Development of a pest identification mobile phone application for mungbean in Northwest Cambodia

Isabel C. Hinchcliffe[1], Rosanne Quinnell[1], Robert Martin[1], Van Touch[1] and Daniel K.Y. Tan[1]

[1] The University of Sydney, Sydney Institute of Agriculture, School of Life and Environmental Sciences, Faculty of Science, Sydney, NSW 2006, Australia, Email: daniel.tan@sydney.edu.au

Abstract
In response to the need for crop diversity, Cambodian farmers have begun incorporating mungbean into rice cropping systems. However, these smallholder mungbean producers are facing significant yield loss due to direct impacts of insect and disease pests. Improper pest management has worsened the issue, causing economic losses to farmers and environmental disruption. Improper and over-use of broad-spectrum pesticides as a solution to all observed pests is common place in mungbean fields of lowland Cambodia and these practices are linked to poor sources of agricultural information. This project aimed to discover the pest and beneficial species most common in mungbean fields of lowland Cambodia, and to use this information to develop an informative image-rich mobile phone application to aid Cambodian farmers and field agronomists with insect and disease identification, and so provide specific management recommendations, aligned with the principles of integrated pest management, applicable to the Cambodian context. This study evaluated the feasibility of the proposed app through a survey with potential users. These survey responses were incorporated into the development of the Pest ID app prototype, which was trialled with farmers and subsequently refined by adding audio content in Khmer. The majority of farmers in this study were unable to distinguish between beneficial and pest insect species. The Pest ID app has been well received by farmers with users seeing its potential to support crop management decisions. This app holds potential as an important agricultural education tool for mungbean farmers in the greater Mekong region.

Key Words
sustainable diversification, education, design, Integrated Pest Management.

Introduction

Pesticides are heavily relied upon throughout Cambodia, and pesticide use is considered an essential part of crop management (Matsukawa et al., 2016). Insect pests account for the majority of crop damage in mungbean crops of lowland Cambodia; inappropriate use of pesticides, attributed to minimal knowledge and inaccurate information on the appropriate use of these chemicals, results in a heightened pest problem (Matsukawa et al., 2016). Insect pests thrive in environments where natural predators have been removed via human intervention. Broad spectrum insecticides reduce populations of natural insect enemies, including predators and parasitoids (Van Emden and Harrington, 2017). It is generally accepted that the integrated pest management (IPM) approach is the most effective and sustainable option for pest control within crops (Altieri et al., 2018). This involves the use of a variety of cultural, physical, biological and chemical control strategies, minimising reliance on any one technique to provide the best outcome for the crop, environment and wider farming community (Altieri et al., 2018). Adoption of IPM in Cambodia has largely been limited by inadequate support to farmers, inappropriate sources of information and interfering economic factors. Alternative methods of extending pest management education to mungbean farmers and farmer communities, particularly considering biological control species, are required (Ngin et al., 2017). A mobile phone application as a tool for pest management holds great potential in improving the productivity of mungbean crops in lowland Cambodia by helping growers to make more informed decisions surrounding pest control (Schreinemachers et al., 2015). This Pest ID app is the sister app to the Cambodian Weed ID app offered in 2016 (Henson et al., 2017). This research aimed to 1. discover the pests and beneficial species present in mungbean fields of lowland Cambodia; 2. evaluate the current pest control situation in three selected villages (Rohal Suong, Angsang Sak and Preaek Trab); 3. develop a mobile phone application for Cambodian mungbean farmers and other key users by providing a means of insect and disease pest identification with species specific control information; and 4. analyse and refine this application using a series of questionnaire surveys with the users.

It was expected that a greater number of pest insects would be observed compared with beneficial species based on the current trends of pesticide use. Adoption of this mobile application is predicted to increase over

the long term as updates and refinements are incorporated and as mobile phone usage further increases. It was expected that Cambodian farmer knowledge of integrated pest management would be improved through this project; and therefore has implications such as reducing overall pesticide applications, providing economic benefits as well as health improvements to the farmers and wider communities.

Methods

Site information

This study took place during January 2018 across three villages in the Aek Phnum district, Battambang, Cambodia, located at approximately 13.155692° latitude and 103.226702° longitude (1. Rohal Suong, 2. Angsang Sak and 3. Preaek Trab). Each of the selected villages is involved in a larger project, CSE-2015-044 (Tan et al., 2018), funded by the Australian Centre for International Agricultural Research (ACIAR). Prior to the survey, ethics approval was obtained from the Human Research Ethics Committee (HREC) (Project Number: 2016/882). Field sampling and interview questionnaires were performed in 28 households across these three villages.

Field sampling design

Sampling farmer fields for pest and beneficial insect species, as well as noting weeds, disease and crop damage, served the aim of discovering the insects present in mungbean crops of lowland Cambodia and was the basis for development of the pest identification mobile app. For each selected farmer household in the study area, two field sampling techniques were used to collect data directly from the corresponding mungbean field. Firstly, a visual inspection was performed at 10 randomly allocated points within a farmer's mungbean field. Collection of in-field data followed a simple random sampling design, used as a basis for inspection points of each field, while noting the variation in field size and shape. Following this, a sweep netting technique was employed, using a cone shaped net attached to a wooden pole and following the generally accepted pattern of a single sweep left and right while trailing a direct line. The net was then inspected and insects were collected in small containers for identification in the laboratory.

Design of mobile application

Design and implementation of the mobile phone application for pest identification was based on the IDEO design process methodology (Moen, 2001). This method of design was developed by David Kelly at Stanford University and is divided into five key steps which have been applied to an app development process, relying on seeking and analysing iterations of user feedback through interview surveys of 28 households from three villages to inform app development (Moen, 2001) (Figure 1).

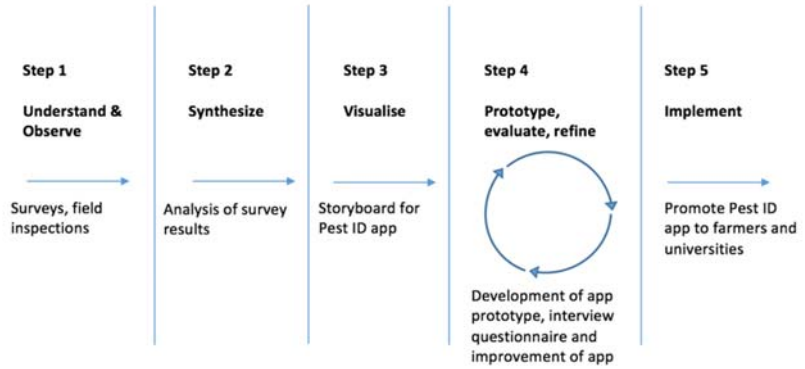
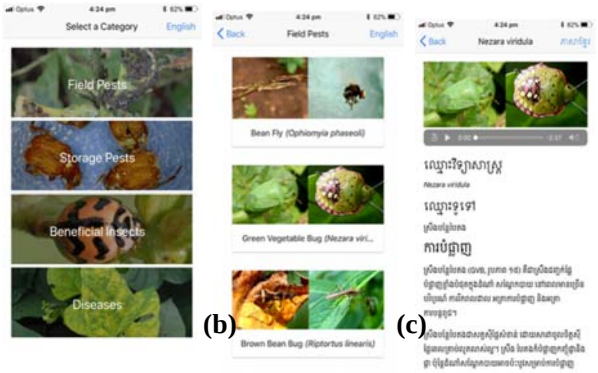


Figure 1. Visual representation of the IDEO innovation model from Moen (2001) adapted with regards to Pest ID app development. The mobile phone application development process had five major steps.

A completed storyboard design, along with an Excel sheet containing the required images and information in both English and Khmer, was developed into a prototype app. Assembly of the app was outsourced to Ngakkan Nyaagu (NGNY), an Indigenous Australian app development company based in Redfern. The initial prototype of the app was given the name 'Pest ID' and contains species considered to have the greatest effect on Cambodian mungbean crops, with division into categories of 'Field Pests', 'Storage Pests', 'Beneficial Insects' and 'Diseases' (Figure 2).



(a) **(b)** **(c)**

Figure 2. Screenshots of the Pest ID app prototype (a) Division into four distinct categories of 'Field Pests, 'Storage Pests', 'Beneficial Insects' and 'Diseases' (b) Scroll-through function relying on images for identification of insect species (c) Species specific information including control recommendations, as well as a voice over feature of all written information.

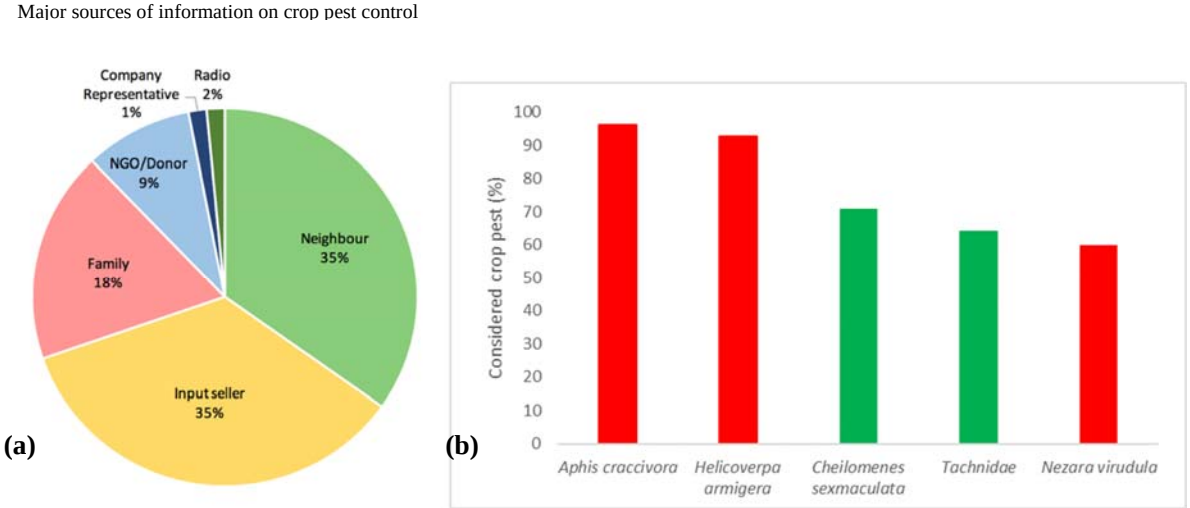
Results

Field Sampling

Visual inspection of mungbean fields found significant populations of cowpea aphid (*Aphis craccivora*) common across all fields inspected in Rohal Suong, Angsang Sak and Preaek Trab. Three species of ladybird (*Cheilomenes sexmaculata, Coccinella transversalis and Micraspis discolor*) each acting as predators to pest aphids, were also observed in Angsang Sak and Preaek Trab but at low population levels. Two Lepidopteron larvae, *Spodoptera litura* and *Omiodes indicata*, were causing the most significant vegetative damage.

Survey Questionnaire

While 64% of interviewees had personal ownership of a mobile phone, 100% had access to at least one smart phone within the household. Survey results showed only 39% recognised that there are both good (beneficial) and bad (pest) insects. These data are very village-specific, with an influence of extension work performed by ACIAR funded project, CSE-2015-044. Villagers receiving education through extension work (Angsang Sak and Rohal Suong) acknowledged the existence of beneficial insects, while 100% of surveyed farmers in Preaek Trab, where the educational program has not yet been offered, did not consider any insects to be beneficial. A lack of understanding of appropriate pest control measures was attributed to unreliable and biased sources of pest control information. The majority of interviewees sourced information on pest control from neighbours (35%) and chemical input sellers (35%) (Figure 3a).



(a) **(b)**

Figure 3. Survey Responses combined answers from all villages surveyed. (a) Survey responses to the question 'Where do you currently receive advice from for management and control of insect pests in your crops?' (b) Participant responses to a quiz on five insect species previously observed in the farmer fields during inspections. *Cheilomenes sexmaculata* (ladybird) and Tachinid flies are beneficial insect species (green), while the remaining three species are considered problematic pests (red).

During a short quiz to gain an understanding of current pest knowledge, interviewees were presented with photographs of 5 insect species found in their mungbean fields, two of which are considered beneficial acting as natural control agents: 71% of interviewees wrongly identified the beneficial ladybird (*Cheilomenes sexmaculata*) as a crop pest, while the remaining interviewees classed ladybirds as either having 'no effect' or 'don't recognise'. No respondent (0%) acknowledged ladybirds as having a beneficial impact on the crop. The majority of responses identified all 5 insects as being bad for the crop (Figure 3b).

Eighty-six percent of interviewees stated they would like to receive more information on insect control, with 82% wanting further information specifically on insecticides. For example, "I want to use the app to learn about good and bad insects and how to control in my field crop" – Farmer A, Preaek Trab, Battambang. This indicates that smallholding farmers are likely to use the app into the future for IPM. Following demonstration of the Pest ID app, 100% of interviewees stated that they would use this app for pest management assistance within their crop. When trialling the Pest ID app with farmers, 39% recommended inclusion of a voice-over option. All individuals suggesting this improvement come from Angsang Sak village.

Conclusions

Insect pests have a significant limiting impact on mungbean production in lowland Cambodia. Insect species observed relevant to mungbean production in the lowland differ to some extent from "Insects of upland crops" (Pol et al., 2010). For example, the green vegetable bug (*Nezara viridula*) is the main pod-sucking insect pest in the upland but has not been found so far in the lowland mungbean crops under study.

Beneficial populations such as *Cheilomenes sexmaculata* (ladybird) are present in high abundance in both upland and lowland, in some cases with higher abundance than pest insects. However, understanding of the role of these beneficial species in pest control, as well as other alternative IPM strategies is minimal among smallholder farmers. Similarly, knowledge of suitable pesticide use is minimal. The potential acceptance of a mobile phone application to share agricultural information is clear and the Pest ID app will be beneficial to farmers with potential to extend to a broader range of crops and countries of focus.

Acknowledgments

We thank Ratha Rien, Sophea Yous, and Bob Martin for their help with fieldwork and surveys in Cambodia, and Ms Pheakdey Tous from Volunteer Service Overseas for organising farmer contacts, particularly in Angsang Sak village. We are grateful to the Australian Centre for International Agricultural Research (ACIAR project CSE-2015-044) for funding this project.

References

Altieri MA, Farrell JG, Hecht SB, Liebman M, Magdoff F, Murphy B, Norgaard RB, Sikor TO (2018). Chapter 13. Integrated pest management. p. 267-281. In "Agroecology: The Science of Sustainable Agriculture." CRC Press: Boca Raton. 448 pp.

Henson, Y., Martin, R.J., Quinnell, R., Van Ogtrop, F., Try, Y., Tan, D. 2017. Development of a weed identifier mobile application for Cambodian rice farmers. Paper presented at the Doing More with Less. Proceedings of the 18th Australian Society of Agronomy Conference., Ballarat, VIC, Australia.

Matsukawa, M., Ito, K., Kawakita, K., Tanaka, T., 2016. Current status of pesticide use among rice farmers in Cambodia. Appl. Entomol. Zool. 51, 571-579.

Moen, R., 2001. A Review of the IDEO Process. Robert Wood Johnson Foundation, Toolkit.

Mohammad, N., Abidin, E.Z., How, V., Praveena, S.M., Hashim, Z., 2017. Pesticide management approach towards protecting the safety and health of farmers in Southeast Asia. Rev. Environ. Health.

Ngin, C., Suon, S., Tanaka, T., Yamauchi, A., Kawakita, K., Chiba, S., 2017. Impact of Insecticide Applications on Arthropod Predators and Plant Feeders in Cambodian Rice Fields. Phytobiomes. 1, 128-137.

Schreinemachers, P., Afari-Sefa, V., Heng, C.H., Dung, P.T.M., Praneetvatakul, S. and Shimamoto, D., Yamada, H., Gummert, M., 2015. Mobile phones and market information: Evidence from rural Cambodia. Food. Policy. 57, 135-141.

Pol C., Belfield S. and Martin R. 2010. Insects of upland crops in Cambodia. ACIAR Monograph No. 143. Australian Centre for International Agricultural Research: Canberra. 132 pp.

Tan, D.K.Y, Martin, R., Ampt, P., Touch, V., Cross, R., Ormiston, J., Nash, T., 2018. Partnerships for the sustainable intensification of farming systems in lowland Cambodia. Dev. Bull. 104.

Van Emden, H.F., Harrington, R., 2017. Aphids as crop pests. CABI.