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Research Application Summary

Manipulating the soil ecosystem for improved management of soil-borne pathogens in small holder 'greenhouse' tomato production in Kenya

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Abstract

The livelihoods of about 40-60% small and medium scale farmers in Kenya is dependent on tomato (*Solanum lycopersicum)* production, farmed mainly under open field conditions and/or until recently under modified high tunnels popularly known as 'greenhouses'. High tunnel production creates an ideal farming environment for pests to thrive. Bacteria wilt caused by *Ralstonia solanacearum* and root-knot nematodes (RKNs) of the *Meloidogyne* spp are among the most serious pests that have threatened the utilization of the high tunnel tomato production in Kenya. The goal of this study is to utilize an interdisciplinary research approach to develop improved and inexpensive strategies by manipulating the plant's chemical defenses using fertiliser to suppress root-knot nematodes and bacterial wilt in tomato. The project is designed to support two graduate students (M.Sc.) who work with a supervisory team to design experiments within two broad objectives: (i) Evaluating the impact of fertiliser types and application rates on the population dynamics of root-knot nematodes and bacterial wilt and on plant growth and yield; (ii) understanding the mechanisms underlying plant-pathogen-fertiliser interaction. Farmer stakeholders, researchers from national and international agricultural centers and universities are involved in the research to help develop methodologies and validate research results for appropriate use. The study is being conducted in Kiambu County, Central Kenya where high tunnel technology is being utilized.

Key words: Bacterial wilt, fertilizer, high tunnel technology, nematodes, plant defense, small holder farmers, tomato

Résumé

Les moyens de subsistance d'environ 40-60% de petits et moyens agriculteurs au Kenya reposent sur la production de la tomate (*Solanum lycopersicum*), principalement produites

dans des conditions de champ et / ou jusqu'à récemment sous de grands tunnels modifiés populairement connu sous le nom de «serres». La production sous hautes tunnels crée un environnement agricole favorable pour le développement des parasites. Le flétrissement causé par *Ralstonia solanacearum* et les nématodes à galles (RKNs) d'espèce *Meloidogyne spp* sont parmi les plus graves ravageurs qui ont menacé l'utilisation de hauts tunnels pour la production de la tomate au Kenya. Le but de cette étude est d'utiliser une approche de recherche interdisciplinaire pour élaborer des stratégies améliorées et moins coûteuses en manipulant les défenses chimiques de la plante à l'aide d'engrais pour supprimer les nématodes à galles et le flétrissement bactérien de la tomate. Le projet est conçu pour supporter deux étudiants en Master qui travaillent avec une équipe de supervision pour la conduite d'expérimentation portant sur deux objectifs globales: (i) évaluer l'impact des types d'engrais et les taux d'application sur la dynamique des populations de nématodes à galles et le flétrissement bactérien et sur la croissance des plantes et le rendement; (ii) comprendre les mécanismes d' interaction plante-pathogène-engrais. Les acteurs agriculteurs, les chercheurs des centres agricoles au niveau national et international et des universités sont impliquées dans la recherche pour aider à développer des méthodes et de valider les résultats de la recherche pour une utilisation convenable. L'étude est menée dans le comté de Kiambu, au centre du Kenya où la technologie de production sous haut tunnel est utilisée.

Mots clés: flétrissement bactérien, engrais, technologie du haut tunnel, nématodes, défense de la plante, petits exploitants agricoles, tomate

Background

Tomato, *Solanum lycopersicum* L., belongs to the vast family of Solanaceae and has been referred to as a "functional food," due to its beneficial phytochemicals (Sharoni *et al*., 2012). Kenya is among Africa's leading producers of tomato and ranked 6th with a total production of 397,000 metric tons (FAO, 2012) accounting for 14% of the total vegetable produce and 6.72% of the total horticultural crops (GOK, 2012). The livelihoods of about 40-60% small and medium scale farmers is dependent on tomato production, farmed mainly under open field conditions and/or until recently under modified high tunnels popularly known as 'greenhouses' (Hortinews, 2015). High tunnel production creates an ideal farming environment but encourages pests and diseases to thrive. Of these, root-knot nematodes (RKNs) of the *Meloidogyne* spp. and bacterial wilt caused by *Ralstonia solanacearum* are a major constraint to the greenhouse tomato production (Mbaka *et al*., 2013). One of the control options based on the farmers' indigenous knowledge is increased application of organic and inorganic fertilizer on the crops in order to reduce wilting (Murungi *et al*., pers. comm. 2011). Interestingly, fertilizer in 30% of the cases reduces symptoms of damage in the short-term, but eventual plant death is inevitable.

A few studies have focused recently on the nutritional requirements of greenhouse tomato in Kenya (Kirimi *et al*., 2011), but the precise mechanisms associated with plant defense metabolites by which the nutrients interact with nematodes and bacterial wilt infection are limited. The question is: What plant defense metabolites are produced or altered by tomato plants grown under different fertilizer types and application levels and how does the plant

respond in the presence of the pathogen? The study outlined below seeks to utilize a multi-disciplinary approach comprising social science by conducting focused group discussions in smallholder greenhouse tomato production, plant pathology and chemical ecology to establish allelochemicals that are produced by tomato plants nourished with different fertilizers and their application rates that may predispose them to soil pathogens. The goal is to use the information generated for optimizing production of metabolites that keep nematodes below the economic threshold and subsequently minimize bacterial wilt infection for increased greenhouse tomato production.

Analytical framework and methods

The study utilizes the knowledge, attitude and practices of high tunnel tomato farmers in three sub-counties in Kiambu County to design experiments that answer the research questions. The five-part flow chart displays the county's analytical framework (Fig. 1). Beginning on the left side of the chart, a red box represents 'county policy inputs' and leads to the 'sub-county processes' box. Below these two boxes is a blue box, labeled 'what policy results in good practices?' which leads back to the county policy inputs and sub-county processes' boxes. The sub-county processes' box ultimately leads to the orange box labeled 'best production practices.' Above and between the sub-county processes box and best production practices is a second blue box labeled 'which practices result in increased production?' The study involved various stakeholders including the county government, primary beneficiaries (tomato growers), research centers and extension staff to guide on developing methodologies and validate research results for appropriate use.

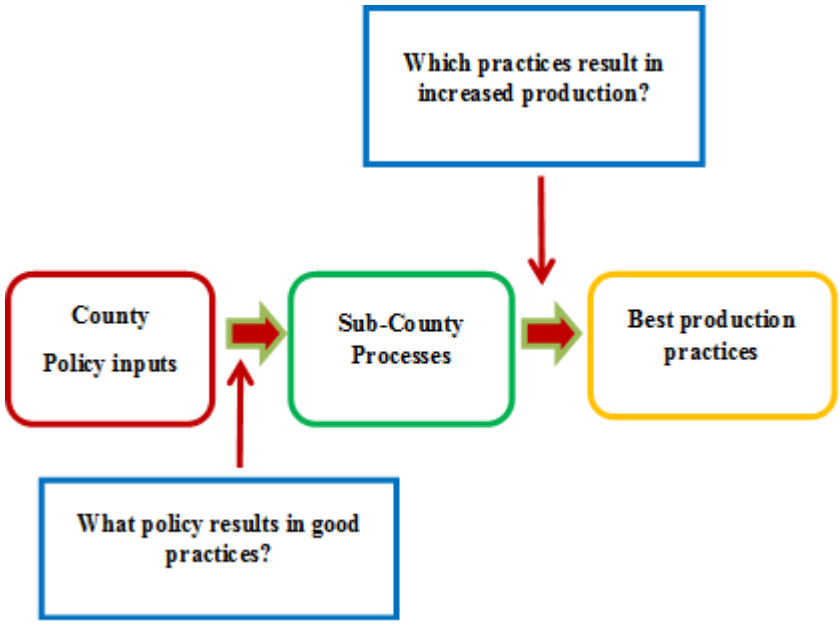

Figure 1. Analytical framework for Kiambu County

Findings and implications

Results from knowledge, attitudes and practices (KAP) focus group discussion regarding bacterial wilt and root-knot nematode indicate that both diseases are the major causes of tomato yield decline (79%) in high tunnel production. However, the farmers' interest in growing tomato has not been reduced (74%). The study established that knowledge gaps on good practices in fertilizer use, source of planting materials, disposal of diseased plants and soil testing may impact on tomato yields in high tunnel production. A multi-disciplinary and sectoral approach is needed to identify these gaps and facilitate the removal of the poor practices related to the management of bacterial wilt and root-knot nematodes. It is also expected that findings from the chemical ecology studies will provide vital information on the importance of fertilizer in influencing plant chemistry and subsequently the populations of soil pathogens affecting 'greenhouse' tomato production. The project is also expected to generate knowlegde and technologies that will promote intensive cultivation of tomato in high tunnels among small holder farmers. These findings will form a basis for more collaborative efforts for improving tomato production which will translate to improving the livelihoods of the smallholder farmers. This could also lead to development of integrated pest management packages for various soil pathogens including above-ground tomato pests.

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