



## **An overview of the diseases constraining the production and productivity in cowpea: With focus in bacterial blight disease caused by *Xanthomonas axonopodis* pv. *vignicola***

**\*Kirarei Ezra, Kipsumbai Pixley, Pascaline Jeruto and Kiprop Ezekiel**

*Department of Biological Sciences, University of Eldoret, P.O. Box 1125-30100 Eldoret*

**\*Corresponding author: [ekirarei@gmail.com](mailto:ekirarei@gmail.com)**

### **Abstract**

*Vigna unguiculata* L. Walp. L. (cowpea) is a significant legume crop mainly cultivated by small-scale growers in sub-Saharan Africa for human food (vegetables and grains) and animal fodder. The main aim of this review was to examine the production and productivity limitations of cowpea cultivars, with an emphasis on bacterial blight disease. To achieve our objective, we evaluated literature from multiple sources, focusing on relevant information for our review. In sub-Saharan Africa, Kenya is among the leading countries in cowpea production, with Nigeria leading in West Africa, which accounts for approximately 61% of global cowpea output. Cowpeas are affected by a broad range of diseases and pests, resulting to the destruction of entire crops. Continuous crop improvement is essential for the development of new cowpea varieties that do well under varied environmental conditions and are resistant to a wide range of diseases and pests. There is a serious need for interdisciplinary cooperation between breeders and other important actors, such as agricultural extension officers and farmers. There is a pressing demand for cowpea breeding initiatives that concentrate on breeding cultivars with early maturity, disease, pest, and drought tolerance due to sub-Saharan Africa's diminishing rainfall pattern, increases in pests and diseases, and changing environmental conditions. The current review evaluates the diseases constraining the yield and performance of cowpea, with an emphasis on the bacterial blight of cowpea.

**Keywords:** *Cowpea, diseases, pathogens, Xanthomonas axonopodis*

### **Introduction**

Cowpea (*Vigna unguiculata* L. Walp.) is a significant leguminous crop that is mostly farmed by small-scale farmers as animal fodder and food security mostly in sub-Saharan Africa (Lazaridi and Bebeli et al., 2023). The leaves of cowpea are nourishing native veggies that are cultivated and utilized among the Kenyan native communities (Owade et al., 2020). Cowpeas are eaten either as fresh vegetables or as dry grain (Nkomo et al., 2021). Despite the wide usage and popularity of the cowpea in some communities in Kenya because of its resiliency, a number of factors limit the production and utilisation of this vegetable in Kenya. The loss of cowpea yield potential is incited by a number of abiotic and biotic variables, including diseases (bacterial, viral, and fungal), insect pests, poor soil fertility, drought, and metal toxicity (Karikari et al., 2023; Nkomo et al., 202; Omomowo et al., 2021). The contribution of in- availability of improved varieties that can tolerate these stressors, inadequate farming methods, and a lack of inputs required for higher profitability and productivity are other factors causing low yields in sub-Saharan Africa. Microbial diseases have been found to be among the main factors limiting cowpea productivity in Kenya (Wanjiku et al., 2024; Owade et al., 2020).

### **Material and methods**

The extensive search procedure for this evaluation found and identified both current and older papers that were relevant to the topic by using predefined key criteria. A collection of research centre reports, journal articles, studies conducted by various researchers, organisations, institutions, and technical reports were analysed and used to create the final review document. To gain a broad understanding of the cowpea diseases, an unrestricted literature search was done on the recent and old published papers. The search query phrases included cowpea, microbial diseases of cowpea, fungal diseases of cowpea, viral diseases of cowpea, fungal diseases of cowpea, diseases linked to cowpea, key diseases of cowpea, cowpea bacterial blight disease, symptoms of cowpea bacterial blight disease, the spread of *Xanthomonas axonopodis* pv. *vignicola*, and predisposing factors in the spread of *Xanthomonas axonopodis* pv. *vignicola*.



Published papers and articles for this review were identified from separate digital databases encompassing Willey, Research Gate, National Center for Biotechnology Information (NCBI), Google Scholar, Science Direct, Scopus, Springer, JSTOR, RefSeek, and PubMed. Inclusion factors were noted for papers and articles to make sure only specific information was obtained. The review noted the inclusion factors as follows: Studies on the microbial diseases of cowpea; reports on fungal diseases of cowpea; reports on the viral diseases of cowpea; reports on the bacterial diseases of cowpea; and reports on the symptoms of cowpea bacterial blight disease, the spread of *Xanthomonas axonopodis* pv. *vignicola*, and predisposing factors in the spread of *Xanthomonas axonopodis* pv. *vignicola*. After critical analysis of the articles, publications were sorted together based on the review aims.

## Results and discussion

### Fungal pathogens/diseases linked with cowpea

The most damaging phytopathogens of cultivated crops worldwide are fungi (Fisher et al., 2012; Omomowo et al., 2021; Akintunde et al., 2023). In the field and post-harvest phase, cowpea is destroyed by a large number of species belonging to several fungal genera. Moreover, cowpea production losses that occasionally reach 100% have been linked to fungal diseases that are disseminated through seeds and the soil. Da Silva et al., (2021) noted that fungal pathogens such as *Fusarium* sp., *Aspergillus* sp., *Macrophomina* sp., *Nigrospora* sp., and *Cladosporium* sp. carried in cowpea seeds lead to a serious reduction in the emergence of seeds. *Mucor* sp., *Aspergillus flavus*, and *Rhizopus* sp. infect cowpea seeds, causing a drastic reduction in grain weight (Joy et al., 2020). According to Mbeyagala et al., (2022) and Deepika et al., (2020), southern blight, also known as stem or stem disease incited by *Sclerotium rolfsii*, damping-off incited by *Phytophthora* sp., seedling blight or collar caused by *Rhizoctonia solani*, and Fusarium wilt incited by *Fusarium oxysporum* f.sp. *tracheiphilum*, are among the major soil-borne fungal diseases limiting the cultivation and production of cowpeas globally.

Akitunde et al., (2023); Etaware et al., (2019); Loeto et al., (2016) noted from their study that *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus fumigatus*, *Rhizopus stolonifera*, *Aspergillus parasiticus*, *Rhizoctonia solani*, *Septoria vignae*, *Fusarium solani*, *Aspergillus temarii*, *Penicillium chrysogenum*, *Cladosporium cladosporioides*, *Colletotrichum gloeosporioides*, *Corynespora cassiicola*, and *Botryodiplodi theobromae* are some of the most prevalent fungal pathogens linked with cowpea seed deterioration and postharvest loss. Kiprof et al. (1987) and Ndalira et al. (2020) noted that cowpeas grown in Eastern and Western Kenya were infected with Septoria leaf spot disease and rust fungus, respectively. Similarly, Kankam et al. (2023), reported that cowpeas grown in Northern Ghana were infected with rust disease, which significantly interfered with root development and mineral, water and nutrient uptake, resulting in poor crop growth. Sindushree et al., (2023) documented that cowpea rust incited by *Uromyces phaseoli* var. *vignae* (Barcl.) Arth. leads to a significant reduction in grain development.

Cowpea seeds have seed-borne pathogens such as *Alternaria* aff. *burnsii*, *Fusarium* sp., and *Epicoccum* sp. that cause serious crop infections as the seedling develops (Pachoute et al., 2024). Bakhshi et al., (2021) and Edet et al., (2022) reported the infection of cowpea with *Cercospora* leaf spot disease caused by a complex of cercosporoid fungi complex (*Cercospora canescens*, *Cercospora* sp. G, *C. iranica*, *Cercospora* sp. T, *Cercospora* cf. *flagellaris*, and *Cercospora vignigena*) and two Pseudocercospora species (*Pseudocercospora* cf. *cruenta* and *Pseudocercospora griseola* f.sp. *griseola*). *Culvularia penniseti* and *Nigrospora sphaerica* fungi are responsible for the browning of the aerial sections of the cowpea crop, resulting in stunted growth of infected plants (Obisesan and Ojo, 2023).

### Viral Diseases

Viral infections can have a negative effect on cowpea production; in some instances, they have been linked to yield losses of up to 90% in cowpeas or, to crop failure entirely. Globally, the production of cowpeas reported to be negatively impacted by more than 20 viruses (Nsa and Kareem, 2015; Horn and Shimelis, 2020). Cowpea mosaic virus has been reported in cowpeas, and the disease incidence decreases with the application of diammonium phosphate fertiliser and farmyard manure (Mutebi and Moranga, 2022; Kiptui et al., 2020). Whitney and Gilmer (1974) associated the dissemination of the cowpea mosaic virus with thrips, chrysomelid beetles, and grasshoppers. Mangeni et al., (2020) demonstrated that the common bean mosaic virus transmitted by an aphid vector is capable of infecting cowpea plants, resulting in symptoms including local lesions, curling, and stunting.

Seven viruses namely cowpea aphid-borne mosaic virus, bean common mosaic virus, blackeye cowpea mosaic strain, cowpea mild mottle virus, cucumber mosaic virus, cowpea mottle virus, southern bean mosaic virus, and



*cowpea yellow mosaic virus*, were detected in diseased cowpeas in Southwest Nigeria, causing symptoms of stunted growth, puckering, mottling, systemic mosaic, leaf deformation, and vein banding (Ogunsola et al., 2023; Praneetha et al., 2022). Abd El-Aziz (2024) and Adams et al. (2020) noted that *cowpea yellow mottle virus* (CYMV), *cowpea mosaic comovirus*, *cowpea mottle virus* (CPMoV), *cucumber mosaic cucumovirus* (CMV), *southern bean mosaic sobemovirus*, *cowpea aphid-borne mosaic potyvirus* (CABMV), *cowpea mild mottle virus* (CPMMV), *cowpea mild mottle Carlavirus* (CPMMV), *southern bean mosaic virus* (SBMV), *cowpea severe mosaic virus* (CPSMV), and *cowpea chlorotic mottle bromovirus* (CPCMV) are among the economically significant cowpea pathogenic viruses capable of causing devastating infections in sub-Saharan Africa.

*Mungbean yellow mosaic India virus* (MYMIV) is the most devastating pathogenic virus in India, inciting yellow mosaic disease in cowpeas during the rainy season, especially late-sown crops where grain yield losses of 58.38% have been recorded (Kumar et al., 2022). *Cowpea mottle virus* (CPMoV) and *Blackeye cowpea mosaic virus* (BICMV) have the ability to infect cowpea with the production of severe symptoms that cause losses in yield (Ahmed et al., 2022).

### Nematode diseases

Nematodes are one of the factors preventing cowpea productivity from improving and are also the reason for significant losses in cowpea yield (Dareus et al., 2021; Omomowo et al., 2021; Joshua, 2023). Divya et al., (2021); Krishna and Nisha (2023); and Ribeiro et al., (2022) reported the infection of cowpea by the *Meloidogyne incognita* nematode, causing root-knot disease. Similar findings were reported by Kusakabe et al. (2023) and Simion and Palle (2022), who noted that *M. incognita* in cowpeas is responsible for the devastating destruction of cowpea plants. Severe infections by the root knot *M. incognita* nematode leads to premature senescence of the cowpea plant (Thakur et al., 2023). *Aphelenchoides besseyi* nematode was reported to be responsible for foliar dark spots on cowpea crops (Nsoronha et al., 2023; Favoreto et al., 2022). Reniform soil nematode, *Rotylenchulus reniformis*, infects the roots of cowpea crops, causing root destruction (Zaki et al., 2024; Ria et al., 2023; Lira et al., 2020).

### Bacterial Diseases

Bacterial infections are a major factor affecting cowpea yields, causing significant crop losses of up to 90% in the form of reduced pod sizes, seed grain, leaf, and fodder (Agbicodo et al., 2010; Praneetha et al., 2022). A number of these detrimental pathogens spread through seeds, whereas others spread through the soil (Constantin et al., 2016; Timilsina et al., 2020). The detrimental signs of bacterial pathogen infection in cowpeas are brownish leaf spots, observable stem splits, necrotizing and yellow halo leaf forms, blotches, and water-filled pods (de Lima-Primo et al., 2019; Saha et al., 2022). Mahesha et al., (2022) further noted that bacterial blight disease is the main biotic stress affecting cowpea. Under severe infections, cowpea bacterial blight can result in up to a 92% yield loss (Nantale et al., 2023).

Bacterial wilt and tan spot disease of cowpea, caused by *Curtobacterium flaccumfaciens* pv. *flaccumfaciens*, is among of the most devastating bacterial infections of cowpea. It produces disease symptoms such as systemic wilt and interveinal chlorosis on leaflets, resulting in necrotic zones. Seed discoloration to orange, yellow, or pink (Osdaghi et al., 2020). El-Nagdi et al. (2021) noted that *Pseudomonas fluorescens* is a plant pathogen capable of infecting cowpea. The *Xanthomonas* genus of bacteria is associated with some of the most harmful cowpea diseases, especially the bacterial blight disease (Durojaye et al., 2019; Saha et al., 2022; Nanthale et al., 2023).

### Bacterial Blight Disease of Cowpeas

The occurrence of bacterial blight disease in Kenya have been documented Njonjo et al., (2018). Further, they noted that the improved cowpea varieties were more resistant to bacterial blight compared to local varieties. The bacterial pathogen, *Xanthomonas axonopodis* pv. *vignicola*, is the main causative agent of the destructive seed-borne cowpea bacterial blight disease (Saha et al., 2022; Agbicodo et al., 2010). The pathogen has been observed to overwinter in plant detritus and can endure up to fourteen years in seeds (Karavina et al., 2011). The main way the disease transmits is through seed infection. Cowpea bacterial blight, also known as canker, is common in cowpea production regions where it is severe during the windy and rainy seasons, due to the contribution of these factors in speeding up the bacterial spread and growth (Durojaye et al., 2019; Mahesha et al., 2022).

Nantale et al., (2023) and Bua et al., (1998) reported the occurrence of bacterial blight of cowpea in Uganda, with devastating effects of crop yield loss of up to 92% in severe conditions. Further noting that some of the improved varieties showed appreciable resistance to bacterial blight disease. Similar conclusions had been noted by Adipala et al. (1995), who noted that cowpea blight in Uganda incited by *Xanthomonas axonopodis* pv. *vignicola* was



common and damaging and that the most promising mitigation measure was the use of resistant genotypes. Similar findings were reported by Saha et al., (2022) in Bangladesh explaining that cowpea bacterial blight hinders production, and the most promising intervention is the breeding of resistant crop varieties. *Xanthomonas* genus pathogens have undergone significant evolutionary changes, including the horizontal transfer of genes coding for traits responsible for pathogenicity and adaptation (Chen et al., 2021).

Several reports Agbicodo et al., (2010); Durojaye et al., (2019); Ganiyu et al., (2017); Oguntade et al., (2021); Williams (1975), have documented the occurrence of cowpea bacterial blight disease in various cowpea-growing agro-ecological regions in Nigeria and it is noted to cause significant losses in grain yield, harvested leaves and fodder. This has been noted to endanger food security in sub-Saharan Africa. Ogbuji and Isalar (2021) noted that cowpea bacterial blight disease is blamed for the serious losses in both harvested leaves and grain yield in sub-Saharan Africa. Similar results had earlier been reported by Shi et al., (2016), who noted cowpea bacterial blight disease to be caused by *Xanthomonas axonopodis* pv. *vignicola* to be the most economically devastating bacterial infection of cowpea since its prevalence is recorded in major cowpea production areas globally, and the deployment of resistant cultivars serves as the critical technique to control the disease.

### **Symptoms and spread of *Xanthomonas axonopodis* pv. *vignicola***

The initial symptom of cowpea bacterial blight disease appears as wrinkled and reddish cotyledons of seeding originating from contaminated seeds (Kumar et al., 2018; Ganiyu et al., 2017). At first, the leaves develop as necrotic lesion which eventually extends to infect the stem. Once the infectious agent enters the vascular bundles, the illness spreads throughout the plant body, infecting the growing tip and ultimately destroying the plant (Agbicodo et al., 2010; Praneetha et al., 2022). The secondary symptoms on the leaf are manifested as light yellow round spots dispersed across the lamina, with a diameter ranging from 4 to 10 mm. These spots have a brown, necrotic centre with crimson veins. Pods develop streaks of deep green colour or wetness. The infected pods shrink and turn yellow; smaller, wrinkled, and contaminated seeds are produced by the sick pods (Agbicodo et al., 2010; Durojaye et al., 2019; Omomowo et al., 2021). The primary effect of *X. axonopodis* pv. *vignicola* infection is on the leaves, and it might result in total defoliation based on the genotype's susceptibility (Claudius-Cole et al., 2014; Ibrahim, 2023).

The major source of the principal inoculum is the contaminated seeds, while wind, rain, and insects cause secondary dissemination (Durojaye et al., 2019). When cowpeas were cultivated as an intercrop with maize over short-term rains and as a relay crop following maize during the long rains, a decrease in disease dissemination inside and between plants were noted Ouko et al., (1989). The cultivation of cowpeas with sorghum or maize intercropping leads to decrease in disease incidence because these plants seem to act as a mechanical barrier to prevent the pathogen from moving between the cowpea plants (da Silva Júnior et al., 2022).

### **Predisposing factors in the spread of *Xanthomonas axonopodis* pv. *vignicola***

Inadequate field preparation, little or no fertiliser application, low altitude, a substantial weed infestation, and a single cropping system are linked to the incidence and severity of bacterial blight and they have played a major role in the disease's epidemics (Mengesha and Yetayew., 2018). Girma et al., (2022), showed a strong linkage between the bacterial blight disease intensity and the independent factors, namely altitude, zone, weed management practices, sowing date, cropping system, crop growth stage, crop cultivar, seed sources and fertiliser application. Mengesha and Yetayew et al., (2018) found that planting early or late lowers, the average severity of the bacterial blight infection compared to the optimal planting time.

The utilisation of infected seeds is accountable for the persistence and dissemination mechanisms of cowpea bacterial blight. When *Xanthomonas axonopodis* pv. *vignicola* infects flower buds and early pods, it can spread to the seed through the vascular system and harm the seedlings (Dell'Olmo et al., 2023; Mahesha et al., 2022). Warm temperatures and heavy rains throughout the growing season promote leaf moisture and infection on leaves and pods (Marcuzzo and Fächter., 2021). One of the best strategies to prevent significant crop losses is to use legume cultivars resistant to various diseases (Adila et al., 2021).

Weeds encircling cropping fields and volunteer plants inside the crop area can harbour insect pests and plant pathogens, or they might establish a microclimate that is conducive to disease development. Weeds in infested fields retain the pathogen that causes cowpea bacterial blight for longer period (Zang et al., 2021). Decreased crop resilience is a result of weeds' fierce competition for resources, which predisposes host crops to both aerial and soil-borne diseases (Degu et al., 2023; Yimer et al., 2018). Interestingly the high-altitude regions are less prone to bacterial blight disease development (Grima et al., 2022).



Intercropping impacts replicate the variability of plant populations, which influences disease cycles by modifying wind speed, host density, microclimate (relative humidity, temperature, and leaf wetness) and vector transmission (Girma et al., 2022; Degu et al., 2023)

## Conclusion

Cowpea is a drought-resilient crop that is extensively cultivated for grains, vegetables, and fodder by small-scale farmers in arid and semi-arid areas of the globe with little rainfall. Its performance is primarily affected by abiotic and biotic stressors. Despite its importance, there has been very little success in breeding crop cultivars resistant to these stressors. There is a serious need for interdisciplinary cooperation between breeders and other important actors, such as agricultural extension officers and farmers. This is to ensure that the developed cultivars match the farmer's desired qualities. The cowpea breeding efforts should concentrate on developing crop cultivars that are drought-tolerant, disease-resistant, and pest-resistant.

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## Conflicting interest

The writers declare they have no conflicting interests.

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