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The Status of Cowpea Bacterial Blight Disease in Cowpea-Growing Regions of Kenya

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Abstract

Cowpea (*Vigna unguiculata* (L.) Walp.) is an economically important crop cultivated both for domestic and commercial purposes. It is one of the most resilient crops suited to arid and semi-arid areas. Numerous diseases caused by phytopathogens impact cowpea production. Bacterial blight caused by *Xanthomonas axonopodis* pv. *vignicola* has been reported in many cowpea-producing areas, causing a reduction in both the quality and quantity of the harvestable leaves and grains. However, in Kenya, the disease occurrence status has not been exhaustively documented. This research conducted random field surveys in 80 farms from six counties representing different zones to analyse the disease occurrence levels. An average of 14 farms were randomly sampled per county. The mean disease incidence was 44.89% which varied across the sampled sites, the lowest farm incidence was 26.87% and 64.67% was the highest mean farm incidence. The bacterial blight of cowpea caused by *X. axonopodis* pv. *vignicola* was prevalent in all the sampled regions of Laikipia, Isiolo, Makueni, Uasin Gishu, Kakamega and Meru, with the highest prevalence 93.33% in both Kakamega and Makueni and the lowest in Meru (20.0%). Because of the wide spread of the disease in the cowpea growing seasons of Kenya, there is need for farmers to be sensitised on the presence and identification of the disease in the farms for the best control measures.

Keywords: Cowpea, bacterial blight, cowpea production zones, incidence, prevalence

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Introduction

Cowpea (*Vigna unguiculata* L. Walp) a leguminous crop belonging to the Fabaceae family is widely cultivated by small-scale farmers, particularly in arid and semi-arid equatorial climates (Lazaridi and Bebeli, 2023) and also cultivated in the regions of Americas, Asia and sub-Saharan Africa (Affrifah et al., 2022) because of its significant economic value. The fresh cowpea leaves serve as human vegetables or animal fodder. The grains are utilised as human food once they are boiled (da Silva et al., 2021). Cowpea is rich in plant protein, providing amino acids such as isoleucine, lysine, phenylalanine, valine, methionine, histidine, and tryptophan (Loushigam and Shanmugam et al., 2023); crude fibre (Ogbonnaya et al., 2024); carbohydrates (Wanjiku et al., 2023); vitamins such as C, A, K, niacin, and total choline (Affrifah et al., 2022); and iron, phosphorus, potassium, sodium, magnesium, zinc, and calcium minerals (Abebe et al., 2022). Further the cowpea provides health advantages, including anti-diabetic and anti-cancer properties (Owade et al., 2020); the leaves serve as antipyretics and diuretics and are used in the control of ulcers, smallpox, burns, adenitis, and menstrual challenges (Abebe et al., 2022) and in the treatment of menopausal syndrome (Fithri et al., 2024).

Currently, Kenya is the largest producer of cowpea in East Africa, with an estimated total land area under cultivation being more than 227,800 hectares (Singh et al., 2023). The main cowpea production regions in Kenya are Kisii, Machakos, Kitui, Makueni, Taita Taveta, Bungoma, Migori, Kakamega, Tharaka Nithi, Kwale, Kilifi and Laikipia. Due to the need for crop diversification and climate resilience, therefore, the crop has recently been introduced in other regions such as Meru, Uasin Gishu, Isiolo, Trans Nzoia, and Baringo, among others (Basweti and Achieng, 2022; Binacchi et al., 2022; Muindi et al., 2021; Mwenda et al., 2023). The major improved cowpea varieties cultivated in Kenya include M 66, KVU 27-1, KVU HB 48E 10, Nyekundu, MTW 610, KCP 022, MTW 63, ICV, Katumani 80 (K80), KVU 419, and other local landrace varieties (Muindi et al., 2023; Odundo, 2023).

Despite its economic significance, the production of cowpea is affected by various biotic factors; among them are viral diseases; root-knot nematodes (Joshua et al., 2023); fungal diseases (Dada et al., 2023; Obisesan et al., 2023); and bacterial diseases, including bacterial spot and bacterial blight, which are the major limiting diseases (Deshpande et al., 2023). Bacterial blight disease caused by *Xanthomonas axonopodis* pv. *vignicola* is among the detrimental diseases hampering the production of cowpeas worldwide, owing to its widespread occurrence in principal cowpea cultivation regions worldwide (Nantale et al., 2023).

The disease leads to a reduction in the quality and quantity of both the leaves and grains, thus further reducing the market value of the leaf produce (Ogbuji and Isalar, 2021). The pathogen is mainly seed-borne (Obafemi et al., 2024). The pathogen has been noted to persist in plant detritus during winter and can survive for up to fourteen years in seeds, with the primary mode of transmission being seed infection. Despite the occurrence of bacterial blight disease in Kenya, it has not been fully documented especially its spread and levels of occurrence among the different cowpea production of Kenya. Hence, this study aimed at evaluating the levels of occurrence of the bacterial blight disease in selected cowpea-growing regions in Kenya.

Materials and Methods

Determination of occurrence and collection of diseased cowpeas

Field surveys were conducted during the dry and wet seasons in the selected regions of the counties of Meru, Kakamega, Uasin Gishu, Isiolo, Laikipia and Makueni, which represented different agro-ecological zones (AEZ) growing cowpeas in Kenya. In each of the agro-ecological zones surveyed, farmers' fields were sampled at about five kilometres apart, having cowpeas at various stages of development. A structured cowpea bacterial blight survey questionnaire was also used during the survey. The key information noted in the questionnaire included farmer's details, production practices such cowpea production years, area under cowpea production, varieties of cowpea grown, source of seeds, disease and pest control strategies, pre-season practices, crop rotation, among other information.

The bacterial blight incidence on individual farms surveyed was noted as a percentage of symptomatic samples per the total number of plants sampled. In each farm, four 1 m^2 quadrants were drawn at random. In each quadrat all cowpea plants were counted, and further those showing disease symptoms were counted separately, and the individual farm incidence was computed as illustrated by Sampathkumar et al., (2023) and Wang et al., (2021).

$$\text{Percentage disease incidence (\%)} = \frac{\text{The number of infected cowpea plants}}{\text{Total cowpea plants in the quadrant}} \times 100\%$$

From the diseased cowpea plants, five leaves (three leaves with intermediate disease appearances and two at the start of disease development) were collected and were maintained in a keep cool box having ice (4^{o}C) and taken to the laboratory for the isolation of the pathogen and further studies.

Isolation and identification of the pathogen

The bacterium was isolated from the diseased cowpea leaves gathered from the different Agro-ecological zones (AEZ) of Kenya as described by Omar et al. (2024); Otieno et al. (2023). The collected leaves for isolating the bacterium were first washed in running tap water to remove soil debris. Approximately 0.5 cm parts of the diseased leaf sections with early stages of infection were cut out and thereafter disinfected in 2.5% sodium hypochlorite in a sterile petri-dish and rinsed in 3 changes of sterile distilled water. The cut leaf parts were then placed in a sterile petri dish containing 10 ml of sterile distilled water and the tissues teased apart using a sterile scalpel until the lesions were very small and allowed to stand for 45 minutes. Eight serial dilutions

were made from the above suspension, and from the 4th to 8th dilution, 1 ml suspension was pipetted aseptically into petri-dishes containing nutrient agar (NA) and carefully spread evenly with a sterile glass rod. The inoculated petri dishes were inversely incubated at 30±2 °C for 24 to 48 hours.

Pure cultures of the suspected pathogen were obtained by picking selected colonies and streaking three time following the techniques elaborated by Kones (2024). The most prevalent colony with typical morphological characteristics of the target pathogen (*X. axonopodis* pv. *vignicola*) was chosen from the diverse bacterial colony populations for transfer from a mixture of colony populations and was re-streaked out aseptically using a wire loop into a freshly prepared nutrient agar media with 5% glucose then incubated at 30±2 °C in an inverted position for 24 hours.

Morphological and biochemical characterization of isolates of X. axonopodis pv. vignicola

The morphological features of *X. axonopodis* pv. *vignicola* isolates such as Gram staining, growth pattern, shape, colony colour, and size were assessed for identification of the isolates as described by Kabade et al., (2020) and Lin et al., (2020). Further the isolates were confirmed by biochemical tests such as starch hydrolysis, mannitol test, sucrose test, Catalase activity, Gelatin liquefaction, lactose utilization, hydrogen sulphite production, indole test, methyl red test, Voges Proskauer test and citrate utilization as described by Kabade et al., (2020); Ogundate et al., (2021).

Data analysis

The bacterial blight disease incidence per farm was first calculated into a percentage per quadrant, and the mean of the three quadrants was taken as the disease incidence of the farm. The obtained percentage incidence levels for bacterial blight disease were then entered into Excel and analysed by ANOVA procedures using the R-program computer software package, R version 4.1.2 (2021-11-01). Means were separated using Tukey multiple comparison of means at $p \leq 0.05$.

Results

Determination of the incidence and prevalence of bacterial blight on cowpea

In the individual farms, the cowpea bacterial blight disease incidence varied from 26.87% at UGO8 (26.87%) in Uasin Gishu county to 64.67%, in farm KK09 of Kakamega county with a mean of 44.89% across all the sites surveyed (Table 1). The disease incidence levels were statistically significant, P≤0.001, when the means were compared by Tukey test at 95% family-wise confidence level.

Table 1: Incidence of bacterial blight of cowpea, Isiolo (IS), Kakamega (KK), Laikipia (LK), Makueni (MK), Meru (MU), and Uasin Gishu (UG) counties.

Site	% Mean incidence
IS01	35.77
IS02	40.60
IS04	42.93
IS06	53.13
IS06-2	45.30
IS08	38.90
IS09	47.67

ISO4	39.73
KK01	49.13
KK02	41.20
KK03	42.20
KK04	46.80
KK05	45.50
KK06	62.43
KK07	51.60
KK08	50.50
KK09	64.67
KK10	57.10
KK12	48.10
KK13	46.47
KK14	50.13
KK15	51.07
LK01	41.10
LK02	31.90
LK04	39.50
LK05	33.90
MK01	61.30
MK02	52.13
MK03	61.37
MK04	48.30
MK05	54.93
MK06	60.70
MK07	52.87
MK08	52.17
MK09	43.77
MK10	42.47
MK12	37.57
MK13	29.07
MK14	37.83
MK15	52.63
MU01	37.93
MU02	30.80
UG02	41.80
UG04	30.80
UG05	36.27
UG07	31.13
UG08	26.87
UG09	34.53
Mean disease incidence	**44.89%**

The cowpea bacterial blight disease incidence was recorded in all the six counties surveyed. The highest mean disease incidence was recorded in Kakamega county (50.49%) and the least disease incidence being recorded in Uasin Gishu county (33.57%) (Figure 1).

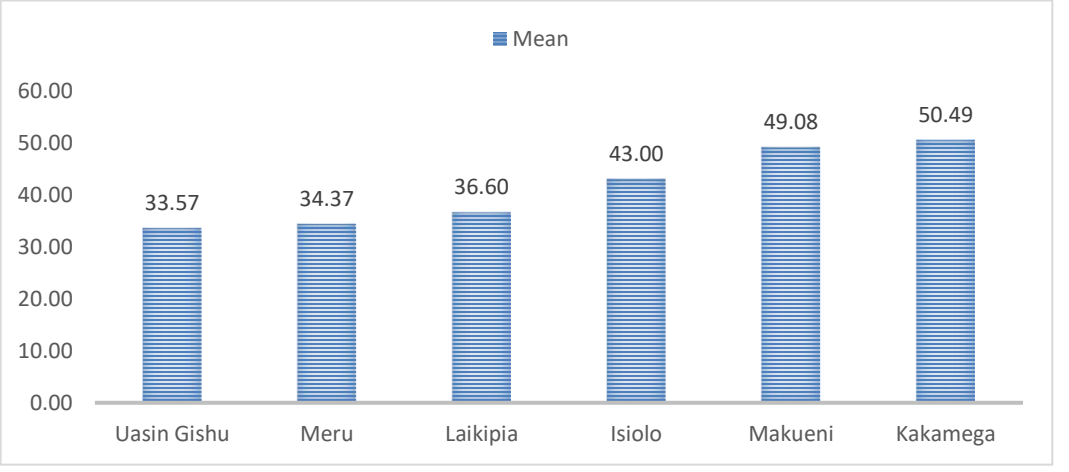

Figure 1: Mean incidence of bacterial blight of cowpea at six counties in Kenya

Cowpea bacterial blight disease was prevalent in all the six counties of Makueni, Isiolo, Kakamega, Uasin Gishu, Laikipia and Meru surveyed. Out of eighty (80) cowpea farms sampled, 60% (48 farms) of the samples were positive for the cowpea bacterial blight disease. The highest disease prevalence was recorded in Kakamega and Makueni counties both at 93.3% and the lowest disease prevalence recorded in Meru County (20%) (Figure 2). There was statistically significant difference ($P \leq 0.001$) in disease prevalence among the counties. Post-hoc analysis showed that the mean incidence in Kakamega was significantly higher than in Uasin Gishu and Meru ($p < 0.05$), but not significantly different from Makueni.

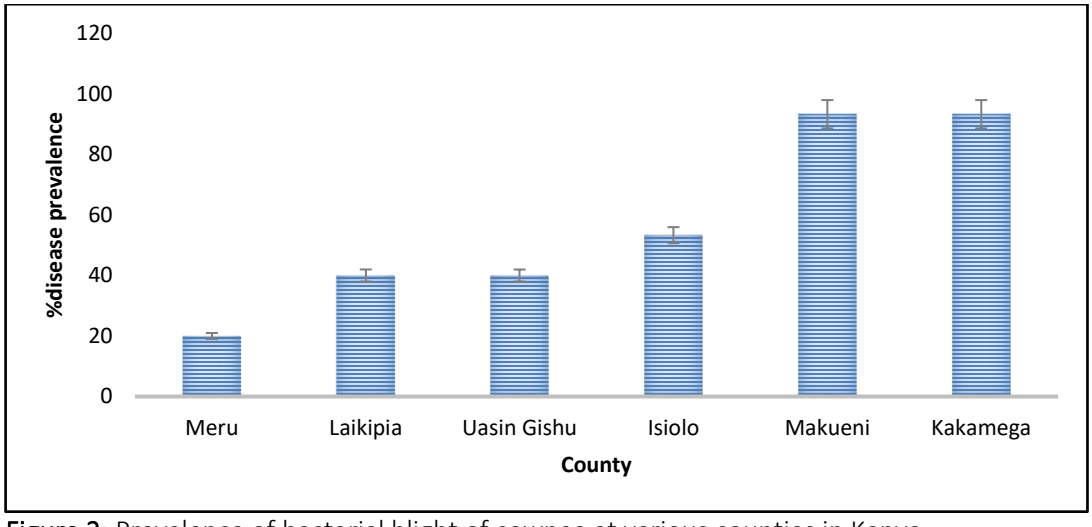

Figure 2: Prevalence of bacterial blight of cowpea at various counties in Kenya

From the analysis, Isiolo, Makueni and Kakamega, displayed a comparatively elevated median prevalence rates, while Uasin Gishu and Meru had lower median levels (Figure 3). Kakamega showed the lowest difference in disease incidence, with two notable outliers while Makueni showed the highest difference in disease incidence among the farms where sampling was done.

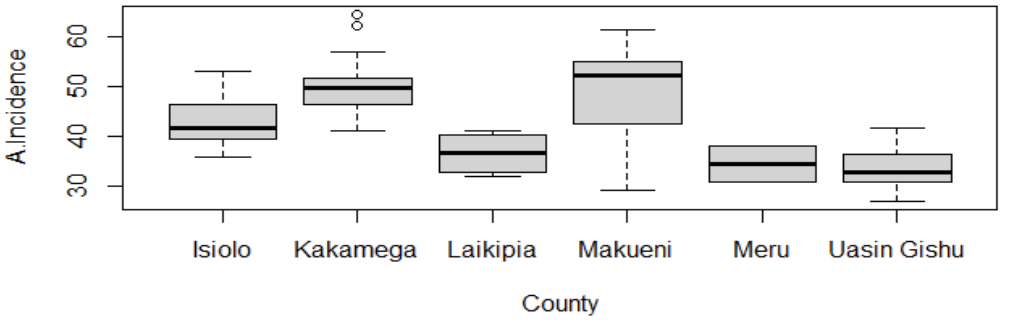

Figure 3: Cowpea bacterial blight disease incidence per county

Discussion

The cowpea bacterial blight disease symptoms recorded during the survey included stunted growth; necrotic lesions on the leaves that extended to the stems; light yellow round spots on the leaf surface, with the larger spots showing a brown necrotic centre with crimson veins; and drying of leaves. The mature infected cowpea crops that had produced the pods had their pods shrink and turn yellow, with smaller, wrinkled, and poorly developed seeds from the sick pods. These leaf symptoms were similar to the typical bacterial blight disease symptoms as noted on the cowpea crops by Agbicodo et al., (2010), Omomowo et al., (2021) and Praneetha et al., (2022). Further, Horn and Shimelis (2020) and Makonnen et al., (2022) noted that the bacterial blight disease of cowpea is capable of inflicting damage on cowpea leaves, seeds, and pods, observations which were noted in the infected cowpea plants in the field during the survey.

Out of eighty (80) cowpea farms sampled, 48 (60%) farms the cowpea was confirmed to be infected by the cowpea bacterial blight disease caused by the pathogen *X. axonopodis* pv. *vignicola*. The cowpea bacterial blight disease incidence varied among the sites surveyed. The highest disease incidence noted in Kakamega County, and the least disease in Uasin Gishu County. Further the bacterial blight disease was prevalent in all the six regions surveyed. Similarly, the cowpea bacterial blight disease prevalence was very high in Makueni, followed by Kakamega, Isiolo, Uasin Gishu and Laikipia counties, but the lowest prevalence was in Meru county. The differences in the disease incidences could be attributed to the climatic conditions; Meru being relatively cooler than Kakamega, Makueni, Isiolo and Laikipia could present unfavourable conditions for the pathogen and the disease development. Girma et al. (2022) reported that the high-altitude regions that grow cowpea are less prone to bacterial blight disease development. Ochichi (2015), from a survey done on cowpea bacterial blight disease in various sites in Western Kenya, reported a disease incidence of between 3 and 70% during the short rainy season when farmers planted drought-resistant crops. In a replica of research done in Bangladesh (Saha et al., 2022), cowpea bacterial blight disease incidence was between 4 and 57% in Bangladesh, which was close to the incidence and prevalence recorded in the current study. In Uganda, Nantale et al., (2023) reported a disease prevalence of 95% for all the cowpea genotypes including the high infectiveness of this pathogen. Ganiyu et al., (2017) reported a common bacterial blight incidence similar to the range in the current research in the Abeokuta region of Nigeria. However though similar, Amodu et al. (2017) noted a higher bacterial blight incidence of

between 60 and 94% from a survey done at selection sites in Northern Nigeria.

In the current study, the differences in the incidence of cowpea bacterial blight in the sampled sites could be attributed to differences in cowpea cultivars farmed, the growth stage of the crop during the survey, the cropping system used, disease control and management measures deployed by farmers, and the handling of the crop waste after harvest. In the study by Njonjo et al., (2019), noted that most farmers in Wote and Makindu in Makueni County, and areas bordering Mwatate in Kenya, were using local cowpea cultivar seeds a phenomenon observed from the current study from the questionnaire response, where all the sampled farmers reported using uncertified cowpea seeds from previous- season saved seed, which could provide the primary inoculum as reported that bacterial blight pathogen is seed borne (Obafemi et al., 2024). Further, Njonjo et al., (2019) noted that the bacterial blight disease incidence and severity were positively correlated with the seed source. The results obtained in the current study, showed the variation in the levels incidence and prevalence, which can be attributable to the cowpea varieties, climatic conditions, source of seeds, and farmer practices. However, has provided the disease status in at least six regions of Kenya, representing different agro-ecological zones and the traditional cowpea production zones in comparison to the new cowpea production zones.

Conclusion and Recommendations

Cowpea is a significant protein-dense and starchy pulse legume indigenous to sub-Saharan Africa, as well as certain regions of America and Asia. Findings from the study showed that bacterial blight of cowpea caused by *X. axonopodis* pv. *vignicola* occurred with varied levels of incidence and prevalence in Uasin Gishu, Kakamega, Laikipia, Isiolo, Makueni, and Meru Counties, being higher in Kakamega and lowest in Meru. The evolving consumer preferences for sustainable plant-based nutrients present an opportunity to broaden cowpea production outside its conventional production areas. Hence, disease management is crucial for the sustainability of cowpea production. The farmers need to be sensitised on the identification of the disease in the farms for the best control measures including: Promoting the use of certified, disease-free seeds; implementing good on-farm sanitation practices such as removing and destroying infected plant debris; encouraging the use of resistant cowpea varieties, and education on identifying early symptoms to facilitate timely intervention.

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References

Abebe, B. K., & Alemayehu, M. T. (2022). A review of the nutritional use of cowpea (*Vigna unguiculata* L. Walp) for human and animal diets. *Journal of Agriculture and Food Research*, *10*, 100383. Doi: https://doi.org/10.1016/j.jafr.2022.100383

Affrifah, N. S., Phillips, R. D., & Saalia, F. K. (2022). Cowpeas: Nutritional profile, processing methods and products—A review. *Legume Science*, *4*(3), e131. DOI: https://doi.org/10.1002/leg3.131

Agbicodo, E., Fatokun, C., Bandyopadhyay, R., Wydra, K., Diop, N., Muchero, W., et al. (2010). Identification of markers associated with bacterial blight resistance loci in cowpea [*Vigna unguiculata* (L.) Walp.]. *Euphytica* 175, 215–226. doi: https://doi.org/10.1007/s10681-010-0164-5

Amodu, U. S., Kenneth, C. S., & Akpa, A. D. (2017). Occurrence and Pathogenic Variation of *Xanthomonas axonopodis* pv. *vignicola* in Selected Locations in Northern Nigeria. *Ibadan Journal of Agricultural Research*. *13*(2)

Basweti, E., & Achieng, O. J. (2022). Cowpea Rust Disease Incidence and Severity on Growth and Yield of Selected Cowpea Genotypes under Different Cropping Systems in Western Kenya. *Ajausud| African Journal of Agriculture and Utilisation of Natural Resources for Sustainable Development*, *1*(1).

Binacchi, F., Rusinamhodzi, L., & Cadisch, G. (2022). The potential of conservation agriculture to improve nitrogen fixation in cowpea under the semi-arid conditions of Kenya. *Frontiers in Agronomy*, *4*, 988090.

da Silva, A. C., de Freitas Barbosa, M., da Silva, P. B., de Oliveira, J. P., da Silva, T. L., Junior, D. L. T., & de Moura Rocha, M. (2021). *Health benefits and industrial applications of functional cowpea seed proteins*. IntechOpen. DOI: 10.5772/intechopen.96257

Dada, A. O., Dania, V. O., Oyatomi, O. A., Abberton, M., & Ortega-Beltran, A. (2023). First Report of *Colletotrichum cliviicola* Causing Anthracnose Disease of Cowpea (*Vigna unguiculata*) in Nigeria. *Plant Disease*, *107*(7), 2254. DOI: https://doi.org/10.1094/PDIS-10-22-2512-PDN

Deshpande, S. K., Kavyashree, N. M., Singh, K., Ramya, K. R., Sharma, N., & Tripathi, K. (2023). Diseases in cowpea (*Vigna unguiculata* (L.) Walp.): Next generation breeding techniques for developing disease-resistant cowpea. in *diseases in legume crops: next generation breeding approaches for resistant legume crops* (pp. 125-139). Singapore: Springer Nature Singapore. DOI: https://doi.org/10.1007/978-981-99-3358-7_6

Fithri, A. N., Yueniwati, Y., Arsana, I. W., Khotimah, H., & Nurwidyaningtyas, W. (2024). The potential health benefit of cowpea estrogen-like activity to restore vaginal epithelial cells thinning due to menopausal syndrome. *Tropical Journal of Natural Product Research*, *8*(3). https://10.26538/tjnpr/v8i3.22

Ganiyu, S. A., Popoola, A. R., Owolade, O. F., & Fatona, K. A. (2017). Control of common bacterial blight disease of cowpea (*Vigna unguiculata* [L.] Walp) with certain plant extracts in Abeokuta, Nigeria. *Journal of Crop Improvement*, *31*(3), 280-288. Doi: https://doi.org/10.1080/15427528.2017.1299065

Girma, F., Fininsa, C., Terefe, H., & Amsalu, B. (2022). Distribution of common bacterial blight and anthracnose diseases and factors influencing epidemic development in major common bean growing areas in Ethiopia. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science*, *72*(1), 685-699. https://doi.org/10.1080/09064710.2022.2063168

Horn, L. N., & Shimelis, H. (2020). Production constraints and breeding approaches for cowpea improvement for drought prone agro-ecologies in Sub-Saharan Africa. *Annals of Agricultural Sciences*, *65*(1), 83-91. https://doi.org/10.1016/j.aoas.2020.03.002

Joshua, B. (2023). Current Knowledge on Biotic Stresses affecting Legumes: Perspectives in Cowpea and Soybean. *Advances in Legume Research: Physiological Responses and Genetic Improvement for Stress Resistance*, 14.

Kabade, S. H., Ingle, R. W., Gore, P. M., & Madavi, P. N. (2020). Cultural, morphological and biochemical studies of *Xanthomonas axonopodis* pv. *punicae*: The causative agent of oily spot in pomegranate. *International Journal of Chemical Studies*, *8*(4), 2518-2523. DOI: https://doi.org/10.22271/chemi.2020.v8.i4ac.10012

Kones, C. (2024). Screening of Beneficial Rhizospheric Bacterial and Fungal Isolates for Control of Bacterial Wilt of Tomato *(Solanum lycopersicum L.) in Kenya* (Doctoral dissertation, JKUAT-CoANRE).

Lazaridi, E., & Bebeli, P. J. (2023a). Cowpea constraints and breeding in Europe. *Plants*, *12*(6), 1339. https://doi.org/10.3390/plants12061339.

Lin, Y. R., Lee, S., Lu, C. H., & Chu, C. C. (2020). Genetic and phenotypic characterization of *Xanthomonas axonopodis* pv. *maculifoliigardeniae* causing bacterial leaf spot of Ixora in Taiwan. *Journal of Phytopathology*, *168*(7-8), 478-489. DOI: https://doi.org/10.1111/jph.12912

Loushigam, G., & Shanmugam, A. (2023). Modifications to functional and biological properties of proteins of cowpea pulse crop by ultrasound-assisted extraction. *Ultrasonics*

Sonochemistry, *97*, 106448. DOI: https://doi.org/10.1016/j.ultsonch.2023.106448

Muindi, M. M., Muthini, M., Njeru, E. M., & Maingi, J. (2021). Symbiotic efficiency and genetic characterization of rhizobia and non rhizobial endophytes associated with cowpea grown in semi-arid tropics of Kenya. *Heliyon*, *7*(4).

Mwenda, K. I., Munyiri, S. W., & Ndukhu, H. O. (2023). Effect of maize-cowpea cropping patterns on soil moisture conservation in Meru and Tharaka Nithi Counties. *East African Agricultural and Forestry Journal*, *87*(1 & 2), 10-10.

Nantale, G., Wasswa, P., Edgar, M., Richard, T., Paparu, P., & Dramadri, I. O. (2023). Combining ability of cowpea (*Vigna unguiculata* (L) Walp) genotypes for resistance to cowpea bacterial blight in Uganda. *American Journal of Agricultural Science, Engineering, and Technology*, *7*(1), 21-28. DOI: https://doi.org/10.54536/ajaset.v7i1.1174

Njonjo, M. W. (2018). Quality of cowpea seed used by farmers in Makueni and Taita Taveta Counties and its effect on crop performance (Doctoral dissertation, University of Nairobi).

Njonjo, M. W., Muthomi, J. W., & Mwang'ombe, A. W. (2019). Production practices, postharvest handling, and quality of cowpea seed used by farmers in Makueni and Taita Taveta Counties in Kenya. *International Journal of Agronomy*, *2019*(1), 1607535. DOI: https://doi.org/10.1155/2019/1607535

Obafemi, O. A., Owolade, O. F., Olasoji, J. O., Olakojo, S. A., Adamu, R. S., Agboola, A. A., & Obembe, M. O. (2024). Registration of 'ARTPEA-204B', an early-maturing cowpea cultivar for the southern agro-ecology of Nigeria, with high fodder, high grain yield and reduced need for insecticidal spray. *Journal of Plant Registrations*, *18*(1), 61-68. DOI: https://doi.org/10.1002/plr2.20335

Obisesan, I., & Ojo, P. (2023). Identification and pathogenicity of *Nigrospora sphaerica* and *Curvularia penniseti* associated with leaf spot disease of cowpea (*Vigna unguiculata* (L.) Walp.) in Nigeria. *Archives of Phytopathology and Plant Protection*, *56*(5), 397-409. DOI: https://doi.org/10.1080/03235408.2023.2195035

Ochichi, P. B. (2015). *Effect of cropping systems on the occurrence of fungal and bacterial diseases of legumes in Western Kenya* (Doctoral dissertation, University of Nairobi).

Odundo, S. N. (2023). Effect of Phosphorus Fertilizer Application on Yields of Cowpea (*Vigna unguiculata*) Varieties across Sites of Differing Soil Fertility in western Kenya.

Ogbonnaya, E., Anigo, K. M., Bala, S. M., Muhammad, A., Bamaiyi, L. J., Precious, E., & Oluchukwu, I. U. (2024). Assessment of the nutritional content of cowpea seed exposed to plant-derived (azadirachtin, myristicin and α-humulene) Insecticides against *Callosobruchus maculatus*. *Journal of Agriculture and Food Research*, *16*, 101130. DOI: https://doi.org/10.1016/j.jafr.2024.101130

Ogbuji, N. G., & Isalar, O. F. (2021). Effect of Some Fungal and Bacterial Organisms on the Growth of Cowpea (*Vigna unguiculata* (L.) Walp) Seedlings. *Journal of Applied Life Sciences International*. *24*(12): 11-19

Oguntade, O., Olufolaji, D. B., Oyetayo, V. O., Popoola, A. R., Kazeem, S. A., & Ayodele, M. A. (2021). Morphological and biochemical characterization of strains of *Xanthomonas axonopodis* pv. *vignicola* isolated from cowpea grown in three agro-ecological zones in Nigeria. *Journal of Agriculture and Food Sciences*, *19*(2), 1-12

Ogunsola, K. E., Fatokun, C. A., Boukar, O., & Kumar, P. L. (2023). Inheritance of resistance to three endemic viral diseases of cowpea in Nigeria. *Journal of Crop Improvement*, *37*(2), 291-308. DOI: https://doi.org/10.1080/15427528.2022.2090476

Omar, F., Neondo, J., Mweu, C., & Muli, J. (2024). Assessment of genetic diversity of latent bacteria in coconut leaves associated with lethal yellowing disease symptoms in Kenya. *Plant Pathology*. 73(4) 739-1022. DOI: https://doi.org/10.1111/ppa.13856

Omomowo, O. I., & Babalola, O. O. (2021). Constraints and prospects of improving cowpea productivity to ensure food, nutritional security and environmental sustainability. *Frontiers in Plant Science*, *12*, 751731.

Otieno, D., Muraya, M.M. & Mungiria, J.N. (2023). Isolation and Identification of Bacterial Soft-Rot-Causing Isolates from Cassava, Homa-Bay County, Kenya. *International Journal of Pathogen Research, 12* (5). pp. 71-84.

Owade, J. O., Abong', G., Okoth, M., & Mwang'ombe, A. W. (2020). A review of

the contribution of cowpea leaves to food and nutrition security in East Africa. *Food Science & Nutrition*, *8*(1), 36-47

Praneetha, S., Srivastava, J. N., Muthuselvi, R., & Malathi, S. (2022). Important diseases of cowpea (*Vigna unguiculata* L.) and their management. In *Diseases of Horticultural Crops: Diagnosis and Management* (pp. 131-152). Apple Academic Press.

Saha, S., Romi, I. J., Khatun, F., Saha, B. K., Haque, M. S., & Saha, N. R. (2022). Assessing high-yielding cowpea varieties for bacterial blight resistance in Bangladesh: A step towards an environment-friendly and sustainable solution. *Saudi journal of biological sciences*, *29*(8), 103365. https://doi.org/10.1016/j.sjbs.2022.103365

Sampathkumar, A., Aiyanathan, K. E. A., Nakkeeran, S., & Manickam, S. (2023). Multifaceted *Bacillus* spp. for the management of cotton bacterial blight caused by *Xanthomonas citri* pv. *malvacearum*. *Biological control*, *177*, 105111. Doi: https://doi.org/10.1016/j.biocontrol.2022.105111

Singh, D., Kesharwani, A. K., & Avasthi, A. S. (2023). The type-III effectors-based multiplex PCR for detection of *Xanthomonas campestris* pv. *campestris* causing black rot disease in crucifer crops. *3 Biotech*, *13*(8), 272. https://doi.org/10.1007/s13205-023-03691-z

Wang, Q., Zhang, C., Long, Y., Wu, X., Su, Y., Lei, Y., & Ai, Q. (2021). Bioactivity and control efficacy of the novel antibiotic tetramycin against various kiwifruit diseases. *Antibiotics*, *10*(3), 289. DOI: https://doi.org/10.3390/antibiotics10030289

Wanjiku, G. J., Kingori, G. G., & Kirimi, K. J. (2023). Effect of Harvesting Stage on Cowpea Leaf Nutrient Composition. *Plant*, *11*(2), 50-59. DOI: https://doi:10.11648/j.plant.20231102.12