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Impact of Climate Change on Dry Root Rot of Chickpea and its Management Strategies

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Chickpea, (*Cicer arietinum* L.), is a member of the *Fabaceae* family, specifically belonging to the *Papilionaceae* subfamily. Chickpea cultivation spans over 50 countries, encompassing the Indian subcontinent, North Africa, the Middle East, southern Europe, the Americas, and Australia.On a global scale, it stands as one of the most widely grown pulses, with impressive production figures of 14.2 million tons and an average yield of 0.96 tons per hectare (FAO, 2014).the production of chickpea is largely constrained by fusarium wilt, however, recent reports indicates that dry root rot (DRR)is emerging as potential threat to chickpea under changing climatic conditions. Dry root rot (DRR), caused by the soil-borne fungal pathogen *Macrophomina phaseolina*, is an increasingly significant threat to chickpea production, particularly in warm and dry regions. Climate change is exacerbating this problem through several key mechanisms:

1. Increased Temperatures:

Macrophomina phaseolina thrives well in high temperatures, with optimal growth and infection rates typically between 30-35°C. As global average temperatures rise due to climate change, larger chickpea-growing areas will experience conditions highly favorable for this pathogen, leading to increased disease incidence and severity.

2. Drought Stress:

Chickpea is often grown in rain-fed conditions and is susceptible to drought stress, especially during the flowering and podding stages, which often coincide with high temperatures. Drought-stressed plants are physiologically weakened and become more susceptible to *M. phaseolina* infection and colonization. The pathogen can also survive for long periods in dry soil as sclerotia (sclerotia are hardened fungal structures).

3. Low Soil Moisture:

Low soil moisture content further favours the development of dry root rot disease. The pathogen's activity and the plant's ability to defend itself are both negatively impacted by dry soil conditions. Climate change is predicted to increase the frequency and intensity of drought events, thus creating ideal conditions for DRR outbreaks.

4. Altered Cropping Seasons:

Changes in rainfall patterns and temperature regimes might lead to shifts in optimal sowing times for chickpea. These shifts could potentially expose the crop to more favorable conditions for DRR at critical growth stages.

5. Geographical Expansion of the Pathogen:

With rising temperatures, *Macrophomina phaseolina* may expand its geographical range, affecting new chickpea-growing regions that were previously less susceptible to DRR.

Impacts:

1. Studies have shown that there is a strong positive correlation between high temperatures, drought conditions, and increased incidence and severity of dry root rot in chickpea.

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2. Central and southern states of India, which often experience high temperatures and water stress, are identified as major hotspots for dry root rot disease.

3. Yield losses due to DRR can range from 5-35% and can reach up to 100% in susceptible varieties under favorable conditions for the pathogen.

4. Climate change models predict a substantial decrease in chickpea productivity in regions prone to DRR due to the increasing frequency of high-temperature and drought stress.

Dry Root Rot of Chickpea Disease Management Strategies under Climate Change:

Effective management of dry root rot disease under the changing climate requires an integrated approach that considers the factors exacerbating the disease:

1. Host Resistance:

Developing and deploying resistant varieties: This is the most sustainable long-term strategy. Breeding programs should prioritize identifying and incorporating resistance genes to Macrophomina phaseolina into high-yielding chickpea cultivars.

* Screening germplasm: Continuous screening of chickpea germplasm for resistance under conditions that mimic future climate scenarios (high temperature and water stress) is crucial.

2. Cultural Practices:

A) Deep plowing in summer: This can expose sclerotia to high temperatures and sunlight, reducing their viability in the soil.

B) Crop rotation: Avoid short period crop rotations with other susceptible crops (as *M. phaseolina* has a wide host range). Longer rotations with non-host crops can help reduce pathogen buildup in the soil.

C) Optimum sowing time: Adhering to recommended sowing times can help avoid periods of peak temperature and drought stress during critical growth stages. Avoid late sowing, which can favor disease development.

D) Proper plant spacing: Adequate spacing can improve air circulation and reduce moisture retention in the canopy, potentially creating a less favorable microclimate for the pathogen.

E) Avoiding water stress: Implementing appropriate irrigation strategies to minimize drought stress, especially during flowering and pod development, can enhance plant vigor and reduce susceptibility. However, avoid over-irrigation, which can favor other root diseases.

E) Soil health management: Practices that improve soil health, such as adding organic matter, can enhance plant resilience to stress and potentially promote antagonistic microorganisms.

G) Sanitation: Removing and destroying infected plant debris can help reduce the inoculum in the field.

3. Biological Control:

A) Seed and soil treatment with biocontrol agents:

Trichoderma viride @ 10gram per kg seed and *Pseudomonas fluorescens* @ 10gram per kg seed have shown promise in suppressing *M. phaseolina*. Seed treatment and soil application of these beneficial microorganisms can help protect the plants, especially during the seedling stage.

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B) Integration with organic amendments:

Combining biocontrol agents with organic amendments like neem cake can enhance their effectiveness.

4. Chemical Control:

A) Seed treatment with fungicides:

Fungicides like Carbendazim and Thiram can provide some protection, particularly during the seedling stage, but may not be fully effective against established soilborne infections. Combination treatments may offer better protection.

C) Soil drenching:

In some cases, spot drenching with fungicides like Carbendazim or biocontrol agents around infected plants might help limit disease spread, but this is often not economically feasible on a large scale.

D) Fungicide resistance management:

If chemical control is used, it's crucial to follow resistance management guidelines to maintain the efficacy of available fungicides.

5. Integrated Pest and Disease Management (IPDM):

*Combining resistant varieties with appropriate cultural practices, biological control, and judicious use of chemical control (if necessary) is the most sustainable approach.

*Regular monitoring of fields for early disease symptoms is crucial for timely intervention.

6. Climate-Smart Agriculture Practices:

*Adopting practices that enhance water use efficiency and soil moisture retention can help mitigate the impact of drought stress.

* Exploring agroforestry systems or intercropping with species that can provide shade and reduce soil temperature might offer some protection.

7. Research and Development:

* Continued research is needed to understand the complex interactions between climate change, the pathogen, and the host plant.

* Developing rapid and reliable diagnostic tools for early detection of DRR is essential.

Investigating the potential of novel control strategies, such as the use of plant extracts or other organic compounds with antifungal properties, is important. By implementing these comprehensive and integrated management strategies, it is possible to minimize the impact of climate change on dry root rot and ensure sustainable chickpea production in the face of a changing climate. The focus should be on proactive and preventative measures, with host resistance being a key component of long-term solutions.