

Research Application Summary

Integrated management of aphid vectors and associated viral diseases of passion fruit in Uganda

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Abstract

This study is intended to develop management strategies for aphid vectors and viral diseases on passion fruit in Uganda. In the absence of resistant varieties, the management techniques evaluated here will provide much needed information for commercial and small-scale passion fruit farmers. Techniques developed will be integrated within current strategies that are expected to manage vegetation to enhance the efficacy of natural enemies. With the validation of vector transmission, pesticide efficacy will be established for sole application or integration with non-chemical control measures for improved effectiveness in management. Being in the early stages of development, and considering the scale of evaluation, these techniques will be evaluated in on-station trials for later validation on-farm.

Key words: Aphid transmission, application rate, pesticides, passion fruit, spray schedule

Résumé

Cette étude vise à élaborer des stratégies de gestion pour les vecteurs des pucerons et les maladies virales sur les fruits de la passion en Ouganda. En l'absence de variétés résistantes, les techniques de gestion évaluées ici fourniront beaucoup d'informations utiles pour les agriculteurs commerciaux et à petite échelle des fruits de la passion. Les techniques développées seront intégrées dans les stratégies actuelles qui sont censées gérer la végétation afin d'améliorer l'efficacité des ennemis naturels. Avec la validation de la transmission vectorielle, l'efficacité des pesticides sera établie pour l'application unique ou l'intégration des mesures de lutte non chimiques pour une meilleure efficacité dans la gestion. Etant dans les premiers stades de développement et compte tenu de l'échelle d'évaluation, ces techniques seront évaluées dans les essais en station pour la validation ultérieure à la ferme.

Mots clés: Transmission des pucerons, taux d'application, pesticides, fruits de la passion, calendrier de pulvérisation

Background

Passion fruit is one of the fruits being promoted for value chain development by the Coca-Cola Company, non-profit TechnoServe, and the Bill and Melinda Gates Foundation partnership. This partnership has targeted over 50,000 small fruit farmers in Uganda and Kenya with the aim of increasing their productivity and doubling their incomes by 2014 (TechnoServe, 2010). Productivity is, however, most limited by viral diseases that cause 40% yield loss and up to 100% crop loss (NARO, 1999). These viral diseases are characterised by a diversity of symptom types including mottling, mosaic, chlorosis, vein clearing and fruit woodiness, among others (Ochwo-Ssemakula, 2008). These symptom types have been attributed to one prevalent and putative novel species, tentatively named the *Passiflora* chlorotic mottle virus (PaCMV) (DSMZ, 2012) and alternatively proposed as the Ugandan *Passiflora* potyvirus (Ochwo-Ssemakula et al., 2012), whose mode of transmission remains unclear although preliminary surveys in five major growing districts of Central Uganda have isolated at least five aphid species infesting passion fruit (IPM CRSP, Unpublished). Related virus species are reported to be transmitted in a non-persistent manner by many aphid species, some of which include the cotton aphid (*Aphis gossypii*) and green peach aphid (*Myzus persicae*) although transmission is also possible through grafting and mechanical inoculation (Fischer and Rezende, 2008). Aphid-borne non-persistent viruses (ABNPVs) are better managed by targeting the source of inoculum (Irwin et al., 2000). This approach involves targeting the planting material, volunteer crops, and alternative hosts of both the vector and viruses. Effective management practices include use of resistant varieties, pre-immunisation with mild virus strains (Novaes and Rezende, 2005) and adoption of cultural practices that minimise incidence and spread of viral diseases (Rezende, 1994).

Resistant passion fruit varieties are currently not available to farmers in Uganda although previous studies have highlighted the benefits of planting virus-free seedlings (Ochwo-Ssemakula, Unpublished). Cultural practices such as barrier cropping (Hooks and Wright, 2008); mulching and weeding (Hooks and Fereres, 2006) that manipulate the cropping environment have been used to reduce the rate of viral disease incidence and dissemination and may be useful for managing viral diseases on passion fruit in Uganda. In fact, an integrated management package is currently under development that incorporates mulching and weeding (IPM CRSP, Unpublished). Chemical control is also being reviewed especially targeted at potential

aphid vectors. Confirmation of the vector that transmits PaCMV would support these efforts. The overall objective is to provide commercial and small-scale farmers with viable management options in the absence of host resistance by delaying virus infection in the early and most vulnerable stages of crop growth. Manipulation of ecological factors that facilitate aphid vector survival and proliferation is in turn expected to discourage crop infestation. Furthermore, improvement of the nutritional status of the crop would support host tolerance and contribute positively towards productivity. By integrating techniques at the four phases of Wyss' model for management of arthropod pests (Zehnder *et al.*, 2007), an ecologically-sound package will be developed that also contributes towards organic farming that is increasing gaining importance.

Literature Summary

The genomic constitution of the Passiflora chlorotic mottle virus comprises amino acid motifs that predispose it to aphid transmission although virus distribution patterns in Uganda also support possible spread through infected planting material (Ochwo-Ssemakula, 2008). The virus is related to the *Passion fruit woodiness virus* (PWV), *Cowpea aphid borne mosaic virus* (CABMV) and East Asian Passiflora virus that are transmitted by one or more aphid species that include: *Aphis gossypii*, *Myzus persicae*, *Aphis craccivora* and sow thistle aphids (*Hyperomyzus lactucae*). Virus transmission by vectors is the result of interactions between the vector, pathogen and host plant. Transmission is also more closely related to progress of aphid infestation from plant to plant than aphid population on a particular plant. Viral diseases are, therefore, most effectively managed using host resistance where available. Once infection sets in cultural and biological methods may be used to target the vector and reduce plant losses. By utilising techniques that employ both preventative and more direct strategies to influence pest survival and proliferation in an integrated manner, pest management is more effective. Biological control has been shown effective against aphid species (Men *et al.*, 2004; Rhainds and Messing, 2005). Bio-pesticides are widely used in South Asia, sometimes in combination with cultural practices, to manage insect vectors such as aphids, whiteflies, mealybugs and leafhoppers (IPM CRSP, 2008).

Study Description

Two graduate students have been recruited to conduct the research in this project. Student 1 will conduct surveys in six major passion fruit growing districts of Uganda identified to have possible strains of UPV. Virus isolates will be collected

from the farmers' fields and passed through ELISA to separate proposed virus sub-groups for extraction of viral ribonucleic acid (RNA) for further verification in RT-PCR with specific primers. Naturally-occurring aphid species and potential biological control agents (predators and parasitoids) of known aphid species will also be collected and multiplied in the screen house at the Makerere University Agricultural Research Institute Kabanyolo (MUARIK). Efficacy of biological control agents in managing aphid vectors will be evaluated in caged screen house trials after evaluation of data on vector population numbers, development and fecundity. Aphids will be tested for presence of virus in laboratory analyses then multiplied and used in caged screen house trials to confirm transmission. Indicator plants will be used to concentrate virus inoculums. Susceptible passion fruit of the small purple type will be used for expression of viral disease symptoms.

Student 2 will evaluate pesticides for efficacy in managing aphid vector populations and viral diseases on passion fruit in on-station trials using a randomised completely blocked design (RCBD) with 2 replicates at the National Crops Resources Research Institute (NaCRRI) in Namulonge. Four pesticides will be evaluated for two seasons in a staggered planting including: synthetic contact, synthetic systemic, synthetic contact-systemic combination and bio-pesticide at the recommended application rates for aphids. Pesticides that show promise will be further evaluated for two seasons to establish the most effective spray schedule for pest and disease management. Cost-benefit analyses will also be conducted. The most commonly grown commercial variety, Kawanda hybrid, will be used. To cater for the long growth cycle of passion fruit evaluation of pesticide application schedules will commence after season one of the first trial.

Research Application

This study is expected to answer some questions on the epidemiology of viral diseases on passion fruit in Uganda. Techniques will also be developed to discourage infestation of passion fruit by aphid vectors of PaCMV. These techniques will be supported by non-chemical strategies that are meant to offer cost-effective pest and disease management, especially under organic production.

Recommendations

The results from this study will contribute towards on-going efforts aimed at developing an integrated package for management of viral disease on passion fruit in Uganda.

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References

- DSMZ, 2012. Plant Virus Diagnostics Catalogue 2012. Leibniz-Institute DSMZ Plant Virus Department. Product code PC-0707.
- Fischer, I. and Rezende, J. 2008. Diseases of passion flower (*Passiflora* spp.). Global Science Book, Hong Kong.
- Hooks, C.R. and Wright, M.G. 2008. Use of living and dying mulches as barriers to protect Zucchini from insect-caused viruses and phytotoxemias. Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii, Manoa.
- Hooks, C.R.R. and Fereres, A. 2006. Protecting crops from non-persistently aphid-transmitted viruses: A review on the use of barrier plants as a management tool. *Virus Research* 120:1-16.
- IPM CRSP. 2008. India IPM CRSP Site visit: Training in vegetable grafting, IPM Research and Demonstration Trials. Trip Report April 29 to May 11, 2008. E.A. Heinrichs, G. Luther, W.U. Deng-Lin, Nutan Kaushik, M. Murugan.
- Irwin, M.E., Ruesink, W.G., Isard, S.A. and Kampmeier, G.E. 2000. Mitigating epidemics caused by non-persistently transmitted aphid-borne viruses: the role of the pliant environment. *Virus Research* 71:185–211.
- Men, X.Y., Ge, F., Yardim, E.N. and Parajulee, M.N. 2004. Evaluation of winter wheat as a potential relay crop for enhancing biological control of cotton aphids in seedling cotton. *BioControl, Dordrecht* 49 (6):701-714.
- Novaes, Q.S. and Rezende, J.A. M. 2005. Protection between strains of Passion fruit woodiness virus in sun hemp. *Fitopatologia Brasileira* 30:307-311.
- Ochwo-Ssemakula, M., Sengooba, T., Hakiza, J.J., Adipala, E., Edema, R., Redinbaugh, M.G., Aritua, V. and Winter, S. 2012. Characterization and Distribution of a *Potyvirus* associated with Passion Fruit Woodiness Disease in Uganda. *Plant Disease* 96 (5):659-665.
- Ochwo-Ssemakula, M.K.N. 2008. Occurrence, identification and characterization of viruses infecting passion fruit in Uganda. Ph.D. Thesis, Makerere University, Kampala, Uganda. 120pp.
- Rezende, J.A.M. 1994. Virus and mycoplasma diseases of passion fruit in Brazil. pp. 116-125. In: San Jose, A.R.

Ochwo-ssemakula, M. et al.

(Ed.). Passionfruit: Production and market. Vitória da Conquista: UESB, 1994.

Rhainds, M. and Messing, R.H. 2005. Spatial and temporal density dependence in a population of melon aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), on established and sentinel taro plants. *Applied and Entomology and Zoology, Tokio* 40(2):273-282.

TechnoServe. 2010. The Coca-Cola Company, TechnoServe and The Gates Foundation Partner to Boost Incomes of 50,000 Small-Scale Farmers in East Africa. Press Release January 20, 2010. <http://www.technoserve.org/resources/press-room/2009-2010-press-releases/tccc-gates-tns.html>. Accessed Aug 26, 2012.

Zehnder, G., Gurr, G.M., Kuhne, S., Wade, M.R., Wratten, S.D. and Wyss, E. 2007. Arthropod Pest Management in Organic Crops. *Annual Reviews of Entomology* 52:57-80.