(26.68) | 28.31<br>(32.15) | 32.22<br>(34.58) | 27.13<br>(31.39) | 8.27       | 9.57       | 5.47     |
| T <sub>15</sub> | 34.82<br>(36.16)  | 35.76<br>(36.73) | 31.83<br>(34.35) | 33.90<br>(35.61) | 30.17<br>(33.32) | 29.97<br>(33.19) | 11.80      | 10.79      | 9.54     |
| Mean            | 26.13<br>(30.75)  | 26.20<br>(30.79) | 21.85<br>(27.87) | 24.73<br>(29.82) | 26.23<br>(30.81) | 26.56<br>(31.02) | 6.41       | 6.87       | 5.15     |
| S. E.m ±        | 1.97              | 2.10             | 1.99             | 2.19             | 1.74             | 1.93             | 3.50       | 4.96       | 3.28     |
| CD at 5 %       | 5.71              | 6.07             | 5.77             | 6.35             | 5.05             | 5.59             | 7.60       | 7.99       | 5.80     |

\*Values in the parentheses are arc sine transformed T<sub>1</sub>: Carbendazim 50 % WP, T<sub>2</sub>: Hexaconazole 5 % SC, T<sub>3</sub>: Propiconazole 25 % EC, T<sub>4</sub>: Tebuconazole 25.9 % EC, T<sub>5</sub>: Carbendazim 12 % + Mancozeb 63 % WP), T<sub>6</sub>: (Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC), T<sub>7</sub>: (Tebuconazole 50 % + Trifloxystrobin 25 % WG), T<sub>8</sub>: (Hexaconazole 5 % + Captan 70 % WP), T<sub>9</sub>: (Tricyclazole 18 % + Mancozeb 63 % WP), T<sub>10</sub>: (Hexaconazole 5 % + Validamycin 2.5 % SC), T<sub>11</sub>: (Metiram 55 % + Pyraclostrobin 5 % WG), T<sub>12</sub>: Mancozeb 75 % WP, T<sub>13</sub>: Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS), T<sub>14</sub>: (Hexaconazole 4 % + Zineb 68 % WP), T<sub>15</sub>: Untreated check, DI – Disease incidence, PDI – % disease index, D- Dharwad, S-Sankeshwar, S. E.m- Standard error of the mean, CD- Critical difference

**Table 4.** Pooled data on grain yield, 100 seed weight and shelling percentage under the management of pokkah boeng disease at Dharwad and Sankeshwar during 2024

| Treatment       | Grain yield (q/ha) |            |          | 100 seed weight (g) |            |            | Shelling percentage |        |                                                          |
|-----------------|--------------------|------------|----------|---------------------|------------|------------|---------------------|--------|----------------------------------------------------------|
|                 | Kharif (D)         | Kharif (S) | Rabi (D) | Pooled              | Kharif (D) | Kharif (S) | Rabi (D)            | Pooled | Pooled                                                   |
| T <sub>1</sub>  | 62.82              | 61.21      | 68.99    | 64.34               | 35.90      | 32.91      | 33.33               | 34.05  | 85.77<br>(67.84)<br>85.42<br>(67.55)<br>85.48<br>(67.60) |
| T <sub>2</sub>  | 55.00              | 52.92      | 58.56    | 55.49               | 28.86      | 26.03      | 26.00               | 26.96  | 83.33<br>(65.90)<br>83.41<br>(65.96)<br>83.58<br>(66.10) |
| T <sub>3</sub>  | 57.36              | 54.85      | 59.41    | 57.21               | 31.24      | 28.57      | 28.67               | 29.49  | 84.54<br>(66.85)<br>84.67<br>(66.95)<br>84.63<br>(66.92) |
| T <sub>4</sub>  | 58.06              | 56.55      | 61.24    | 58.62               | 32.05      | 29.12      | 29.67               | 30.28  | 84.56<br>(66.86)<br>84.77<br>(67.03)<br>84.86<br>(67.10) |
| T <sub>5</sub>  | 64.17              | 63.91      | 76.34    | 68.14               | 36.19      | 35.12      | 35.67               | 35.66  | 86.12<br>(68.13)<br>86.08<br>(68.09)<br>86.01<br>(68.04) |
| T <sub>6</sub>  | 54.65              | 52.07      | 56.65    | 54.46               | 26.31      | 25.91      | 25.67               | 25.96  | 83.27<br>(65.86)<br>83.12<br>(65.74)<br>83.04<br>(65.76) |
| T <sub>7</sub>  | 58.22              | 56.59      | 65.59    | 60.13               | 33.25      | 30.12      | 30.67               | 31.34  | 84.98<br>(67.20)<br>84.89<br>(67.13)<br>84.95<br>(67.17) |
| T <sub>8</sub>  | 59.54              | 58.58      | 66.13    | 61.42               | 33.45      | 30.79      | 31.33               | 31.86  | 85.15<br>(67.33)<br>85.03<br>(67.24)<br>85.22<br>(67.32) |
| T <sub>9</sub>  | 54.63              | 52.05      | 53.24    | 53.31               | 25.35      | 25.79      | 25.67               | 25.60  | 82.96<br>(65.62)<br>83.05<br>(65.69)<br>82.93<br>(65.63) |
| T <sub>10</sub> | 56.14              | 54.71      | 58.88    | 56.58               | 30.57      | 27.12      | 27.67               | 28.45  | 84.42<br>(66.75)<br>84.22<br>(66.59)<br>84.37<br>(66.69) |
| T <sub>11</sub> | 55.73              | 53.84      | 58.59    | 56.05               | 30.33      | 27.12      | 27.67               | 28.37  | 83.41<br>(65.96)<br>83.76<br>(66.23)<br>83.72<br>(66.13) |
| T <sub>12</sub> | 51.92              | 50.13      | 50.79    | 50.95               | 23.97      | 24.45      | 24.33               | 24.25  | 82.41<br>(65.20)<br>82.74<br>(65.45)<br>82.79<br>(65.38) |
| T <sub>13</sub> | 59.63              | 60.67      | 66.65    | 62.32               | 33.65      | 31.12      | 31.67               | 32.14  | 85.36<br>(67.50)<br>85.11<br>(67.30)<br>85.29<br>(67.42) |
| T <sub>14</sub> | 52.61              | 51.09      | 53.62    | 52.44               | 24.66      | 25.00      | 25.67               | 25.11  | 82.67<br>(65.40)<br>82.95<br>(65.51)<br>82.81<br>(65.51) |
| T <sub>15</sub> | 47.81              | 48.12      | 44.30    | 46.74               | 22.30      | 21.33      | 21.67               | 21.77  | 82.37<br>(65.17)<br>82.68<br>(65.41)<br>82.56<br>(65.32) |
| Mean            | 56.55              | 55.15      | 59.93    | 57.21               | 29.87      | 28.03      | 28.36               | 28.75  | 84.09<br>(66.49)<br>84.13<br>(66.52)<br>84.12<br>(66.52) |
| S. E.m ±        | 3.38               | 3.92       | 3.98     | 2.16                | 2.63       | 2.39       | 2.36                | 1.77   | 3.82<br>3.80<br>3.60<br>3.41                             |
| CD at 5 %       | 9.79               | 11.36      | 11.53    | 6.25                | 7.62       | 6.92       | 6.83                | 5.12   | 11.07<br>11.01<br>10.43<br>9.88                          |

\*Values in the parentheses are arc sine transformed T<sub>1</sub>: Carbendazim 50 % WP, T<sub>2</sub>: Hexaconazole 5 % SC, T<sub>3</sub>: Propiconazole 25 % EC, T<sub>4</sub>: Tebuconazole 25.9 % EC, T<sub>5</sub>: Carbendazim 12 % + Mancozeb 63 % WP), T<sub>6</sub>: (Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC), T<sub>7</sub>: (Tebuconazole 50 % + Trifloxystrobin 25 % WG), T<sub>8</sub>: (Hexaconazole 5 % + Captan 70 % WP), T<sub>9</sub>: (Tricyclazole 18 % + Mancozeb 63 % WP), T<sub>10</sub>: (Hexaconazole 5 % + Validamycin 2.5 % SC), T<sub>11</sub>: (Metiram 55 % + Pyraclostrobin 5 % WG), T<sub>12</sub>: Mancozeb 75 % WP, T<sub>13</sub>: Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS), T<sub>14</sub>: (Hexaconazole 4 % + Zineb 68 % WP), T<sub>15</sub>: Untreated check, DI – Disease incidence, PDI – % disease index, D- Dharwad, S-Sankeshwar, S. E.m- Standard error of the mean, CD- Critical difference

**Table 5.** Pooled data on cob length and cob girth under the management of pokkah boeng disease at Dharwad and Sankeshwar during 2024

| Treatment       | Cob length (cm) |            |          | Pooled | Cob girth (cm) |            |          | Pooled |
|-----------------|-----------------|------------|----------|--------|----------------|------------|----------|--------|
|                 | Kharif (D)      | Kharif (S) | Rabi (D) |        | Kharif (D)     | Kharif (S) | Rabi (D) |        |
| T <sub>1</sub>  | 17.10           | 16.45      | 16.47    | 16.67  | 4.51           | 4.52       | 4.52     | 4.52   |
| T <sub>2</sub>  | 14.80           | 14.81      | 14.80    | 14.80  | 4.26           | 3.98       | 4.27     | 4.17   |
| T <sub>3</sub>  | 15.67           | 15.51      | 15.50    | 15.56  | 4.35           | 4.34       | 4.37     | 4.35   |
| T <sub>4</sub>  | 15.86           | 15.53      | 15.53    | 15.64  | 4.45           | 4.39       | 4.38     | 4.40   |
| T <sub>5</sub>  | 19.96           | 17.25      | 17.27    | 18.16  | 4.76           | 4.69       | 4.68     | 4.71   |
| T <sub>6</sub>  | 14.46           | 14.70      | 14.70    | 14.62  | 4.25           | 4.24       | 4.23     | 4.24   |
| T <sub>7</sub>  | 15.93           | 15.68      | 15.70    | 15.77  | 4.45           | 4.45       | 4.44     | 4.45   |
| T <sub>8</sub>  | 15.99           | 15.98      | 16.00    | 15.99  | 4.48           | 4.42       | 4.49     | 4.46   |
| T <sub>9</sub>  | 14.25           | 14.10      | 14.10    | 14.15  | 4.19           | 4.19       | 4.20     | 4.19   |
| T <sub>10</sub> | 15.67           | 15.23      | 15.23    | 15.38  | 4.31           | 4.35       | 4.32     | 4.33   |
| T <sub>11</sub> | 15.19           | 14.81      | 14.80    | 14.93  | 4.27           | 4.27       | 4.27     | 4.27   |
| T <sub>12</sub> | 13.88           | 13.69      | 13.70    | 13.76  | 4.15           | 4.17       | 4.16     | 4.16   |
| T <sub>13</sub> | 16.47           | 16.10      | 16.10    | 16.22  | 4.50           | 4.51       | 4.51     | 4.51   |
| T <sub>14</sub> | 14.07           | 13.90      | 14.40    | 14.12  | 4.19           | 4.19       | 4.20     | 4.19   |
| T <sub>15</sub> | 11.12           | 11.44      | 11.43    | 11.33  | 4.02           | 4.04       | 4.05     | 4.04   |
| Mean            | 15.36           | 15.01      | 15.05    | 15.14  | 4.34           | 4.32       | 4.34     | 4.33   |
| S. E.m ±        | 1.10            | 0.85       | 0.83     | 0.69   | 0.13           | 0.13       | 0.09     | 0.10   |
| CD at 5 %       | 3.19            | 2.45       | 2.41     | 2.01   | 0.37           | 0.37       | 0.28     | 0.28   |

T<sub>1</sub>: Carbendazim 50 % WP, T<sub>2</sub>: Hexaconazole 5 % SC, T<sub>3</sub>: Propiconazole 25 % EC, T<sub>4</sub>: Tebuconazole 25.9 % EC, T<sub>5</sub>: (Carbendazim 12 % + Mancozeb 63 % WP), T<sub>6</sub>: (Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC), T<sub>7</sub>: (Tebuconazole 50 % + Trifloxystrobin 25 % WG), T<sub>8</sub>: (Hexaconazole 5 % + Captan 70 % WP), T<sub>9</sub>: (Tricyclazole 18 % + Mancozeb 63 % WP), T<sub>10</sub>: (Hexaconazole 5 % + Validamycin 2.5 % SC), T<sub>11</sub>: (Metiram 55 % + Pyraclostrobin 5 % WG), T<sub>12</sub>: Mancozeb 75 % WP, T<sub>13</sub>: Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS), T<sub>14</sub>: (Hexaconazole 4 % + Zineb 68 % WP), T<sub>15</sub>: Untreated check, DI – Disease incidence, PDI – % disease index, D- Dharwad, S-Sankeshwar, S. E.m- Standard error of the mean, CD- Critical difference

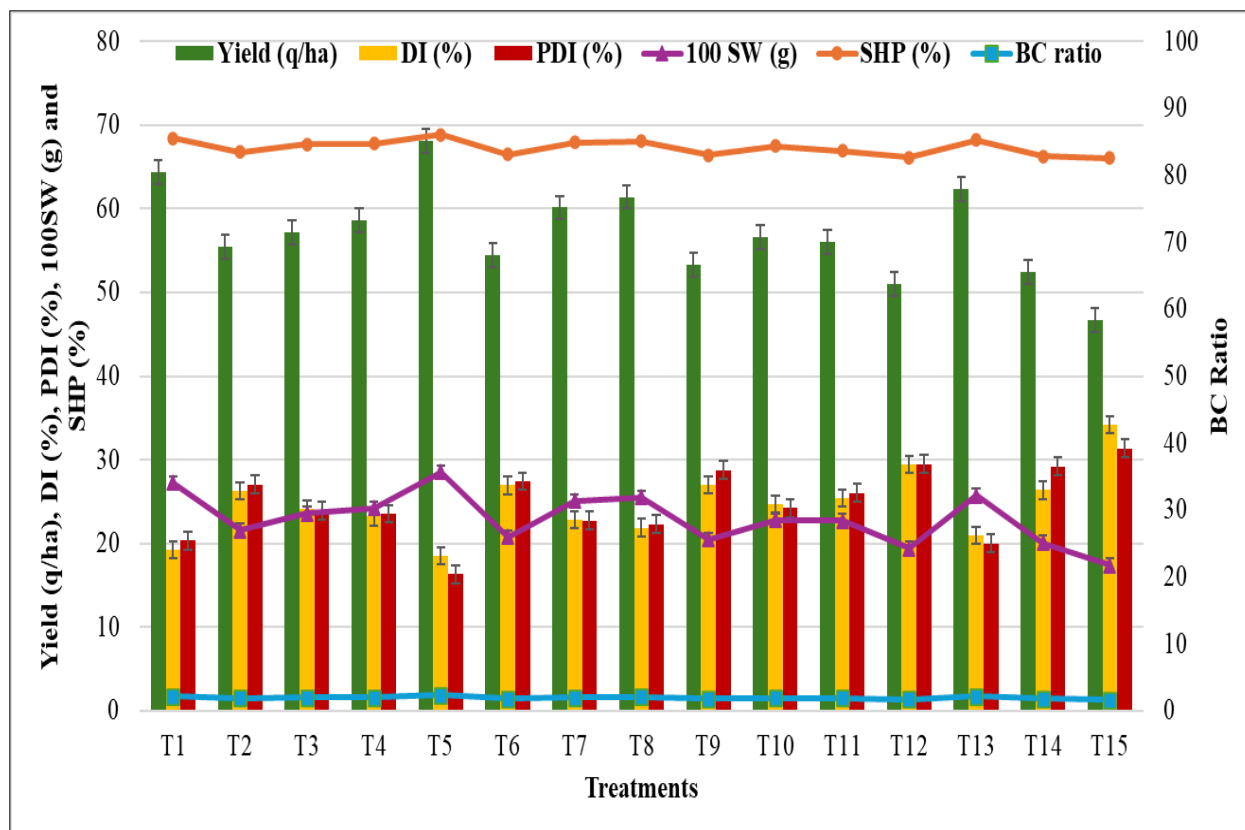


**Fig 2.** Pooled data of field evaluation of fungicides for the management of pokkah boeng disease of maize. Showing disease incidence (DI), % disease index (PDI), 100 seed weight (100SW), shelling % (SHP), yield and B:C ratio. T<sub>1</sub>: Carbendazim 50 % WP, T<sub>2</sub>: Hexaconazole 5 % SC, T<sub>3</sub>: Propiconazole 25 % EC, T<sub>4</sub>: Tebuconazole 25.9 % EC, T<sub>5</sub>: (Carbendazim 12 % + Mancozeb 63 % WP), T<sub>6</sub>: (Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC), T<sub>7</sub>: (Tebuconazole 50 % + Trifloxystrobin 25 % WG), T<sub>8</sub>: (Hexaconazole 5 % + Captan 70 % WP), T<sub>9</sub>: (Tricyclazole 18 % + Mancozeb 63 % WP), T<sub>10</sub>: (Hexaconazole 5 % + Validamycin 2.5 % SC), T<sub>11</sub>: (Metiram 55 % + Pyraclostrobin 5 % WG), T<sub>12</sub>: Mancozeb 75 % WP, T<sub>13</sub>: Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS), T<sub>14</sub>: (Hexaconazole 4 % + Zineb 68 % WP), T<sub>15</sub>: Untreated check, DI: Disease incidence, PDI: % disease index, D: Dharwad, S: Sankeshwar, S. E.m: Standard error of the mean, CD: Critical difference

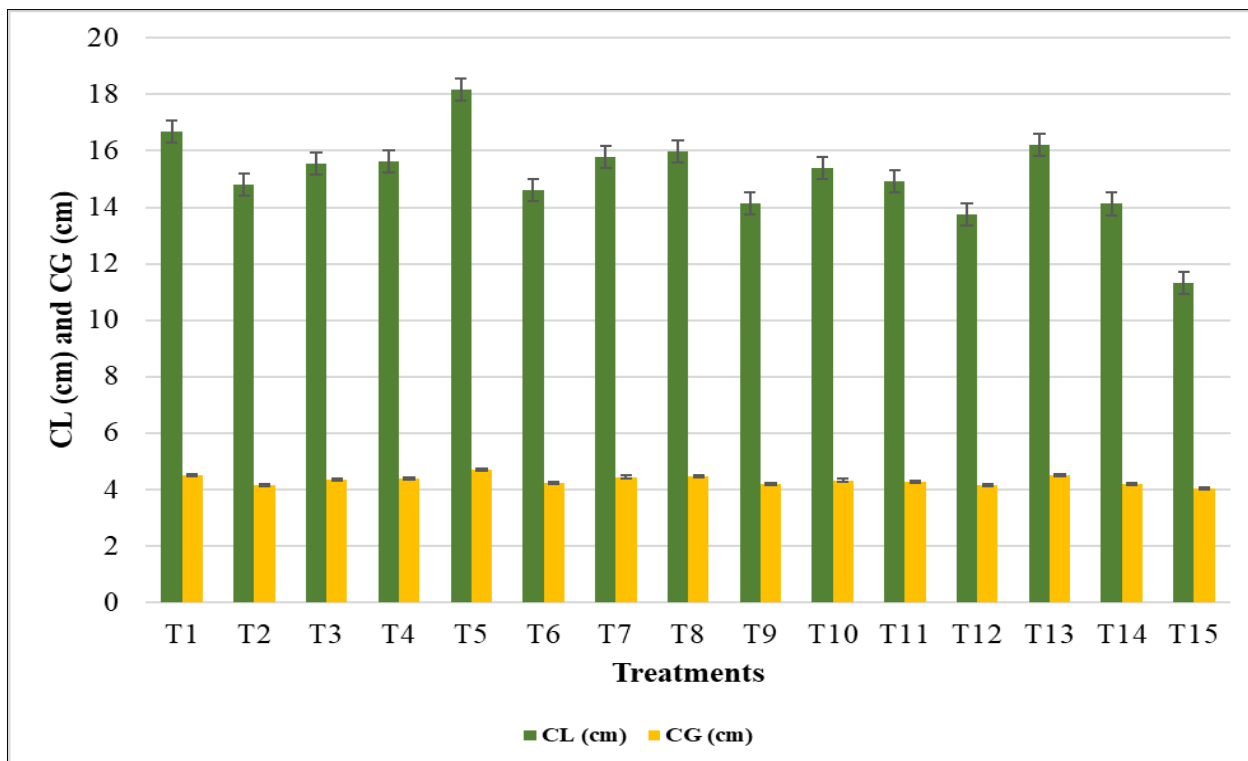


**Fig. 3.** Efficacy of fungicides with respect to cob length and cob girth in the management of pokkah boeng disease of maize. CL: Cob length (cm); CG: Cob girth (cm). T<sub>1</sub>: Carbendazim 50 % WP, T<sub>2</sub>: Hexaconazole 5 % SC, T<sub>3</sub>: Propiconazole 25 % EC, T<sub>4</sub>: Tebuconazole 25.9 % EC, T<sub>5</sub>: (Carbendazim 12 % + Mancozeb 63 % WP), T<sub>6</sub>: (Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC), T<sub>7</sub>: (Tebuconazole 50 % + Trifloxystrobin 25 % WG), T<sub>8</sub>: (Hexaconazole 5 % + Captan 70 % WP), T<sub>9</sub>: (Tricyclazole 18 % + Mancozeb 63 % WP), T<sub>10</sub>: (Hexaconazole 5 % + Validamycin 2.5 % SC), T<sub>11</sub>: (Metiram 55 % + Pyraclostrobin 5 % WG), T<sub>12</sub>: Mancozeb 75 % WP, T<sub>13</sub>: Seed treatment with (Carbendazim 25 % + Mancozeb 50 % WS), T<sub>14</sub>: (Hexaconazole 4 % + Zineb 68 % WP), T<sub>15</sub>: Untreated check, DI: Disease incidence, PDI: % disease index, D: Dharwad, S: Sankeshwar, S. E.m: Standard error of the mean, CD: Critical difference

residual activity failed to provide prolonged protection, resulting in higher disease pressure and yield loss. Overall, the results confirm that successful management of PBD in maize requires treatments with strong, long-lasting activity against *Fusarium* spp., ideally integrated with good agronomic practices. Based on the present study, T<sub>5</sub> (Carbendazim 12 % + Mancozeb 63 % WP) is the most promising treatment under Dharwad and Sankeshwar conditions, followed by Carbendazim 50 % WP, for minimising disease impact and achieving higher yields.

## Conclusion

These findings highlight the critical role of timely fungicidal applications in reducing the impact of pokkah boeng disease and improving crop productivity. The superior performance of Carbendazim-based treatments, particularly the combination of (Carbendazim 12 % and Mancozeb 63 %), indicates that integrated chemical management strategies can be effectively employed to minimise disease severity and enhance maize yield under naturally affected Pokkah boeng field conditions of northern Karnataka. For practical disease management, farmers may adopt this fungicidal combination as part of a need-based spray schedule; however, to minimise the risk of fungicide resistance, its use should be integrated with non-chemical approaches such as crop rotation and field sanitation. Future research should focus on evaluating fungicide rotation strategies and integrating biological control agents to develop sustainable, long-term management options for pokkah boeng disease.

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## Authors' contributions

MTS conceived and designed the experiments, performed the experiments, analysed the data, prepared figures and/or tables and approved the final draft. PGU conceived and designed the experiments, performed the experiments, analysed the data, authored or reviewed drafts of the article and approved the final draft. AM analysed the data, prepared figures and/or tables and approved the final draft. SIH analysed the data and approved the final draft. AB provided the facilities to conduct the research at ARS, Sankeshwar, analysed the data and approved the final draft. SRS analysed the data and approved the final draft. RMK analysed the data and approved the final draft. SCT analysed the data and approved the final draft. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

## References

1. Singh AK. Early history of crop presence/introduction into India: VII. American cereal, maize (*Zea mays* L.). Indian J Genet. 2023;83(1):1–7.
2. Troyer AF. Adaptedness and heterosis in corn and mule hybrids. Crop Sci. 2006;46:528–48. <https://doi.org/10.2135/cropsci2005.0065>
3. Food and Agriculture Organization. Area, production and productivity of maize. Rome; 2025. <http://www.fao.org/faostat>
4. Erenstein O, Jaleta M, Sonder K, Mottaleb K, Prasanna BM. Global maize production, consumption and trade: trends and R&D implications. Food Secur. 2022;14:1295–319. <https://doi.org/10.1007/s12571-022-01288-7>
5. Indiatat. Area, production and productivity of maize. New Delhi: Indiatat. <http://www.indiatat.com/data>
6. Khokhar MK, Hooda KS, Sharma SS, Singh V. Post flowering stalk rot complex of maize - present status and future prospects. Maydica. 2014;59(3):226–42.
7. Prakruthi N, Harlapur SI, Prema GU, Salakinkop SR. Evaluation of botanicals, bioagents and ITK's against *Exserohilum turcicum* (Pass.) Leonard and Suggs., causal agent of turcicum leaf blight of maize. J Farm Sci. 2025;38(2):134–8.
8. Hilton A, Zhang H, Yu W, Shim WB. Identification and characterization of pathogenic and endophytic fungal species associated with Pokkah boeng disease of sugarcane. Plant Pathol J. 2017;33(3):238–48. <https://doi.org/10.5423/PPJ.OA.02.2017.0029>
9. Khambalkar PB, Bharose AA, Gawande ND, Manape TK. Identification, characterization and molecular validation of Pokkah boeng disease causal organism (*Fusarium moniliforme*) of *Sorghum bicolor* in Maharashtra. Trends Biosci. 2014;7(17):2578–82.
10. Sajeev MT, Prema GU, Salakinkop SR, Kachapur RM, Talekar SC, Harlapur SI, et al. First report of *Fusarium acutatum* as the causal agent of Pokkah boeng disease of sorghum in northern Karnataka, India. J Adv Biol Biotechnol. 2025;28(7):319–31. <https://doi.org/10.9734/jabb/2025/v28i72551>
11. Harlapur SI, Iliger K, Salakinkop SR, Talekar SC, Kachapur RM, Balol G, et al. First report of *Fusarium verticillioides* causing Pokkah boeng disease on maize in India. Plant Dis. 2023;107(4):1239–45. <https://doi.org/10.1094/PDIS-08-22-1764-PDN>
12. Parime BC, Penumatsa KV, Injeti SK, Hooda KS. First report of Pokkah boeng of maize (*Zea mays* L.) caused by *Fusarium luffae* in India. Indian Phytopathol. 2021;75(1):293–5. <https://doi.org/10.1007/s42360-021-00451-y>
13. Supriya. Investigations on Pokkah boeng disease of maize caused by *Fusarium* spp. [PhD dissertation]. Dharwad (India): University of Agricultural Sciences; 2024.
14. Sajeev MT. Host range and management of Pokkah boeng disease of maize caused by *Fusarium* species. MSc [dissertation]. Dharwad (India): University of Agricultural Sciences; 2025.
15. Gulzar N, Naveed A, Kamili A, Mir M. The process of early blight disease development in tomato. J Res Dev. 2018;18:112–5.
16. Sajeev MT, Prema GU, Harlapur SI, Arunkumar B. Survey on the prevalence of Pokkah boeng disease of maize caused by *Fusarium* species in Karnataka. J Farm Sci. 2025;38(4):438–43.
17. Sajeev MT, Prema GU, Harlapur SI, Arunkumar B. Host range and seed borne nature of Pokkah boeng disease of maize caused by *Fusarium verticillioides*. J Farm Sci. 2025;38(4):444–7.
18. Elmer WH. Influence of inoculum density of *Fusarium oxysporum* f. sp. *cyclaminis* and sodium chloride on cyclamen and the development of Fusarium wilt. Plant Dis. 2002;86(4):389–93. <https://doi.org/10.1094/PDIS.2002.86.4.389>
19. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi (India): Indian Council of Agricultural Research; 1985. p. 87–9.

20. Das BK, Jha DN, Sahu SK, Yadav AK. Analysis of variance (ANOVA) and design of experiments. In: Concept building in fisheries data analysis. Singapore: Springer; 2022. p. 119–36. [https://doi.org/10.1007/978-981-19-4411-6\\_7](https://doi.org/10.1007/978-981-19-4411-6_7)
21. Gomez KA, Gomez AA. Statistical procedure for agricultural research. New York (USA): John Wiley & Sons; 1984.
22. Karupaiyan R, Ram B, Ramdiya S, Ali M, Meena M. The incidence of pokkah boeng in indigenous and exotic sugarcane (*Saccharum officinarum*) clones. Indian J Agric Sci. 2015;85:596–601. <https://doi.org/10.56093/ijas.v85i4.47953>
23. Gandhi V, Mehra R. Efficacy of different fungicides on Pokkah boeng disease of sugarcane. J Pharmacogn Phytochem. 2021;10(5):285–7.

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