International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

IJEP March 2025, 12(2): 01-06

Crossref

Article IJEP5974a

Full Research

Stress Management

Doi: HTTPS://DOI.ORG/10.23910/2/2025.5974a

Assessment of Fruit Rot Disease Incidence in Chili Caused by *Alternaria* spp. in Telangana State

Irene Terrance, B. Vidya Sagar*, G. Padmaja and P. Rajanikanth

Dept. of Plant Pathology, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad, Telangana (500 030), India

Corresponding Author

B. Vidya sagar
e-mail: bvidyasagar24@gmail.com

Article History

Received on 28th November, 2024
Received in revised form on 25th February, 2025
Accepted in final form on 10th March, 2025
Published on 22nd March, 2025

Abstract

A roving survey was conducted during *rabi* (December, 2023) in major chilli producing areas of Telangana i.e., Warangal, Mahabubabad and Khammam to assess the fruit rot incidence and distribution in the state. Samples were collected at harvesting stage from 14 villages of 3 districts in Telangana. Maximum disease incidence of 67.59% was observed in Jagguthanda village of Khammam district and minimum disease incidence of 9.90% was recorded in Banjarathanda village of Mahabubabad district. Maximum mean disease incidence was observed in Khammam district (36.45%) followed by Warangal (36.29%). Chapata variety exhibited maximum mean incidence (55.60%) and Teja gemini exhibited minimum mean incidence (21.78%). Fruit rot incidence was more in red chalka soil (48.93%) followed by sandy loam soil (40.13%). Maximum mean disease incidence was observed in flooding (42.45%) and minimum mean disease incidence was noticed in check furrow (17.31%). Farmers cultivating chilli over years without crop rotation is also a reason for severe incidence of chilli fruit rot. In the field symptoms of leaf curl and traces of fusarium wilt was observed. According to Principal Component Analysis (PCA), it was found two principal components are significant, and % disease incidence has a strong influence on the principal components. % disease incidence contributed maximum to variance followed by village, soil type, variety and irrigation. In PCA biplot, variables in the same direction and close to each other have a positive correlation. Results showed positive correlation for variety and irrigation.

Keywords: *Alternaria* spp., chilli, fruit rot, disease incidence, PCA

1. Introduction

Chilli (*Capsicum annuum* L.) is an important vegetable belongs to the family Solanaceae. In India, it is considered as an important spice, vegetable as well as a cash crop and its fruits are the powerhouse of antioxidants such as vitamin A, flavonoids, β-carotene, α-carotene, lutein, zeaxanthin and cryptoxanthin. It also contains carbohydrates, minerals, proteins, amino acids and phytochemicals (Moreno-Ramírez et al., 2018; Saha and Bera, 2021; Vysali and Mishra, 2024). India reigns as the world's largest producer, consumer and exporter of chilli meeting the needs of domestic and international trade. (Abarna et al., 2019; Kiruthika, 2024). Chilli contains numerous health benefits like controlling cholesterol, blood pressure, and diabetes, while also combating cancer, blood clotting, and respiratory issues like cold and fever, and boosting digestive health (Nawaka et al., 2022; Sarfaraz, 2022). Capsaicin is the bioactive compound responsible for the spicy and pungent flavor of chili. Capsaicin's analgesic properties make it a key ingredient in over-the-counter pain-relieving creams, gels, and lotions (Bannerjee and McCormack, 2020; Basith et al., 2016). Capsaicin can suppress the development and progression of multiple human cancer types, including breast, lung, prostate, gastric, renal, oral, and liver cancers (Basith, et al., 2016; Chapa-Oliver and Mejía-Teniente, 2016; Clark and Lee, 2016; Wu et al., 2020).

In India, major chilli producing states are Andhra Pradesh, Telangana, Madhya Pradesh, Karnataka and West Bengal. In India, chilli production estimate was 15.78 lakh t for 2021–22 as against 20.49 lakh t in 2020–21 (Anonymous, 2021). Indian chili peppers are globally renowned for their exceptional quality, characterized by two key attributes: their vibrant color and intense pungency, making them a highly prized commodity in the international spice market. Telangana contributes 22% of the total chilli cultivation area and 46% of the chilli production in India. The major chilli growing districts are Khammam, Mahabubabad, Gadwal, Suryapet and Warangal (Rural). Telangana chilli production estimate was 5.21 lakh t for 2022–23 as against 7.16 lakh t in 2021–22 (Anonymous,

2022). Production of chilli is reduced due to biotic-abiotic constraints which exploit its extreme delicacy and succulent nature making it vulnerable to many diseases and pests (Vijay et al., 2023; Ponnam et al., 2024)

Chilli anthracnose causes a yield loss of 10–80% in India. Notably, Telangana has experienced the most severe losses, with yield reductions reaching as high as 80–89% (Kavy et al., 2024). *Colletotrichum capsici, C. gloeosprioides, C. acutatum, Colletotrichum scovillei, C. siamense, C. fructicola, C. brevisporum, Epicoccum latusicollum. Alternaria alternata* and *Fusarium* spp. (Machenahalli et al., 2014; Kumari et al., 2022; Nguyen et al., 2024) are known to be associated with the chilli fruit rot complex. Fruit rot is a major challenge in chilli production, resulting in significant losses in quality, yield and market value (Ridzuan et al., 2018; Fajardo-Rebollar et al., 2021). In India, Alternaria fruit rot in chilli was first reported in Delhi (Dutt, 1937). Currently, it is becoming a serious threat to the chilli crop. Alternaria, a genus of Ascomycete fungi, is a significant contributor to agricultural spoilage, accounting for at least 20% of global crop losses. In severe cases, *Alternaria* species can cause devastating yield reductions of up to 80% (Rathod, 2022). Balamurugan and Kumar (2023) reported symptoms of *A. alternata* causing fruit rot of chilli began with a dense, white-greyish mycelium spreading across infected fruits, accompanied by advancing rotting lesions. As the fungal infection progressed, the growth transformed into greenish-black powdery masses. This led to loss of fruit structural integrity, shrinkage and eventual collapse. Therefore, this study was conducted with an objective to study the occurrence and disease instensity of Alternaria fruit rot in Telanagana state.

2. Materials and Methods

An extensive survey was conducted during *rabi* (December, 2023) in major chilli growing areas of Telangana *i.e.,* Warangal, Khammam, and Mahabubabad in order to study the incidence and prevalence of *Alternaria* fruit rot. A total of 14 villages were covered under these 3 districts. A range of 5 to 10 fields were visited in each district and a distance of minimum 10–15 km was allowed between the field. A total of 19 fields were covered in 3 districts in Telangana state, and information on cultivars grown, soil type, irrigation method, fruit rot incidence and other diseases observed in the farmer's field was recorded. At each location, 10 plants were randomly selected in a zigzag pattern during the harvesting stage, representing the entire field. The number of diseased and healthy fruits on each plant was recorded. By using total no. of fruits and no. of infected fruits plant^{-1}, disease incidence was calculated using the following formula (Thori, 2012). % Disease index=(Number of infected fruit samples/total number of fruits evaluated)×100. The chilli fruits infected with *Alternaria* fruit rot symptoms were identified, collected, packed in brown paper bags, labelled, and it was further used for isolation of the pathogen.

Later, the survey data was standardized by scoring common variables and characteristics. Subsequently, Principal Component Analysis (PCA) was performed using R software.

3. Results and Discussion

3.1. Occurrence and distribution of fruit rot of chilli

A roving survey was conducted during *rabi* December, 2023 in three major chilli growing districts of Telangana *i.e.,* Warangal, Khammam, and Mahabubabad. Samples exhibiting visible fruit rot symptoms were collected from the field and information regarding cultivar grown, soil type, irrigation method, fruit rot incidence and other diseases observed in the farmers field was recorded (Table 1) (Figure 1 A and B). Characteristic symptom of chilli fruit rot observed in green fruits as small brown lesion surrounded by yellow halo. As the fruit matures, the lesion enlarges and forms into sunken irregular patches, which were dark black or greyish or green leathery in appearance. Lesions covered the entire fruit, and the fruit becomes soft, shrivelled, rotted and finally drops off. Symptoms of disease was also observed on leaves, stem, petiole, seeds and the infection affect quality of fruit (Figure 2).

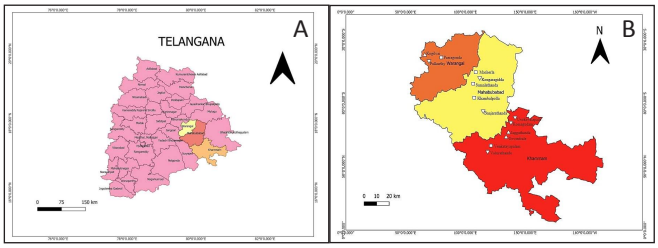

Figure 1: A) Map showing major chilli growing districts of Telangana; B) Map showing sample collection sites in chilli growing areas. △ High disease incidence; □ Medium disease incidence; ▽ low disease incidence

Figure 2: Chilli fruit rot symptoms under field (A: fruit rot infected pods, B: fruit rot infected sample after grading during harvesting time)

From Table 1, it was evident that fruit rot % disease incidence ranged from 9.90 - 67.59. Maximum disease incidence was recorded in Jagguthanda village of Khammam district (67.59) followed by Kogilvai village of Warangal district (60.12), Macherla village of Mahabubabad (51.03) and Govindrale village Khammam (48.08). Minimum % disease incidence was recorded in Banjarathanda village of Mahabubabad district

Table 1: Data collected during sample collection from chilli growing fields of Telangana during 2023–24

District	Mandal	Village	Latitude N°	Longitude E°	Previous crop grown	Variety	Irrigation	Stage of the crop (Das)	Other diseases	Soil type	% Disease incidence
Warangal	Damera	Kogilvai	18.112378	79.60952	Chilli	Chapata	Corrugation	Harvesting	Leaf curl	Red chalka	60.12
Warangal	Damera	Kogilvai	18.112248	79.60824	Chilli	Teja 341	Corrugation	Harvesting	Leaf curl	Red chalka	37.04
Warangal	Damera	Kogilvai	18.114432	79.60811	Chilli	Teja 341	Ridge and furrow	Harvesting	Leaf curl	Sandy loam	32.29
Warangal	Damera	Kogilvai	18.120713	79.654596	Chilli	Tejaswini	Ridge and furrow	Harvesting	Leaf curl	Sandy loam	29.31
Warangal	Damera	Pulkurthy	18.120131	79.652242	Chilli	Tejaswini	Flooding	Harvesting	Leaf curl	Black	24.83
Warangal	Atmakur	Pasragonda	18.104241	79.663264	Chilli	Tejaswini	Corrugation	Harvesting	Leaf curl	Black	24.65
Warangal	Atmakur	Pasragonda	18.099219	79.668008	Chilli	Teja341	Ridge and furrow	Harvesting	Leaf curl	Red chalka	45.79
Mahabubabad	Gudur	Macherla	17.771682	80.000768	Chilli	Teja gemini	Ridge and furrow	Harvesting	Fusarium wilt	Clay loam	10.89
Mahabubabad	Gudur	Macherla	17.771718	80.001088	Chilli	Chapata	Ridge and furrow	Harvesting	Leaf curl	Sandy loam	51.03
Mahabubabad	Gudur	Kongaragidda	17.731103	80.021862	Chilli	Tejaswini	Drip irrigation	Harvesting	Fusarium wilt	Sandy loam	23.40
Mahabubabad	Gudur	Sumalathanda	17.682225	80.033137	Chilli	Tejaswini	Drip irrigation	Harvesting	Fusarium wilt	Sandy loam	31.94
Mahabubabad	Mahabubabad	Khambalpolla	17.66902	80.053643	Chilli	Teja gemini	Ridge and furrow	Harvesting	Fusarium wilt	Sandy loam	32.68
Mahabubabad	Kuravi	Banjarathanda	17.571078	80.069382	Chilli	Tejaswini	Check and furrow	Harvesting	Fusarium wilt	Clay loam	9.90
Khammam	Singareni	Usirkayalapalli	17.548897	80.322181	Chilli	Tejaswini	Ridge and furrow	Harvesting	Fusarium wilt	Black	26.25
Khammam	Singareni	Komagudam	17.483248	80.30034	Chilli	Tejaswini	Check and furrow	Harvesting	Nil	Black	24.71
Khammam	Kamepalli	Jagguthanda	17.473719	80.283384	Chilli	Tejaswini	Flooding	Harvesting	Leaf curl	Red chalka	67.59
Khammam	Kamepalli	Govindrale	17.404995	80.242995	Chilli	Tejaswini	Ridge and furrow	Harvesting	Leaf curl	Red chalka	48.08
Khammam	Khammam	Venkatayapalam	17.304905	80.090117	Chilli	Tejaswini	flooding	Harvesting	Fusarium wilt	Red chalka	34.94
Khammam	Khammam	Valayathande	17.341924	80.074085	Chilli	Tejaswini	Ridge and furrow	Harvesting	Leaf curl	Clay loam	17.15

(9.90). The mean maximum % disease incidence was observed in Khammam district (36.45) followed by Warangal (36.29) and Mahabubabad (26.64). Suresh et al. (2022) reported high incidence of *Alternaria* fungi in chilli during 2015 *Rabi* season in Nadia district, West Bengal. % Leaf disease intensity was recorded as 83.00 and % fruit disease intensity was recorded as 77.00. Goswami and Mishra (2022) reported *A. alternata* causing chilli leaf spot in Jabalpur recording a % disease incidence from 20.00 to 40.00.

Among the different varieties grown, maximum mean % disease incidence was seen in Chapata variety (55.60) followed by Teja 341 (38.37) and Tejaswini (31.41). Minimum mean % disease incidence was seen in Teja gemini (21.785). Samples were collected at the harvesting stage as maximum disease incidence was seen on ripe fruits. Kumari et al. (2022) found that mature ripe chili fruits exhibited a higher severity of fruit rot disease (34.50%) compared to immature fruits (8.50%) and semi-ripe fruits (20.65%).

Information regarding soil type observed in the locations indicates that red chalk soils might be the reason for more % disease incidence (48.93) in the districts of Warangal and Khammam, followed by sandy loam soil (40.13) in Mahabubabad and Warangal districts. Lowest % disease incidence was observed in clay loam soil (12.65) of Mahabubabad and Warangal. In red chalka disease incidence was observed more as soil crust may be formed due to heavy rain which cause no infiltration of water. Nutrient deficiency and lack of beneficial microorganisms are also factors for disease proneness. Similarly, high chilli fruit rot incidence was recorded in red soil (25.15–36.15) by Kumar et al. (2019) during their survey in Krishnagiri and Cuddalore districts of Tamil Nadu.

Among the different irrigation systems, maximum mean % disease incidence was noticed in flooding (42.45) followed by corrugation (40.60), and ridge and furrow method (34.54). Minimum mean % disease incidence was noticed in check furrow (17.305) followed by drip irrigation (27.67) situations. Flooding creates a wet environment and reduce air circulation. Thus, high humidity and prolonged moisture are ideal condition for *Alternaria* fungi. The fugus was found to grow and sporulate under heavy rain, dew and good soil moisture conditions (Singh, 2015). Further, it was also reported that Alternaria seedling blight was severe with increase in soil moisture (Mundel et al., 1997).

The incidence of anthracnose disease increased as farmers practiced monocropping. This may be due to plant debris left in the field in which fungi survive and continuous availability of host can lead to more spore production. Conner et al. (2019) reported more disease incidence of bean anthracnose when same crop was rotated compared to bean-fallow bean and bean-wheat-bean cropping systems. Srivastava et al. (2005) reported the *A. alternata* to survive in plant debris and its viability was more at 5 cm deep soil.

Alternaria develops disease at a temperature range of 25°C to 35°C, with maximum infection at 28°C and relative humidity ranging from 70% to 90% (Goswami and Mishra, 2022). Leaf curl disease and fusarium wilt have been detected in the field, with leaf curl being more prevalent and fusarium wilt showing sparse infection. Aboomer et al. (2019) found that Alternaria leaf spots on cabbage crop was favoured by moderate-low temperature, high humidity, and prolonged wetness. These factors contribute 99.99% of disease development during growing season. During the survey, it has been observed that leaf curl infection and traces of fusarium wilt incidence.

3.2. Principal component analysis

The data collected during survey was scored based on common variables and characters. Further, Principal Component Analysis was done using R software and the results are shown in the Table 2.

Table 2: Principal component analysis of fruit rot population of different survey variables

Components	PC1	PC2	PC3	PC4	PC5
Eigenvalues	2.498	1.140	0.678	0.430	0.251
Proportion of variance	0.499	0.228	0.135	0.086	0.050
Cumulative proportion	0.499	0.728	0.863	0.949	1.000

According to the scree plot (Figure 3) first principal component (PC1) shows most variance around 50% followed by PC2 showing 22.8% variance and other principal components *i.e.,* PC3, PC 4 and PC5 shows comparatively less variance. The elbow point in the scree plot is where the slope becomes to flatten and determines the no. of principal component to be taken. In this graph elbow seems to occur at PC1 and PC2, suggesting that first two principal components exhibit maximum variance in the data.

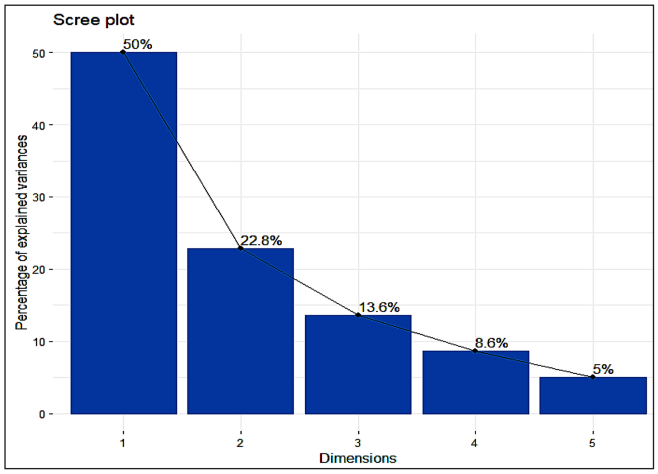

Figure 3: Scree plot displaying survey data of major chilli growing regions of Telangana state by Principal component analysis

A principal component is considered significant if its eigenvalue is ≥ 1and if <1 is deemed to be non-significant. Therefore, PC1 and PC2, with eigenvalues greater than 1 showing more variance (Table 2).

The PCA biplot (Figure 4) shows the relationship between the variables (village, % disease incidence, irrigation, soil type and variety) and the variation among the villages. As, the length of the arrow(vector) increases it shows a strong influence on principal components. Here, % disease incidence has a longer vector, indicating a strong influence on PC1. Variables in the same direction and close to each other have a positive correlation. Therefore, variety and irrigation show positive correlation.

The PCA- variables graph (Figure 5) shows contribution of each variable towards diversity. It reveals that % disease incidence shows highest contribution to variance followed by village, soil type, variety and irrigation.

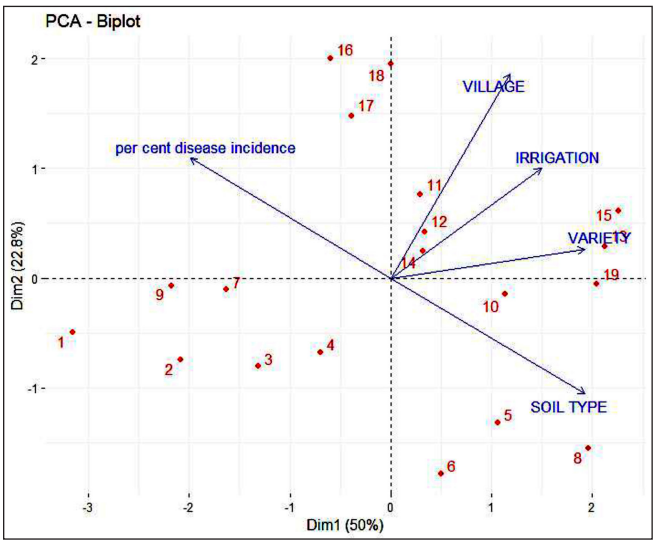

Figure 4: Two-dimensional graph showing relative positions of 19 villages and other variable based on PCA score

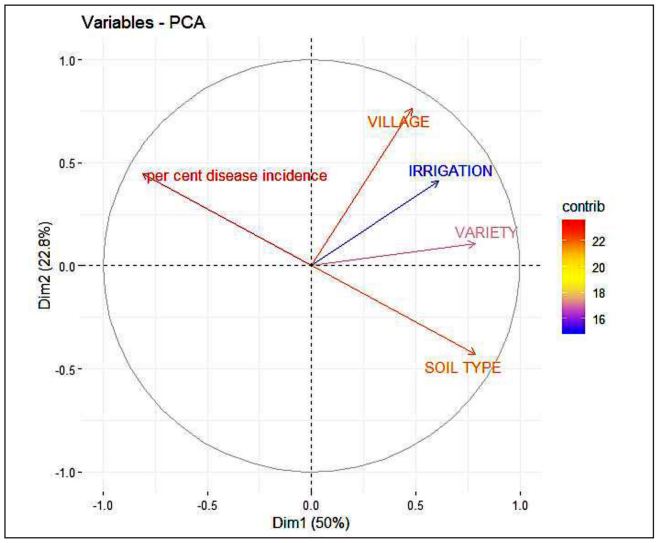

Figure 5: Two-dimensional graph showing contribution of characters towards the divergence in 19 villages and other variable based on PCA score

4. Conclusion

A preliminary survey was conducted on occurrence of Alternaria fruit rot in major chilli growing districts of Telangana. The maximum % disease (67.59) was recorded in Jagguthanda and minimum (9.90) was recorded in Banjarathanda. Chilli landraces (Chapata) showed 60.12% disease incidence, while most of the hybrids had over 25%. The maximum disease occurrence was seen in fields with red chalka soil and fields using flood irrigation. Varied level of disease might be due to variation in environmental factors.

5. References

Abarna, T., Raheem, A.A., Livingstone, R.A., Abichandra, K., Abikannan, A., Raj, T.S., 2019. Bio efficacy of *Bacillus subtilis* and plant extracts against *Colletotrichum capsici* (Syd.) Butler and Bisby under *in vitro* condition. Journal of Applied Science and Computations 6(4), 2110–2123.

Aboomer, Safder, M.W., Usman, M., Iqbal, S., Abbas, M.H., Anum, H.H., Firdous, H., Sarwar, M.I., 2019. Epidemiological factors increasing the Alternaria leaf spot of cabbage and their management strategies. The International Journal of Biological Research 2, 01–16.

Anonymous, 2021. Indiastat Socio-Economic Statistical data and facts about India 2021. Available from https://www.indiastat.com/data/agriculture/agricultural production. Accessed on 21st November, 2023.

Anonymous, 2022. Indiastat Socio-Economic Statistical data and facts about India 2022. Available from https://www.indiastat.com/data/agriculture/agricultural production. Accessed on 21st November, 2023.

Balamurugan, A., Kumar, A., 2023. Postharvest fruit rot of Bell pepper (*Capsicum annuum* L.): pathogenicity and Host range of *Alternaria alternata*. Scientia Horticulturae 319, 112–156.

Basith, S., Cui, M., Hong, S., Choi, S., 2016. Harnessing the therapeutic potential of capsaicin and its analogues in pain and other diseases. Molecules 21(8), 966.

Chapa-Oliver, A.M., Mejía-Teniente, L., 2016. Capsaicin: From plants to a cancer-suppressing agent. Molecules 21(8), 931.

Clark, R., Lee, S.H., 2016. Anticancer properties of capsaicin against human cancer. Anticancer research 36(3), 837–843.

Conner, R.L., Gillard, C.L., Mcrae, K.B., Hwang, S.F., Chen, Y.Y., Hou, A., Penner, W.C., Turnbull, G.D., 2019. Survival of the bean anthracnose fungus (*Colletotrichum lindemuthianum*) on crop debris in Canada. Canadian Journal of Plant Pathology 41(2), 209–217.

Dutt, K.M., 1937. Alternaria species on chilli in India. Current Science 6(3), 97–98.

Fajardo-Rebollar, E., Estrada, K., Grande, R., Ek Ramos, M.J., Vargas, G.R., Villegas-Torres, O.G., Juarez, A.M., Sanchez-Flores, A., Díaz-Camino, C., 2021. Bacterial and fungal microbiome profiling in chilhuacle negro chili (*Capsicum annuum* L.) associated with fruit rot disease. Plant Disease 105(9), 2618–2627.

Goswami, S., Mishra, S., 2022. Field screening of chilli leaf spot caused by *Alternaria alternata* and the effect of weather parameters on the development of the disease. Biological Forum – An International Journal 14(4), 40–46.

Kavya, R.G., Madhavi, M., Rajeswari, B., Sujatha, P., Pushpavalli, S.N.C.V.L., 2024. Chilli anthracnose: survey for the incidence and characterization of *Colletotrichum* spp. isolates in telangana state. Plant Archives 24, 344–355.

Kiruthika, N., 2024. Economics of Mundu Chilli cultivation in Ramanathapuram District of Tamil Nadu, India. Asian Journal of Agricultural Extension, Economics & Sociology 42(1), 44–48.

Kumar, K.S., Balabaskar, P., Kumar, S., Kumar, T.S., Muthukumar, A., 2019. Studies on the cultural and pathogenic variability among isolates of *Colletotrichum capsici* (Syd.) Butler and Bisby causing anthracnose fruit rot incidence of chilli. Plant Archives 19(2), 3295–3299.

Kumari, L., Kumar, S., Kumar, J., Shivali., 2022. Effect of epidemiological factors on fruit-rot of chilli caused by *Alternaria alternata* (Fr.) Keissler. International Journal of Phytology Research 2(4), 23–26.

Machenahalli, S., Nargund, V.B., Patil, S., 2014. Quick detection and diagnosis of chilli fruit rot pathogens. Vegetos 27(3), 188–191.

Moreno-Ramírez, Y.D.R., Martínez-Ávila, G.C., González-Hernández, V.A., Castro-López, C., Torres-Castillo, J.A., 2018. Free radical-scavenging capacities, phenolics and capsaicinoids in wild piquin chili (*Capsicum annuum* var. *glabriusculum*). Molecules 23(10), 2655.

Mundel, H.H., Huang, H.C., Kozub, G.C., Daniels, C.R.G., 1997. Effect of soil moisture, soil temperature and seed-borne *Alternaria carthami*, on emergence of safflower (*Carthamus tinctorius* L.). Botanical Bulletin of Academia Sinica 38, 257–262.

Nawaka, N., Wanmasae, S., Makarasen, A., Dechtrirat, D., Techasakul, S., Jeenduang, N., 2022. Allicin and capsaicin ameliorated hypercholesterolemia by upregulating LDLR and downregulating PCSK9 expression in HepG2 Cells. International Journal of Molecular Sciences 23(22), 14299.

Nguyen, V.Q.H., Tran, T.T.N., Tran, L.T., Nguyen, T.T.T., Pham, T.T.T., Hoang, Q.T., Pham, T.T.D., 2024. Identification of fungal species associated with chilli fruit disease in North-Central Vietnam. Journal of Plant Pathology 106(2), 507–526.

Ponnam, N., Barik, S., Shaik, M., Pasupula, K., Narigapalli, P., DC, L.R., 2024. Breeding for resistance to biotic and abiotic stresses and quality traits in chilli. In: Capsaicinoids 231–248. Springer Nature. ISBN 978-981-99-7778-9. ISBN 978-981-99-7779-6 (eBook). DOI 10.1007/978-981-99-7779-6_11.

Rathod, S.R., 2022. *Alternaria*: Isolation and identification from different plant parts. International Journal Innovative Science and Research Technology 7, 238–44.

Ridzuan, R., Rafii, M.Y., Ismail, S.I., Mohammad Yusoff, M., Miah, G., Usman, M., 2018. Breeding for anthracnose disease resistance in chili: progress and prospects. International Journal of Molecular Sciences 19(10), 3122.

Saha, P., Bera, S., 2021. Weather impact assessment and development of prediction model for yield loss in chilli anthracnose patho-system. Journal of Agrometeorology 23(3), 352–355.

Sarfaraz, V., Yadav, S., Srivastav, P., 2022. Seed production of chilli (*Capsicum frutescense*). Organic Horticulture. Bright Sky Publications, Rohini, Delhi, 145–155.

Singh, V., 2015. *Alternaria* diseases of vegetable crops and its management control to reduce the low production. International Journal of Agriculture Sciences 7(13), 834–840.

Vijay, A., Kumar, A., Islam, K., Momo, J., Ramchiary, N., 2023. Functional genomics to understand the tolerance mechanism against biotic and abiotic stresses in *Capsicum* species. In: Transcriptome Profiling. Academic Press, 305–332.

Vysali, K., Mishra, B.P., 2024. A study on training needs of chilli growers in Andhra Pradesh. Plant Science Today 11(2).

Wu, M., Miao, H., Fu, R., Zhang, J., Zheng, W., 2020. Hepatic stellate cell: a potential target for hepatocellular carcinoma. Current Molecular Pharmacology 13(4), 261–272.