

EFFICACY OF REHABILITATION METHODS ON CITRUS CANCKER DISEASE IN NORTHERN UGANDA

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ABSTRACT

Citrus (*Citrus sinensis*) is an important crop in Uganda, where it is produced for both domestic consumption and regional markets. Unfortunately it is increasingly devastated by canker disease. Several measures are often recommended for citrus canker management worldwide; the major ones being orchard inspection, quarantines, protective copper sprays and the on-site burning of infected trees. The adoption rate for these options in Northern Uganda has not been possible and as a result, the disease has reached epiphytotic level. Cultural practices and phytosanitary measures, consisting of removal of inoculum sources, timely application of protective chemical sprays and field sanitation could restore citrus orchards in areas affected by citrus canker. This study was carried out to determine the most effective method of eliminating inoculum sources and appropriate chemical sprays after inoculum suppression, to prevent re-infection. On-station trials were carried out in three fields (orchards), with 90-100% of trees infected at the beginning of the experiment. Treatments evaluated were: (i) bark horning during the dry season, (ii) bark horning during the wet season, and (iii) protective copper sprays. Each orchard was divided into three portions and each portion consisted of a minimum of 10 trees. For each orchard, one portion received bark horning treatment during the wet season (November) and the other portion during the dry season (December). The third portion was treated with 0.2% copper oxychloride. Inspection and removal of twigs emerging with symptoms two months after bark horning treatment, application of protective copper and insecticide sprays two, three and four months after bark horning were administered as a follow up treatments to bark horning. The effect of treatments on citrus canker incidence was significant ($P < 0.05$). The incidence of re-infection was highest in plots that were bark horned during the wet season (23.4%), and lowest in plots bark horned during the dry season (3.3%). Complete bark horning of infected orchards at the beginning of dry season, followed by at least 6 months of regular orchard inspection; removal of re-infected branches and judicious application of chemical sprays (copper oxychloride fungicide and pyrinex insecticide) was the best option for managing citrus canker disease. Use of cultural practice and phytosanitary measures is, hence, recommended.

Key Words: *Citrus sinensis*, fungicide, phytosanitary

RÉSUMÉ

Le citronnier (*Citrus sinensis*) est une culture importante en Ouganda, où il est produit pour la consommation domestique et pour des marchés régionaux. Malheureusement, il est de plus en plus dévasté par la maladie du chancre. Plusieurs mesures sont souvent recommandées pour le contrôle du chancre du citronnier dans le monde, entre autre les plus importantes sont l'inspection des vergers, la mise en quarantaine, pulvérisation protectrice du cuivre et l'incinération des arbres infectés. L'adoption de ces pratiques au nord de l'Ouganda n'a pas été possible, et en conséquence, la maladie a atteint un niveau épiphytotique. Ces pratiques culturelles et mesures phytosanitaires consistant à l'enlèvement des sources d'inoculum, application opportune des produits chimiques de pulvérisation et la sanitation du champ pourraient restaurer les vergers de citronniers dans les milieux affectés par le chancre du

citronnier. Cette étude était conduite pour déterminer la méthode la plus efficace pour l'enlèvement des sources d'inoculum et les produits chimiques appropriés de pulvérisation après l'enlèvement de l'inoculum, afin de s'assurer que les vergers ne seront plus réinfectés. Des essais en station étaient utilisés pour évaluer les systèmes de gestion intégrée du chancre du citronnier. Ces essais étaient conduits dans vergers, avec 90-100% d'arbres infectés au début de l'expérimentation. Les traitements incluaient: (i) bark horning pendant la saison sèche, (ii) bark horning pendant la saison humide, et (iii) pulvérisation protectrice du cuivre. Chaque verger était subdivisé en trois parties et chaque partie contenait un minimum de dix arbres. Chaque partie de chaque verger avait reçu un traitement de bark horning pendant la saison humide (Novembre) et l'autre portion durant la saison sèche (Décembre). La troisième partie était traitée avec 0.2% de l'oxychlorure de cuivre. L'inspection et l'enlèvement des brindilles poussant avec symptômes deux mois après le traitement du bark horning, application protectrice du cuivre et la deuxième pulvérisation d'insecticide, trois et quatre mois après l'administration du bark horning comme traitements de suivi du bark horning. L'effet de traitements sur le chancre du citronnier était significatif ($P < 0.05$). L'incidence de la réinfection était la plus élevée dans les parcelles traitées avec le bark horn pendant la saison humide (23.4%), et moins élevée dans celles traitées avec le bark horn pendant la saison sèche (3.3%). Un traitement complet au bark horn des vergers infectés au début de la saison humide, suivi d'au moins six mois d'inspection régulière de verger, l'enlèvement des branches réinfectées et une application judicieuse des pulvérisation chimiques (fongicide du chlorure de cuivre et insecticide pyrinex) était la meilleure option pour la gestion du chancre du citronnier. L'utilisation de la pratique culturale et les mesures phytosanitaires, et ainsi recommandée.

Mots Clés: *Citrus sinensis*, fongicide, phytosanitaire

INTRODUCTION

Citrus (*Citrus sinensis*) is an important crop in Uganda, where it is produced for both domestic consumption and regional markets (Uganda Investment Authority, 2009). Production is characterised by low input in terms of pest and disease control, use of improved planting materials and soil fertility enhancement measures. Major diseases constraining production of citrus in the zone are citrus canker, citrus greening, *Alternaria* brown spot and citrus scab. Citrus canker, citrus greening, and *Alternaria* brown spot are recent entrants in the northern agro-ecological zone (NAEZ) of Uganda. Farmers lack management options for these diseases. Yield loss due to citrus canker and *Alternaria* brown spot range between 50 and 100% (Anonymous, 2012).

Citrus canker is one of the most feared of citrus diseases, affecting all types of important citrus crops (Prakash and Karmegam, 2012). The disease causes extensive damage to citrus and severity of infection varies with species, varieties and the prevailing climatic conditions. The disease is common in India, Japan and other South- East Asian countries, from where it has spread to all other citrus producing continents, except Europe (Das, 2003). Citrus canker diseases emerged in northern Uganda in 2010 (Anonymous, 2012), where it was first detected

in an orchard in Lira district. The disease, however, has spread to all citrus growing areas in the region.

Citrus canker is a bacterial disease characterised by the occurrence of conspicuously raised necrotic lesions that develop on leaves, twigs and fruits (Schubert *et al.*, 2000; Nikhil *et al.*, 2013). On leaves, first appearance is oily looking, 2-10 mm circular spots, usually on the abaxial surface (reflecting stomatal entry following rain dispersal). Lesions are often similar in size. Later, both epidermal surfaces may become ruptured by tissue hyperplasia induced by the pathogen. On leaves, stems, thorns and fruit, circular lesions become raised and blister-like, growing into white or yellow spongy pustules (Brunings and Gabriel, 2004). These pustules then darken and thicken into a light tan to brown corky canker, which is rough to the touch. Often a water-soaked margin develops around the necrotic tissue and is easily viewed with transmitted light.

Other peculiar symptoms have been ably described by Gottwald *et al.*, 2002; Graham *et al.*, 2003.

When citrus canker disease was initially detected in Northern Uganda, several measures were recommended, e.g. nursery and orchard inspections, quarantines, protective copper sprays and the on-site burning of infected trees

to eradicate or reduce disease spread. These strategies were based on experience in controlling other crop diseases with similar epidemiology. Generally, the adoption rate of these options has been extremely low and the disease has reached epidemic levels in the zone. Many farmers with infected citrus orchards have lost hope and have abandoned their plantations. One approach to restoring citrus productivity would involve the removal of inoculum sources through complete bark horning, followed by judicious application of chemical (protective copper and insecticide) sprays, and strict adherence to field sanitation. The objective of the study was to determine the most effective method of eliminating inoculum sources, and appropriate chemical sprays after inoculum removal to ensure treated orchards are not re-infected.

MATERIALS AND METHODS

The study was conducted at Ngetta Zonal Agricultural Research and Development Institute (Ngetta ZARDI), located in northern Uganda at 02° 29'57" N; 032° 09'20" E; 1, and at 101 metres above sea level (masl). Average daily temperature is 25 °C; while maximum temperature is 29 °C. The climate is moist, sub-humid, with a mean annual rainfall of 1,639.1 mm that is bi-modally distributed (March- June and August-December). Trials were carried out at three sites, in orchards with 90-100% of trees infected with citrus canker at the beginning of the experiment.

The experimental design was randomised complete block design with three replications. Each orchard was divided into three equal plots measuring 12 m x 24 m. In the first plot, plants were completely bark horned during the wet season (November); in the second plot, plants were completely bark horned at the beginning of the dry season (December); while in the third plot, the plants were sprayed with protective copper spray (0.2% copper oxychloride) twice a month starting in November for a period of three months.

The citrus plant debris were piled five meters away from the trial site, allowed to dry and then burnt. Inspection and removal of twigs emerging with citrus canker disease symptoms started two months after bark horning; and application of protective copper (0.2%) and insecticide sprays

(pyrinex-0.2 %) started three months after bark horning in the first and second plots. The copper and insecticide sprays were repeated fortnightly for the first two months; followed by one treatment a month for four months. Access to the trial sites was restricted using lockable gates and labels warning unauthorised personnel not to access the trial fields. This measure was necessary to avoid transmission of citrus canker disease from infected orchards to the trial fields or from one plant to another.

The plants were inspected through tree by tree observations for citrus canker disease symptoms 2, 4 and 7 months after the first treatment. Data on citrus canker incidence and percentage fruit damage were subjected to both descriptive statistics and ANOVA using the SAS 9.2 Software (SAS Institute Inc., Cary, NC, USA). Means were separated using LSD at $P < 0.05$.

RESULTS AND DISCUSSION

For all treatments, the citrus canker incidence within the experimental plots decreased with the ability of the treatments to reduce the concentration of the inoculum (Fig. 1). Citrus trees bark horned at the beginning of the dry season had less than 4% re-infection, while 23.3 % of trees bark horned during the wet season were re-infected as early as two months after treatment administration. Over 90% of plants treated with protective copper sprays had citrus canker disease symptoms.

The effect of treatments on citrus canker incidence within the orchards was significant at two, four and seven months after main treatments were administered (Table 1). The mean incidence was highest in plots treated with copper sprays, followed by those bark horned during the wet season and lowest in plots that were bark horned during the dry season.

Fruit damage was also significant ($P < 0.05$) at seven months after the treatment. Portions of orchards bark horned during the dry season produced fruits with canker damage of 1%; the portions bark horned during the wet season had isolated incidences of fruit damage ($< 10%$); while the portions sprayed with chemicals had the highest incidence of fruit damage ($> 95%$) (Table 2).

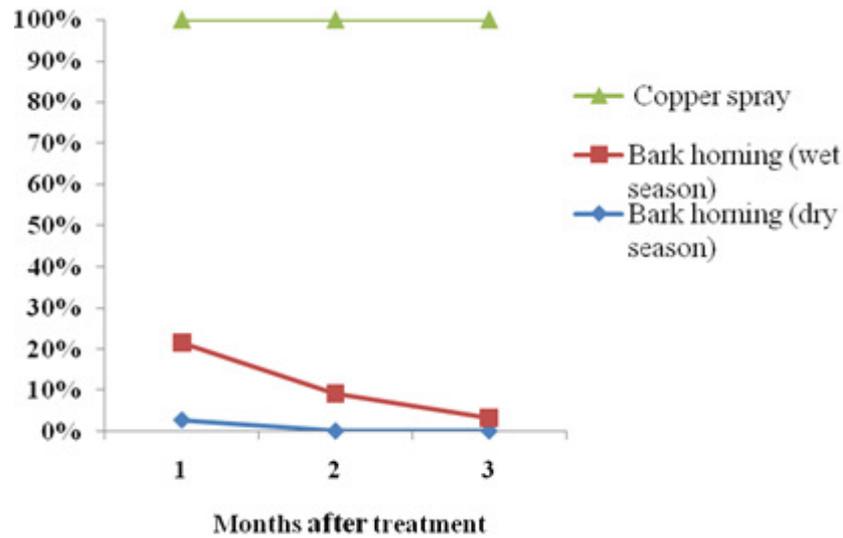


Figure 1. Citrus canker incidence after different treatments by month.

TABLE 1. Effect of treatments on citrus canker disease incidence in the orchards in northern Uganda

Treatments	Citrus canker disease incidence		
	2 month	4 months	7 months
Bark horned during dry season	3.3	0.0	0.0
Bark horned during wet season	23.3	10.0	3.3
Sprayed with copper based fungicide	96.7	100.0	100.0
LSD (0.05)	25.8	11.5	6.7

TABLE 2. Mean comparison of percentage fruit damage seven months after main treatment

Treatments	Percentage fruit damage
	7 months
Bark horned during dry season	1.1
Bark horned during wet season	9.3
Sprayed with Copper based fungicide	95.3
LSD	8.1

These observations suggest that complete severe bark homing of all infected trees in the orchard at the beginning of the dry season (December), followed by judicious application of copper sprays (Copper oxychloride fungicide) and insecticide (Pyrinex) at a concentration of 0.2%, is required to restore health to orchards after devastation with citrus canker disease caused by bacterium *Xanthomonas* (Tables 1 and 2). Generally, a higher re-infection rate was observed on variety 'Tangelo' compared with other varieties, suggesting that citrus varieties

may respond differently to bark horning treatments, particularly, during the wet season.

In this study, it seems that control of citrus canker with copper sprays as a stand-alone measure is not efficacious on susceptible cultivars. Leite *et al.* (1990) had earlier reported that effective suppression of citrus canker by copper sprays depends on susceptibility of the citrus cultivar, environmental conditions and adoption of other control measures. A study conducted in Brazil by Leite (1990) revealed that copper sprays are effective for control of citrus canker only on citrus cultivars with intermediate levels of resistance under a seasonally drier and a less tropical climate.

In the plots where citrus trees were bark horned at the beginning of the dry season, the bacterial cells that had oozed from existing lesions on stems and leaves during wet weather to provide inoculum for further disease development probably dried and died upon exposure to direct sunlight and drier weather conditions, thus resulting in the very low level of re-infection observed (Table 1).

CONCLUSION

It is apparent that complete severe bark horning at the beginning of the dry season, followed by chemical (copper and insecticide) sprays, is an effective measure for managing citrus canker disease. Complete bark horning of infected orchards is, hence, recommended; followed by at least 6 months of regular orchard inspection, removal of re-infected branches and judicious application of chemical sprays (copper oxychloride fungicide and pyrinex insecticide).

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