An evaluation of small groups serving as an engine room for innovation in the Northern Territory mango industry

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Abstract. An extension project based around small groups was conducted with the Northern Territory mango industry from 2012-2015. It involved up to 20 NT mango businesses and affiliated agribusiness services people from two growing regions i.e. Darwin and Katherine. It was conducted around a self-directed experiential learning process where participants in collaboration with research and extension personnel. Specific novel research projects launched from the exercise included: trials to assess the efficacy of foliar calcium application on reducing lenticel spotting and under-skin browning; studies to better understand and affect floral induction; addressing a new unknown problem in mango fruit termed as resin canal discoloration; instigating improvements in harvest maturity technologies; and research to understand the behaviour, ecology and potential mitigation strategies that could be used against large flock incursions of a native waterfowl Magpie Geese (*Anseranas semipalmata*). There were also a range of shorter-term extension activities undertaken to address grower' needs.

Key words: Experiential learning, mango extension, magpie geese.

Introduction

This paper describes the functions of a small-group orientated extension project undertaken in the Northern Territory mango industry from 2012 to 2015. It details the impact it had on innovation and adoption of both established and new practices by NT mango farmers, as well as the role the groups played in identifying new areas of research to resolve vexing problems. This was a pilot activity funded by Horticulture Australia Limited to test the value of small-group extension as a tool.

The NT Mango Industry has been steadily expanding since the late 1990s, and has grown to produce around 30,000 tonnes annually, valued at $88 million in 2016-17 (DPIR 2017). This expansion has been in both additional land area planted to mangoes, as well as the adoption of new and more highly productive varieties. Mangoes are the Territory's single most economically valuable horticultural crop. Approximately 50% of Australia's mangos are produced in Northern Territory.

Despite the apparent growth in the sector, there was an ongoing problem in the adoption of best practices in agronomic, pest management and post-harvest areas. In a survey conducted by White as early as 2005, it was found that many producers at that time relied principally upon their own efforts in seeking out knowledge and information in farm practices. This was probably due to a rundown of extension services by the NT Department of Primary Industry and Resources (DPIR) beginning in the early 2000s. The survey also indicated that many producers were resorting to the less-than-optimal method of their own 'trial and error' for testing out practices to resolve problems. It was, and still, remains the case, that only the larger corporate farms in the NT businesses employ expert external consultants. Most of these consultants are conducting limited scientific research. Other private sector services capacity in the NT is based mainly around local sales agronomists, again with an absence of accompanying research support. The investigation also revealed that the private sector possessed no institutional systems for succession of production knowledge and expertise. Overall, White (2005) inferred that there had been a level of public and private sector failure in terms of extension services. Therefore, the development of mango-specific extension capacity that could link back into a dedicated research effort became a priority for the local industry and the Department.

The extension literature shows interactive small-group processes are highly effective at delivering changes in practice in rural industries (Hunt & Coutts 2009). Small groups enable farmers to have more control over the information that they need or want, and the way it is delivered. This way extension can operate by 'demand-pull' rather than 'science-push' forces (Marsh & Pannell 1999; Marsh & Pannell 2000; Crawford et al. 2007). The process of facilitating and empowering groups increases members' participation in the direction, planning and carriage of research and extension activities. It also provides stakeholders the opportunity to govern their own education and training needs based on their situation. This is a key principle for effective adult learning (Coutts et al. 2005; Hunt & Coutts 2009).

The initiative involved forming two small groups of mango growers in the Darwin and Katherine regions of the Top End. These two modestly sized groups played a key role in shaping the industry's research agenda in the NT, which has also had spillover benefits to the wider industry.

Unfortunately, Department restructuring and changes in the industry's research and development corporation priorities have since seen the cessation of this useful innovation process. The research projects generated under this effort remain signature mango industry development initiatives that have delivered substantial gains in production focused knowledge and understanding.

Methodology of the project

The project was run in accord with the Continuous Improvement and Innovation Model™ (CI&I), an experiential learning approach where clients identify and address their own needs (Kolb 1984; Clarke & Timms 2001). Experiential learning takes participants through a process of reflecting, thinking, applying and experiencing new ideas or ways of doing things. In practice it involved benchmarking the current situation facing group members, identifying needs and opportunities, and addressing those areas with the greatest leverage for making improvements or gains. The approach requires systematically revisiting the process and measuring gains made.

Group participation varied, but involved up to 20 businesses and eight different industry service providers in the process. The various activities attracted industry participants of different scales, ranging from small mango businesses constituting only 50 trees, to large corporates with in excess of 50,000 trees. The farming businesses involved represented substantial proportions of the total mango production of their respective regions.

The group meetings were coordinated by the project leader with resources and assistance sourced from technical experts both inside and external to the DPIR. Attendance numbers typically varied from 4 to 15 businesses at a meeting. The level of participation was dependent on timing or the relevance of the topic for the region, or for individual growers. Katherine was always expected to have lower participation to Darwin, as the total industry is represented by only 12 commercial operations. Service sector participation was largely confined to commercial entities and the local peak agri-representative agency, NT Farmers.

Meetings were conducted in a cordial and friendly atmosphere and dialogue was actively encouraged. Meetings were largely held on-farm in grower's sheds. The project leaders managed the project relationships and communications with the various bodies in the respective stakeholder groups.

The end-of-project evaluation to review the impact of the project was undertaken by an independent agent to eliminate any potential bias. Ten of the 20 involved in the small-groups were interviewed by the independent evaluator. The evaluator is a co-author on this paper.

The evaluation was designed around the framework of Bennett's Hierarchy (Bennett 1975). Bennett's Hierarchy provides a system for designing, implementing and assessing the impact of extension programs. It can be applied to most programs that are aimed at changing behaviour through learning or training processes (Steel 2005).

Results

The small-group process identified a wide range of industry knowledge and practice gaps around proven production techniques, as well as a wide diversity of opinion about unknown or less understood issues with their production systems. These could be broken down into two main areas i.e. those that could be addressed in the short term using current knowledge or by undertaking research that had a relatively swift turn around with results; and those with significant unknowns that would need to be addressed over a longer term.

The various issues identified in the small-groups process are listed in Table 1, alongside the types of activities that were undertaken to address them.

The shorter-term issues were invariably dedicated to either programmed learning activities such as workshops or farm-walk activities around a range of topics, or some applied research. For example, testing the efficacy of a local farming practice of foliar calcium treatments on mango trees that has been said to reduce lenticel spotting and under-skin browning.

Table 1. Short and Long-term issues identified and addressed by research and extension activities

Issues	Action
Shorter term	
Biosecurity laws and bushfire regulations	Workshop
Insect integrated pest management	Workshops and demonstrations
Harvesting maturity determination	Workshop and distribution of maturity colour grading guides
Fruit quality	Post-harvest handling workshops and transport guides
New mango varieties	Workshop and travel and learning opportunity
Crop nutrition	Workshops and field walks
Orchard disease management	Workshop
The effect of foliar calcium on fruit quality	2 year replicated DPIR-funded research trial
Longer term	
Understanding floral induction parameters in Top End mango orchards	Industry funded research project On farm demonstrations and workshop
Refining harvesting maturity by use of near infrared (NIR) technology	Industry-funded research project
Understanding the causes for resin canal discoloration in mango fruit	Industry-funded research project
Mitigating the effects of Magpie Geese on Darwin regional mango orchards	Industry-funded research project with PhD and Master's candidates from Charles Darwin University

The longer-term issues were novel in nature, and were targeted at resolving important production issues such as manipulating floral induction; refining harvesting maturity by use of near infrared technology; understanding the causes for resin canal discoloration in mango fruit (a condition where ruptures occur in the vascular tissue of the fruit rendering it unsalable); and learning about the ecology and mitigating the effects of Magpie Geese on Darwin regional mango orchards. Adopting technologies and learnings from these areas would have long reaching benefits for individual businesses and the wider NT and Australian mango industry beyond the life of this project.

Evaluation findings

The evaluation conducted at the end of the project in 2015 found that farmers and service providers saw the small-group learning process as enjoyable and useful. There were three main reasons given:

- The process is informative ($n=8$), allowing for growers to hear what other growers are doing as well as identifying common problems.
- There is an open and friendly environment that allows for growers to give their opinion/input, as well as ask questions of each other and service providers.
- It facilitates networking with growers and service providers, particularly as the small-group meetings are the only time that most of the interviewed growers get together.

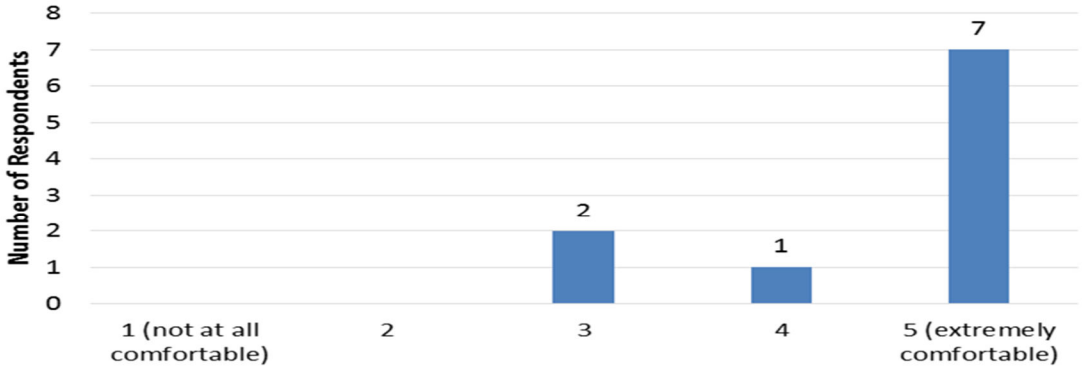
The following statement was typical of reactions gleaned from growers involved in the small-group process:

> [If] there was an activity that we didn't like or wasn't useful, we would just drop it… We were in control of the topics. It was our fault if we didn't steer the activities and learning towards areas we wanted. (Grower respondent).

Comments indicated that more useful activities tended to focus on the practical, such as on-farm demonstrations, or meeting to discuss specific issues or topics of interests for growers at the time.

Respondents were asked to consider the extent to which they felt comfortable participating and sharing information in small groups. As shown in Figure 1., seven out of the ten respondents felt extremely comfortable participating in the small group setting. This reinforces earlier comments regarding the open and friendly environment of the small-group process which gives space for growers to contribute.

Figure 1. Extent to which growers feel comfortable in participating and sharing information in a small-group environment

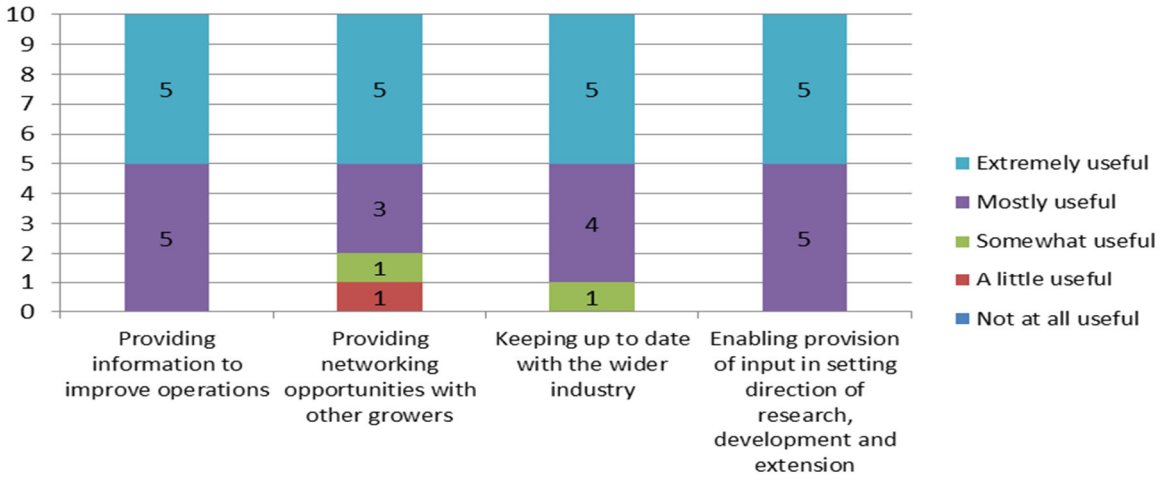


Respondents were asked to consider overall if program activities and information have been useful to them in four areas:

- Providing information to improve operations.
- Providing networking opportunities with other growers.
- Keeping up to date with the wider industry.
- Enabling provision of input in setting direction of research, development and extension.

Figure 2 reflects the participants' opinions on the usefulness of the process.

Figure 2. Usefulness of small-group activities in different areas



In all four areas listed, respondents felt that the small-group activities were either extremely useful or mostly useful. There were no respondents who found the activities of no use.

Two grower respondents also provided comments which are quite telling of their positive perspective of the project and their desire to see the process continue:

> I would like to see it continue. If it was to end, I don't think there would be a whole heap that would change. In the longer term you are getting the growers and government talking together which is very valuable to sharing/accessing information (Grower respondent).
>
> Small groups are very relevant and I would like to see it continue. Having the Department involved was fantastic; small grower meeting could be combined with industry meeting; these meetings are the glue between the farmers and the areas we need to work on (Grower respondent).

The longer-term issues were difficult to assess in the 2015 evaluation. However, the progress and outcomes on the longer issues identified in Table 1 are discussed further in the next section.

Discussion

Process issues

Participating growers found the small-group approach informative, open and friendly – thereby providing a safe learning environment for participants. The small-groups enabled growers to give their opinion and ask questions of each other and service providers/presenters. Most growers felt comfortable sharing information in the small-group environment. Growers felt empowered over their ability to control the content, which in turn meant they felt a degree of ownership over the process. Service providers tended to find that specific research activities and workshops were more useful from their perspective than the general grower dialogue or information sharing. Overall, growers felt that the small-group approach was appropriate for most growers. The small-group process started fostering a community among mango growers which seems appreciated and desired by respondents.

The growers agreed that they gained new knowledge and their general attitude was that there are always things to learn. The fact that growers felt empowered by having an input into shaping future research and government priorities was also noted. The small-groups became the engine room for ideas and a way to resolve a range of knowledge gaps and problems confronting the local industry.

Growers wanted to see the process continue and particularly, appreciated the ability for industry, government and growers to meet under the same roof.

Engaging various sub-groups from non-English speaking backgrounds was cited as priority to address in future work. Specifically, this relates to the Vietnamese and Cambodian growers in the Darwin region.

It was suggested that the process should continue to be supported by the industry's research and development corporation – Hort Innovation, and potentially expanded so to increase the function and reach of the extension effort across the industry.

Short-term gains

There were short-term gains derived from activities identified by growers. The indication of the level of change amongst participants can be gleaned from Figure 2. Many of the activities to address short-term objectives were typical farm-centric extension exercises that involved programmed learning, workshops and farm walks but also included an applied research project looking into the efficacy of foliar calcium on fruit quality (Moore & Hunt 2013). This last activity was particularly instructive as it determined that investment in such treatments with the intention of reducing lenticel damage could not be recommended from the results. However, there was some indication that the treatments might have some benefit against under-skin browning. Anecdotal reports have since indicated that this has been a savings advantage to some producers in the group, however, the message has not resonated more widely since the cessation of the project.

Contribution to long-term industry innovation

The research projects that had their genesis in the small-groups have delivered a range of findings that are already having many spillover benefits to industry beyond the Northern Territory.

Floral induction. The research into understanding mango flowering investigated the climatic conditions associated with flowering in mango in the Northern Territory and evaluated chemical treatments that could be used to promote this process. It showed that flowering is associated with the occurrence of anticyclonic winds from high pressure cells moving across central and Southern Australia in the dry season (winter). These deliver low night temperatures leading to flower induction. For the first time, both the lower and upper temperature limits for flower induction have been described for various varieties (McConchie 2015).

This work has furthered the industry's understanding of the role of climate and growth regulators on mango flowering and subsequent fruit production in the NT's key production regions. These findings can be used to improve mango best management practices, while maintaining sustainable and profitable production systems in northern Australia. It precisely described the temperature requirements for flowering of mango cultivars in the NT. This is the first time that temperature thresholds for flowering of mango have been defined globally. This work has revealed the critical importance of cool night-time temperatures and associated weather systems. It has demonstrated that differences exist between cultivars in both low temperature requirements and high temperature limitations for floral induction. The methods used to quantify these temperature requirements have the capacity to screen cultivars for their genetic capacity for climate change

adaptation while also quantifying the ability of chemical treatments to modify these responses (McConchie 2017a; McConchie 2017b; McConchie 2017c).

Near Infrared (NIR) spectrometry for refining harvest maturity. This research initiated by NT DPIR began to investigate avenues for adapting and applying NIR in the industry. In addition to the push from growers, there was also pressure from stakeholders in the retail sector on industry to persuade the industry peak body - the Australian Mango Industry Association (AMIA), to achieve better harvest maturity outcomes as consumer feedback on poor fruit quality caused by immaturity was affecting sales. In response to these concerns the AMIA set new industry standards for harvest maturity raising the benchmark harvest dry matter from 14% to 15% dry matter and ripe brix to 14 °Bx (Brix is the sugar content of an aqueous solution).

The NT DPIR led the adoption of the Felix NIR quality meter in 2016 to measure dry matter and brix levels. There were significant introductory problems with the supplied proprietary software, though researchers overcame this. The devices were fully functional for the rest of the 2016-17 Australian mango season and delivered improved retail outcomes. In the subsequent seasons the NT DPIR took a leading role NT through working with Central Queensland University (CQU), to develop ongoing calibrations.

This technology also enabled the post-harvest performance of the National Mango Breeding Program cultivars to be carried out using the now accepted minimum maturity standard of 15% dry matter used across the Australian industry. While helping to precisely identify the likely annual harvest time for these cultivars it also showed the duration over which these cultivars could be harvested without ripening on the tree (also known as hang-time). This proved to be much greater than the most widely grown cultivar Kensington Pride. This attribute has numerous economic advantages associated with harvesting logistics.

Resin canal discoloration (RCD). The NT DPIR undertook various means to identify the source of the problem. Initially the department conducted a survey to understand current farm and pack house practice that could potentially impact on RCD. In addition, the department provided support to monitor post-harvest performance of fruit collected on farm and along the supply chain. This involved forwarding samples to Queensland for assessment as well as assessing locally ripened fruit. The original assumption was that RCD was similar to another condition under-skin browning in mango – sometimes observed in the cultivar Honey Gold. However, there was no evidence to demonstrate links to this condition.

High levels of RCD were found in samples retained and ripened in Darwin and similarly samples shipped to Queensland also developed extensive RCD, but there was a poor relationship between the two assessment locations. Inoculation of fruit on trees that had a history of RCD were also inconclusive in that uninfected controls developed symptoms while manually infected fruit only developed marginally more symptoms. It was concluded that RCD were sensitised either genetically or due to environmental conditions that could then be triggered, resulting in the development of symptoms due to physical injury, stress or infection. This provided no clear method to control RCD (Macnish et al. 2015a; Macnish et al. 2015b)

However, further NT research revealed that RCD was based on infection by a bacterium that could occur from harvest but lay dormant under cool chain conditions until after ripening. No overt physical damage was required and that the fruit only need to come in contact with the inoculum via for a short time to become infected (e.g. via contaminated fruit wash in the harvest process). It also showed that some cultivars were more resistant to infection and would not develop symptoms while other susceptible cultivars would only develop mild symptoms when grown at different sites. Sanitisers proved unable to disinfect fruit once they were infected. If the fruit were not infected or in other words did not come in contact with inoculum, they did not develop symptoms (M. Umar & and C. McConchie 2019, pers. comm., 11 June). This provided the mango industry clear direction to develop improved packing and handling options for controlling this formerly mysterious problem.

Mitigating the effects of Magpie Geese on Darwin regional mango orchards. This research investigated the movement behaviour, patterns of habitat use, and nutritional ecology of the Magpie Goose (*Anseranas semipalmata*) to develop sustainable management strategies that would fit with the new learnings of the ecology and population dynamics of this native protected species.

Magpie Goose individuals were captured on multiple mango orchards throughout the Greater Darwin Region and fitted with GPS tracking devices. This provided high-resolution movement information which allowed different movement metrics to be calculated (e.g. distances, speed, rates of movement) and to define behavioural patterns that determine how mango orchards are integrated in the Magpie Goose daily and seasonal movement patterns. Magpie Goose carcasses

were also collected from recreational hunters on or near mango orchards to evaluate the contribution of mangoes to the seasonal and longer-term diet of Magpie Geese across the Greater Darwin Region. An additional component of this project was an evaluation of the effectiveness of different bird deterrents to provide growers with more practical advice for addressing the conflict with Magpie Geese on farms. The different mitigation techniques assessed were: 1) ground disturbances (i.e., active chase from quad bike), 2) auditory disturbances (long-range acoustic device), 3) flying devices (i.e., drones), and 4) chemical deterrents. The knowledge gained from these two research components was combined to formulate recommendations for the development of management strategies for Magpie Geese on mango orchards.

The results showed that geese visiting mango orchards have wide ranging movements and migration patterns throughout their annual cycle. Beside these far ranging movements, including when birds visit mango orchards, birds utilised a small home range within which they displayed short, regular movements daily, usually moving between several locations; namely roosting, feeding and watering sites. The data showed that the birds are coming to the Darwin agricultural area from all over northern Australia. Therefore, there is no 'quick fix', to the issue. The geese are highly mobile moving between orchards and other areas far outside the Darwin agricultural area. Geese present on an orchard one week are unlikely to be the same birds on the orchard a few weeks later. Therefore, shooting the birds is not an effective long-term deterrent. Whilst it does immediately reduce the number of birds on the orchard, new birds will arrive constantly throughout the season. We believe it will be possible to reduce the birds on mango orchards, because the birds are not fixed to the one location (Corriveau et al. 2017a; Corriveau et al. 2017b; Corriveau et al. 2018; Corriveau et al. 2019).

From the research a set of more informed and effective integrated pest management (IPM) principles were able to be developed to mitigate against the effects of the species. These are now being extended to growers. The learnings also have application to other crops and farming regions in northern Australia. This work has also provided new knowledge for government managers of the species. The research and ongoing feedback from NT mango growers have also identified important knowledge gaps to be considered for future work.

Conclusion

This project has shown that practice of engaging and working with farmers and service sector people in small groups can yield both short-term and longer-term innovation benefits to both individuals and a wider industry. The success of the project can be attributed to it being firstly welcoming and safe for people to participate, and secondly that it was responsive to their concerns, both through better accessing established knowledge, as well as persevering and seeking out means by which more complex issues could be pursued and understood through dedicated research.

Whilst these findings are not revolutionary in the expansive field of agricultural innovation; what is instructive is that a deliberate and planned process with even a small-group of stakeholders, can yield considerable gains in the advancement of an overall industry innovation system. This was a very modest initiative and yet it served as an engine room for research innovation that has had spill over effects well beyond those involved in the groups.

The disappointment is that no stakeholder agency – either industry or public sector, has taken up the small-groups approach and continued to apply it. This paper has been directed at creating a tangible record of the nature, actions and results that a coordinated innovation approach can deliver, so that it might not be lost, and could be again implemented. Important next steps for any future efforts will be to ensure that these new learnings be further embedded throughout the regional and wider Australian mango industry.

The key messages from this exercise is that those agents involved in the research, extension, and policy fields of primary industries cannot escape the value of actively engaging with producers at their level. Also, producer commitment to this process will only be retained where there is ongoing relevance to their needs or concerns. This project was able to deliver those outcomes.

Even though this program has ceased, the longer-term program initiatives are now only beginning to be more fully realised as the science projects that emerged from the farmer dialogues yield results. The farmers involved in the small-groups project remember it fondly, recognising its value, and question as to why this type of engagement with industry is no longer supported.

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