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Distribution and factors influencing chickpea wilt and root rot epidemics in Ethiopia

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ABSTRACT

Chickpea is a major food legume crop in the mid-highlands of Ethiopia where its yield is negatively impacted by the wilt and root rot disease complex. The pathogens associated with WRR complex and their associations with biophysical factors have not been well understood in the past. We report here a survey of five major chickpea-growing regions covering 30 districts in the central and northern highlands of Ethiopia. The associations between disease parameters and biophysical factors were assessed using logistic regression analyses. Moreover, pathogens associated with wilt and root rot were identified, and their frequency of occurrence was determined. Mean percent wilt and root rot incidence and percent severity index were the highest in Gojam followed by Gondar and the lowest in Shoa. The major pathogens associated with infected roots were *Fusarium oxysporum* f. sp. *ciceris, Fusarium solani, Rhizoctonia bataticola, Sclerotium rolfsii,* and *Rhizoctonia solani*. The most frequently isolated pathogen was *F. oxysporum* f. sp. *ciceris* followed by *R. solani*. Moreover, significant ($P < .001$) associations between disease parameters and planting date and between weeding practice and soil and chickpea types were observed. High disease incidence and percent severity index showed high probability of association with planting date and chickpea types. Desi chickpea and chickpea that were planted early in the season had approximately 2 and 9 times greater probability of experiencing a high disease incidence and a 6–5 times greater probability of experiencing high wilt and root rot severity, respectively. High disease incidence and percent severity index were also correlated with weed infestation and planting on heavy black soils. Therefore, late planting, appropriate weeding, and the use of chickpea cultivars with a high level of resistance are important options to manage WRR complex.

1. Introduction

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop grown under rain-fed conditions in the mid-highlands of Ethiopia. Approximately 1 million smallholder households cultivate this crop, covering over 230,000 ha, with an average productivity of 1.8 t/ha (CSA, 2014). Chickpea is an important source of food, income, and animal feed, and it improves soil fertility through a symbiotic association with nitrogen-fixing bacteria that benefits succeeding crops such as wheat and tef. On conventionally farmed fields, the productivity of chickpea (both Desi and Kabuli types) is below 2 t/ha, while farmers adopting improved technologies can harvest up to 4 t/ha. The added income from this enhanced production contributes to rural development and can boost local economies (Verkaart et al., 2017). The key factors for the high yield gaps are a low adoption rate of new chickpea technologies, weak seed delivery system, utilization of low-yielding landraces, poor agronomic practices, terminal drought, diseases (both foliar and soil-borne), and insect pests. The major diseases affecting chickpea are wilt and root rot (WRR) complex caused by *Fusarium oxysporum* f. sp. *ciceris* (*Foc*), *Fusarium solani*, *Rhizoctonia solani*, *Rhizoctonia bataticola*, and *Sclerotium rolfsii,* which reduce crop stand, leading to a reduction in overall chickpea yield (Beniwal et al., 2008).

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Among the pathogens in WRR complex, *Foc* is the most serious pathogen in reducing chickpea yield in Ethiopia and other chickpea-producing countries (Navas-Cortés et al., 2000; Ahmed and Melkamu, 2006; Jiménez-Díaz et al., 2015).

Cultural management methods such as crop rotation and ridge and furrow planting are recommended to manage WRR disease (Tebkew and Ojiewo, 2016). However, cultural management options alone are not sufficient as root-inhibiting pathogens are known to persist in the soil for several years. The use of a wide array of fungicides has been suggested, but the application of chemical fungicides is harmful to humans, living organisms, and the environment. A more efficient, economical, and environmentally friendly approach to managing WWR disease complex relies on the use of resistant chickpea varieties. Moreover, sustainable management of WRR requires a good understanding of the pathogen's associated with the complex and how biophysical factors impact disease epidemics. Surveys on the incidence of WRR disease complex in the highlands of Ethiopia have been reported previously, but no attempts were made to relate biophysical factors to disease epidemics (Negussie, 1996; Negussie et al., 1998; Tebkew and Ojiewo, 2016). The objectives of this study were to (1) determine the association between bio-physical factors and WRR epidemics as measured by incidence and percent disease severity and (2) identify pathogens associated with WRR disease complex in major chickpea-growing regions of the country.

2. Materials and methods

2.1. Survey areas and disease assessments

During the 2014/15 cropping season, a field survey was conducted in five major chickpea-growing areas, covering 30 districts in the mid-central and northern highlands of the country (Fig. 1). Districts were selected according to chickpea area coverage (CSA, 2014) and accessibility to main and feeder roads. A total of 156 chickpea fields were inspected at 5–10-km intervals along roadsides. Three spots in each field were inspected using 1 m^2 quadrat, and mean disease incidence was calculated. Severity of infected plants was rated using a 1–9 scale, where 1 = 0–10% plant tissue affected, 3 = 11–20% plant tissue affected, 5 = 21–30% plants tissue affected, 7 = 31–50% plant tissue affected, and 9 = more than 50% of plant tissue affected (Iqbal et al., 2005). Severity scores were subsequently converted to percent severity index (PSI). In addition, data on previous crops, chickpea types, cropping systems, altitude, planting dates, weeding practices, soil types, and crop growth stages were recorded. Samples of diseased chickpea plants were collected to identify the pathogens associated with WRR complex.

2.2. Isolation and identification of WRR-associated pathogens

Five hundred twenty-two representative diseased chickpea samples were used to identify the pathogens associated with WWR complex. Infected root and stem samples were cut into ~1 cm pieces using sterile scissors and washed under running tap water. The segments were surface sterilized with 2% sodium hypochlorite solution for 2–3 min, washed three times with sterile distilled water, and dried on sterile filter paper. Samples were subsequently plated on potato dextrose agar (PDA) containing chloramphenicol (120 mg/L) and incubated at 26 °C for 7 days under a 12 h dark–12 h light cycle. Colonies were sub-cultured on fresh PDA plates using a hyphal tip technique to obtain pure cultures. The organisms were subsequently identified according to their cultural and morphological features (Leslie and Summerell, 2006).

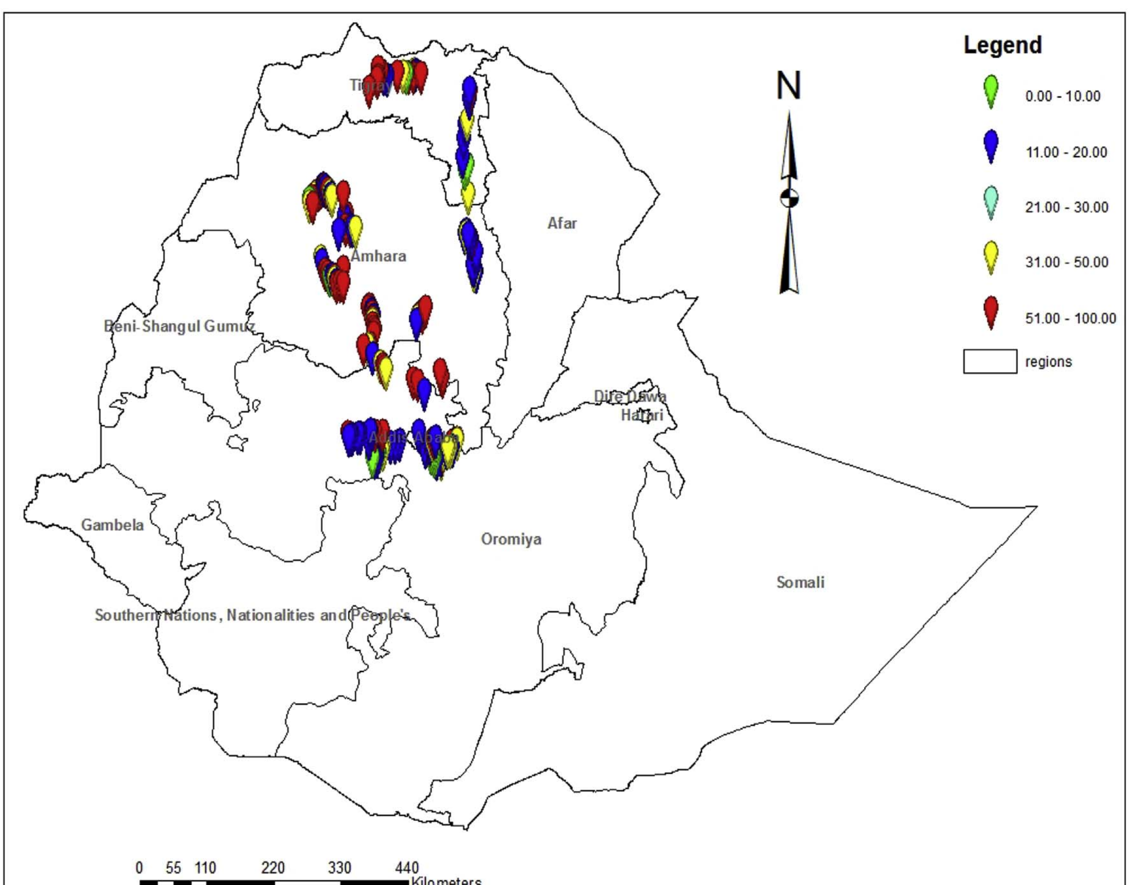

Fig. 1. Map showing surveyed locations and chickpea wilt root rot incidence ranges in the surveyed districts of Ethiopia.