

The use of participatory approaches in the development and extension of fall armyworm management practices for the Australian vegetable industry

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Abstract. *Spodoptera frugiperda* (fall armyworm) was first detected in Northern Australia in February 2020 and its establishment caused economic losses to sweet corn and maize. We used Participatory Action Research (PAR) methods to co-develop and deliver the best management options (BMOs) for the sweet corn industry and valuable information for other crops. Various extension methods combined with three FAW BMOs demonstrations in sweet corn were delivered. A total of 402 vegetable industry participants and service providers engaged in the project. Over 60% rated the field day as a useful resource for engaging, sharing, learning, and accessing BMOs. Surveys showed that the PAR improved the participant's knowledge of pest biology and natural enemies, skills in FAW diagnostics, and changed pest management practices. It indicates regular crop monitoring and choosing appropriate insecticides with targeted applications to eggs and larvae can improve FAW control and minimise insecticide resistance development.

Keywords: fall armyworm, participatory action research, co-development, extension, best management options, eHub

Introduction

Spodoptera frugiperda (J.E Smith) (Lepidoptera: Noctuidae), commonly known as fall armyworm (FAW), is a highly polyphagous noctuid moth native to the tropical regions of the Americas that was officially reported in Western Africa in early 2016 (Goergen et al. 2016). Since 2016, this highly invasive species has become a global pest, expanding into Asia, the Pacific and Australia (Kearns et al. 2020).

FAW was first detected in Queensland's Bowen, Burdekin and Mareeba agricultural production regions in March 2020 (Subramaniam 2022). Subsequent detections were reported in the Northern Territory (Darwin and Katherine), Western Australia (Broome and Kununurra), Southeast Queensland (Bundaberg and Lockyer Valley), Northern NSW, Victoria (Gippsland) and Tasmania (Wynyard). Within a short period of detecting FAW, significant crop damage (up to 50%) was recorded in organic and conventional sweet corn crops (Subramaniam 2022). The rapid rise in FAW numbers has greatly increased the use of insecticides on these crops, disrupting the Integrated and Pest Management (IPM) practices currently being used by the horticultural industry in the Bowen and Burdekin regions (Subramaniam 2023).

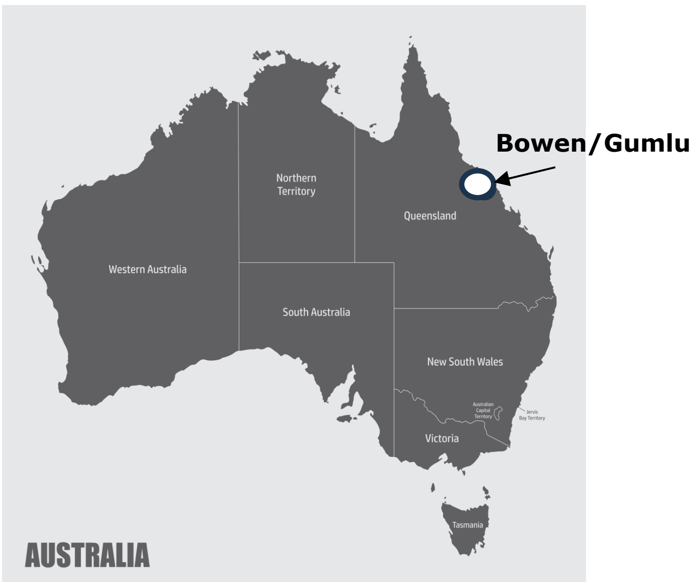
In Australia, growers largely rely on insecticides to control FAW because non-chemical management options are limited. However, extensive chemical use can harm non-target organisms and natural enemies of FAW and beneficial insects released through biological control programs (Desneux et al. 2007). Globally, heavy reliance on chemical control strategies for FAW has led to resistance to at least 29 insecticidal active ingredients in six modes of action groups (Gutierrez-Moreno et al. 2019). Scientists have confirmed that FAW populations in Australia (NT, NSW, QLD and WA) have gene alleles associated with insecticide groups of organophosphate and carbamate resistance (Nguyen et al. 2021). Judicious use of selective chemical options with non-chemical control measures within an IPM framework is the most effective strategy for minimising the risk of resistance and managing FAW sustainably (Bateman et al. 2018).

In response to FAW, several research projects were funded through governments and industry to understand and address this new threat to Australian horticulture and grain crops. Hort Innovation Australia funded the project MT19014, where Agriculture Victoria researchers validated FAW Loop-Mediated Amplification Technology (LAMP) for in-field detection of the FAW in Australia (Blacket 2022). Similarly, Hort Innovation funded the MT19015 project, where the Queensland Department of Agriculture and Fisheries (QDAF) collaborated with the Western Australia Department of Primary Industries and Regional Development (DPIRD), and the Northern Territory Department of Industry, Tourism and Trade (DITT) and discovered 18 endemic parasitoid species that attack egg and larval stages of FAW (Subramaniam 2022). Duong et al. (2021) reported that the Australian FAW populations are genetically resistance to organophosphate and carbamate group insecticides. Similarly, a baseline screening of the Australian FAW populations (2020-2021) identified a moderate level of resistance to carbamate and organophosphate insecticides and a high level of resistance to synthetic pyrethroids (Bird et al. 2022). Economic modelling was also used to assess the financial impact of FAW in Northern Australia and the potential benefit of IPM to horticultural crops. Losses in horticultural crops across Northern Australia in the first year of the FAW incursion (2020) were estimated to be $AUS409 million or 23 per cent of total losses over the previous 30 years. However, losses were dramatically reduced to an estimated $AUS59 million once the industry adjusted its conventional and integrated pest management practices with effective chemistries and biologicals (Subramaniam 2022).

To strengthen linkages between FAW research projects and to optimise resources and research outcomes for the horticulture industry, Hort Innovation Australia funded the project "VG20003 Co-developing and extending integrated *Spodoptera frugiperda* (fall armyworm) management systems for the Australian vegetable industry". The one-year extension project aimed to facilitate co-development of effective integrated FAW management strategies using a 'Participatory Action Research' approach (PAR), and to communicate these strategies to the Australian vegetable industry. The PAR involved collaborative research (Kindon et al. 2007), where the stakeholders (growers, vegetable researchers, consultants involved in the vegetable production system, extension officers, and service providers) were empowered to work together to investigate and develop solutions to shared issues and challenges. PAR enables participants to build capacities and establish ownership and autonomy of the resulting innovations (Barbon et al. 2021). A key reason for using this approach was to bring expert knowledge from growers and agronomists together with scientific knowledge to improve FAW management through active participation in planning, implementation, observation, and reflection stages (FaHCSIA 2008).

This paper describes the 'Participatory Action Research' approach to facilitate the co-development of knowledge and practice for FAW management in the Bowen-Gumlu region or the North Queensland Dry Tropics, Australia (Figure 1). Furthermore, it delineates the shifts in knowledge, attitudes, skills, aspirations (Bennet 1975), and practices (KASAP) among growers in the region regarding FAW management while extending the scope of FAW management on a broader, area-wide scale. Identifying changes will allow the current project to review processes and methodology to "fill the gaps" and improve the project's focus.

Figure 1. Bowen-Gumlu region in the North Queensland, Australia

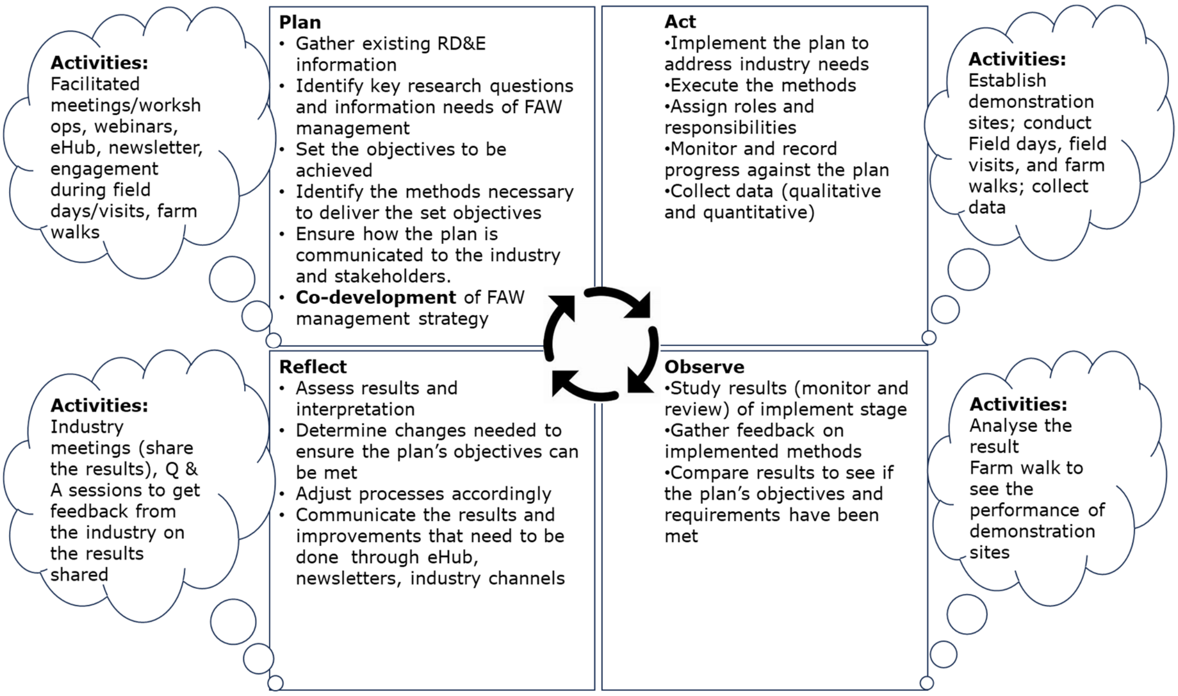


Methodology

Participatory action research approach

The participatory action research (PAR) approach was used in the VG 20003 project to co-develop knowledge and practices applicable to FAW and other pest management in sweet corn. This is a collaborative approach (Kindon et al. 2007) where stakeholders, including growers, researchers, farm agronomists, extension officers, private companies, and consultants, work together in the planning, implementation, observation, and reflection stages to develop knowledge, strategies and tools for FAW management. The project used the four-step PAR framework of Plan, Act, Observe and Reflect (Figure 2) in objective setting, activity planning and delivery, and evaluation and reflection to build knowledge and skills in FAW management. The supporting prompts were used to encourage participation and engagement of PAR group members during the project period. Additionally, knowledge, attitude, skills, aspirations, and practice changes (KASAP) on FAW management were documented in the PAR process (Table 1).

Figure 2. A framework to support Participatory Action Research with steps and the activities for each stages



Adapted and modified from FaHCSIA (2008, p. 7)

Table 1. Supporting prompts to engage participants (PAR group members) and document KASAP changes on FAW management

Step 1. Plan	What are we trying to do, learn or achieve in FAW management? What is the FAW situation and pressure? How does it differ from previous years? What are our current industry practices for managing FAW? What do we not know? (Insecticide resistance, FAW host crops, where are FAW breeding during off-season?) What are the likely changes in knowledge, attitudes, skills, aspirations, and practice (KASAP) due to the activity?
Step 2. Act	What control measures were used? What are our current practices for managing FAW (biological, cultural, chemical, crop monitoring)? How do we study insecticide resistance and FAW sample collection (larvae size, insecticide spray history? How and when do we proceed with the demonstration site establishment (commercial farm or research station)?
Step 3. Observe	What were the results? What was the effect of insecticide treated seeds and other foliar treatments?
Step 4. Reflect	What does the data say (interpretation)? What is its application to the growers and other stakeholders? What did we learn? What will we do differently? What is the impact on growers and stakeholders (KASAP)? What do you want to see in the next meeting?

Step 1. Plan

Formation of Participatory Action Research Group

A regionally based PAR group was formed in the Bowen-Gumlu, located in the North Queensland Dry Tropics, Australia's largest winter vegetable growing region, with an annual value of $650 million. Key commodities produced in the region include sweet corn, tomato, capsicum, melons, mangoes, cucurbits, eggplant and green beans (D Shorten 2023, pers. Comm., 20 September 2023). The PAR group members in the Bowen-Gumlu region consisted of 17 members, including growers, agronomists, consultants, VegNET RDOs (National Vegetable Extension Network, Regional development officers), researchers, extension officers, and service providers (seed and chemical companies and spray operators). The PAR members were selected based on their knowledge, skills, involvement and interests in FAW and other pests in vegetable crops. Also, they considered their local experiences and interactions with the vegetable production system and their willingness to allocate their time for PAR activities. The project team finalised the PAR members in consultation with the local industry.

Engagement with the PAR group and stakeholders nationally

The PAR group members and stakeholders were involved in multiple facilitated meetings, communications and field visits to understand the fall armyworm situation in the region, share the latest research updates, identify the industry needs and co-develop the FAW management strategy for establishing demonstration sites. The half-day facilitated meetings were structured around the following sessions:

1. Growers and industry updates on the FAW situation, FAW pressure and potential management practices.
2. Updates of field and laboratory experiments from researchers and agronomists.
3. Facilitated sessions on FAW knowledge and experiences followed by a 'questions and answer' session.
4. Identifying knowledge gaps and information needs to guide the project's next steps.
5. Evaluation survey to document feedback from the participants.

Co-development of demonstration sites and a field day

In facilitated meetings, field visits, farm walks, and one-on-meeting with PAR group members, outcomes of the previous year FAW trials and industry experiences were analysed and potential best management options (BMOs) for FAW were discussed with focus on sweet corn crops. In designing the options, the group considered best-performing chemistries and their impact on beneficial insects, crop phenology stages, fall armyworm and other pest pressures, spray application methods and varieties with industry standards. The two best management options were based on the approved products and currently available resources for the industry. The third-best management option had a promising new chemistry for sweet corn and improved sweet corn varieties.

The co-developed BMOs included conventional chemistries, similar to the industry practices, but a study to see their impact on beneficial insects differed from the industry practice. Likewise, the demonstration blocks were monitored weekly and sprayed using an air-assisted boom with a spray volume of 300 to 500 L/ ha, which is different from industry practice. Further, the release of larval parasitoids (*Cotesia* sp.) in a demonstration block was first practised in the region. Interestingly, *Cotesia* sp. was commonly detected in the FAW samples collected from sweet corn fields in the Bowen Research Facility. PAR group members were prompted by the extension officer with questions to encourage participation and engagement (Table 1, Step 1. Plan). This step helped identify the knowledge gaps and key research questions.

Step 2. Act

Establishment of demonstration site and conduct a field day

Three sweet corn blocks, each 0.072 ha with 16 rows of 60 m length, were sown on 10 Aug 2022 at Bowen Research Facility DAF. The purpose was to demonstrate the three BMOs against FAW during the moderate to high FAW pressure period in the Bowen production region. The two BMOs were based on the approved and readily available products for sweet corn crops. The third BMO had a new promising chemistry and improved sweetcorn varieties. These options were identified from the facilitated meetings in Step 1.

The demonstration blocks were monitored on a weekly basis from sowing to harvest. BMO treatments were initiated based on the weekly monitoring results. Insecticide sprays were applied using a tractor-mounted, air-assisted boom with a 300 to 500 L/ ha spray volume. The commercially available egg parasitoid, *Trichogramma pretiosum* for *Heliothis* and ladybird beetles (*Harmonia octomaculata*) for aphids were released using a drone attached with a calibrated delivery device. Larval parasitoids (*Cotesia* sp.) were released to observe their impact on fall armyworm. The data and information collected from this demonstration site were summarised and distributed to participants at a field day organised on the demonstration sites on 19 October 2022. Twenty-two agronomists, researchers, and representatives from sweetcorn, chemical companies, and seed companies participated.

Another two blocks of sweet corn at tasselling and early silking stage were selected to demonstrate aerial spray applications with three different spray volumes. A drone sprayer applicator to deliver three different volumes of 30, 40, and 50 L /ha using non-toxic dye was used for the demonstration. Other activities included displays and field demonstration of endemic parasitoids, predators and pathogens that attack FAW in Australia. Specific prompts for growers and other stakeholders were asked to encourage participation and notes were taken during the discussion (Table 1, Step 2. Act).

Step 3. Observe

Observation of demonstration sites and field day

FAW infestation and damage levels and other pest and diseases were monitored from seedling emergence to harvest in all three demonstration blocks. At weekly intervals, 96 plants per block (16 rows x 60 m) were searched in a stratified random fashion for FAW egg masses and larval presence per plant (6 plants/row, one plant randomly from each 10 m interval of row). Plant damage scores were also recorded according to the Davis Scale (Davis & Williams 1992) and by project staff.

Growers and agronomists were also invited to visualise the performance of seed treatments on sweet corn crops at the 3-4 leaf to late vegetative stages. Often, FAW treatments were initiated when more than 5% of plants had healthy FAW eggs or larval stages. The control treatments were varied to each BMOs and based on FAW infestation levels recorded (Davis and Williams 1992) during the weekly monitoring. Spray application details such as delivery rate and pressure, type of nozzles, and wind speed and direction were recorded.

For the field day, forty cobs from each BMO demonstration block (each 0.072 ha with 16 rows of 60 m length) were randomly collected, stripped of their husk and displayed on benches next to the crop. This exhibited the proportion of cobs with FAW damage at the tip and along the side of each cob. Furthermore, a 10 m deep clearing was forged into the crop to display cobs while still attached to the plants. This allowed field day participants (PAR group members), to access the crop and view the FAW damage pattern, infestation levels and marketable quality of cobs in each BMO blocks. Specific prompts for the field day participants were asked to encourage participation in the observation step (Table 1, Step 3. observe). Feedback from the participants was collected using a questionnaire with the following questions:

- How did you find the field day on fall armyworm management on sweet corn? (Not useful, useful, very useful)
- What aspects of this field day were the most useful or valuable to you? (FAW management options, knowledge and understanding of beneficials, on-ground delivery of the technologies, engagement with researchers and extension officers, extension and communication resources, UAV spray, and other)
- Do you intend to change your management practices/business from what you have seen/heard today? (Yes, No) If yes, please tell us what you intend to do differently.
- Would you like this type of demonstration site and/or field day event for next year?? (Yes/No)
- Any other feedback and comments/suggestions to improve?

Step 4. Reflection

The PAR group members (N=17) were invited to the facilitated meetings, after the crop season, to share the results and get their feedback and comments for the establishment of future demonstration sites. The half-day facilitated meetings were structured as described in Step 1.

Specific prompts for growers and other stakeholders were asked to encourage participation in the reflection step (Table 1, Step 4. Reflect).

Documentation of knowledge, attitude, skills, aspiration and practice changes

The KASAP documentation was initially, derived from the pre-defined questions asked to the PAR group members (Table 1) during 2021-2022, mainly at PAR's planning and reflection stages, as a baseline. The KASAP documentation was conducted during the facilitated meetings, field days, field visits and one-on-one communication throughout the project period (2021-2022). These data were then the baseline and end of the project KASAP information were compared to capture the changes in KASAP on FAW management.

Communication of FAW research, development and extension nationally

The FAW engagement hub (FAW eHub), released in August 2022, was managed to provide regular updates on FAW research, development and extension (RD&E), project activities and share learnings to the vegetable industry development managers, growers, and agronomists, and provide a forum for feedback and discussion, nationally. The web analytics data were used to monitor its effectiveness using the data under page views, unique visitors, aware and informed visitors. Unique visitors excluded project administration visits and was the number of visitors who viewed the page. Aware was the number of unique visitors who had viewed the project page, whereas informed was any unique visitor who had viewed the latest news item, a document, a video, or a FAQ.

Results

Engagement of PAR group

A total of 402 vegetable industry agronomists, growers, researchers, and representatives from chemical and seed companies nationally were engaged in facilitating the knowledge and co-development of the interim FAW management strategy. The participants were engaged through PAR group facilitated meetings, field visits by industry participants representing different Australian States and through the newsletters. The facilitated meetings were useful in identifying the research and information needs on three broad topics: biological control, insecticide resistance and sustainable integrated FAW management and monitoring. The highest-rated needs of the industry were:

- Whether adjuvants are adding to the efficacy of insecticides or not for FAW management.
- The best time to spray (crop stage, time of the day, insect stage).
- The method to control FAW in the whorl.
- Where are FAW coming from in the production system?
- How and where does FAW survive during the off-season to initiate infestation in the immediate season?
- Fast-track commercialisation of beneficial insects (predators and parasitoids) and biologicals (fungi, viruses) if they are effective in managing FAW.
- Toxicity of insecticides on beneficial insects and biologicals.
- Communicate FAW RD&E information to the industry.

New knowledge and research needs identified from the meetings were communicated nationally to the researchers and other vegetable industries using the project's communication channels (FAW newsletter and engagement hub).

Facilitated discussions were critical, allowing PAR group members, extension officers and researchers to understand the industry practices and share the research updates on FAW management. A similar report was suggested by Sewell et al. (2017), where it is mentioned that researchers' and extension officers' engagement with the growers and industry provides an opportunity to engage with science, and interactions help span the world of science and farm decision-making.

Co-design of FAW management options

Co-development of three BMOs

Participants in the field day viewed the differences in spray droplet distribution and penetration patterns with three spray volumes, engaged with displays of natural enemies of fall armyworm and discussed fall armyworm management issues facing the industry. Over 60% of the field day participants responded that it was a useful forum for engaging, sharing, learning, and accessing BMOs. Similarly, the respondents intended to change their practice regarding UAV use during the wet season (if permitted), using beneficial insects and increasing the monitoring frequencies considering the crop stages (Figure 3). Demonstration sites and field days helped translate research into application by allowing participants to observe innovations and making it simpler for researchers and extension officers to communicate the innovation, as reported by Singh (2018) and Boleman & Dromgoole (2007).

Changes in KASAP

The project used the initial KASAP information from the PAR group members as the baseline and the end-of-project KASAP as the basis for reporting on the changes in KASAP.

Participants reported improved knowledge in:

- understanding of FAW biology and seasonal activities relating to local temperature and cropping conditions
- understanding the efficacy of chemistries and resistance to FAW populations in their locations
- understanding the endemic parasitoids, predators and pathogens attacking FAW eggs and larval stages
- understanding various aspects of sprayer settings, including nozzle selections, droplet sizes and spray volumes
- understanding the effective spray adjuvants for improving FAW control

- understanding of insecticide resistance
- understanding insecticide seed treatments to protect the early vegetative stages of sweet corn.

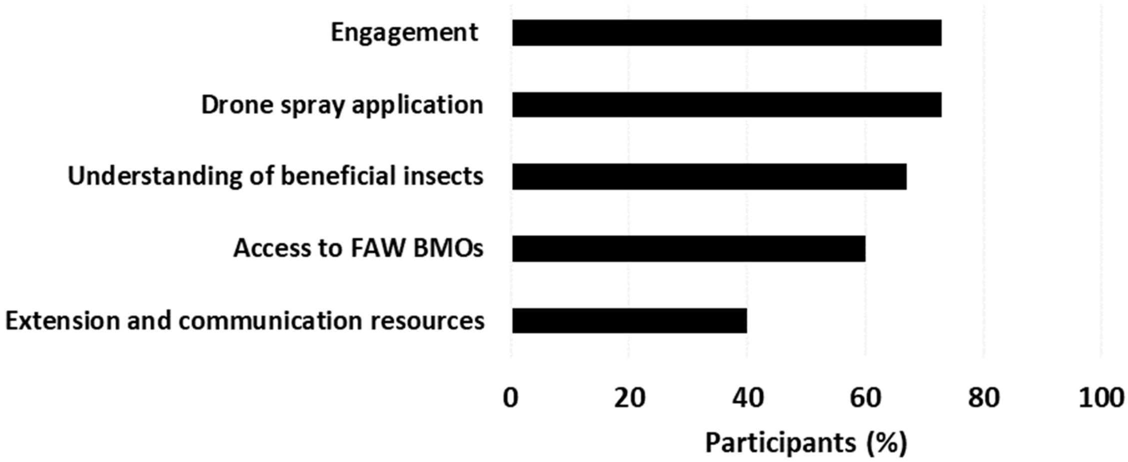


Figure 3. Top five responses given by participants as useful aspects of the field day

Participants reported improved skills in:

- identifying FAW eggs and larvae in the field condition
- managing FAW in the commercial farm
- identifying the endemic parasitoids and predators
- monitoring FAW in the crop.

Participants reported increased aspirations to:

- adopt the outcomes for FAW resistance management
- incorporate beneficial insects and biopesticides within the existing management practices.

Participants reported the following practice changes:

- minimising the use of ineffective chemistries such as synthetic pyrethroids, organophosphate and carbamates. Local research has indicated that fall armyworm has developed high-level resistance to these chemistries.
- choosing more effective insecticides for targeting FAW life stages. Choosing the right insecticide products and using them at the right time to target eggs or larvae.

Sweet corn growers also showed interest in FAW IPM to minimise the risk of insecticide resistance and adopt the research findings to achieve sustainable and integrated FAW management. These results indicate that participants improved their knowledge and skills in managing FAW. The results suggest that the growers have increased their confidence to grow sweet corn in the region.

Communication of FAW RD&E nationally

The FAW eHub has 5,367 page views and 1,721 unique visitors to the portal. Likewise, 1,334 and 443 stakeholders became aware (a number of unique visitors who have viewed the project page, minus any visitors who have undertaken any activity such as downloaded a document, viewed a video, completed a survey) and were informed (any unique visitor who has viewed the latest news item, viewed a document, viewed a video, viewed a FAQ, minus any user that has engaged such as done a poll, survey, ideas wall, interactive mapping, interactive document, forum), respectively (Figure 4).

Discussion

The introduction of *Spodoptera frugiperda*, commonly known as the fall armyworm (FAW), to Australia, has presented significant challenges for the horticultural sector. This necessitates the facilitation of co-development of knowledge and practices for FAW management while delineating the shifts in knowledge, attitudes, skills, aspirations (Bennet 1975), and practices (KASAP) among growers in the Bowen-Gumlu region or the North Queensland Dry Tropics Australia.

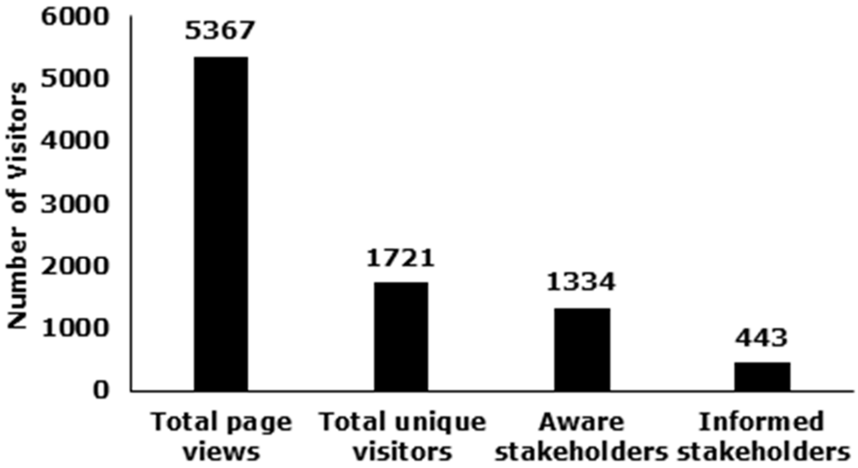


Figure 4. Stakeholders' engagement in FAW eHub.

Engagement and co-development

The PAR approach facilitated extensive stakeholder engagement, bringing together growers, agronomists, researchers, extension officers, and industry representatives to co-develop FAW management strategies. This collaborative effort led to the identification of research and information needs, particularly regarding biological control, insecticide resistance, and sustainable IPM practices. The facilitated meetings were crucial in bridging the gap between research and practical application, enabling a dynamic exchange of knowledge and experiences. Previous studies have demonstrated the effectiveness of stakeholder collaboration in pest management. Sewell et al. (2017) reported that engagement between researchers and growers fosters a deeper understanding of scientific practices, enhances farm-level decision-making, and assists in generating pest management technologies with and for growers (Norton et al. 1999). Similarly, Barbon et al. (2021) emphasised that participatory approaches empower stakeholders to take ownership of pest management strategies, leading to more sustainable outcomes. Additionally, the demonstration sites provided a medium for the growers and agronomists to visit the sites and interact with the researchers about the performance of the co-developed FAW management options. Diverse engagement activities and attendees enhance understanding of current knowledge and create an environment appropriate for integrating new knowledge (Nguyen et al. 2014). This project has also broadened its concern beyond the horticulture industry and initiated a discussion on the Area-Wide Management of FAW.

Co-development of best management options

The co-development of three BMOs showcased the practical application of research findings in managing FAW. The demonstration sites and a field day allowed participants to observe the efficacy of different insecticide applications and the role of natural enemies in FAW control. This hands-on experience was highly valued by participants, indicating an intention to change their management practices based on the field day insights.

The effectiveness of demonstration sites in translating research into practice is well-documented. Singh (2018) and Boleman & Dromgoole (2007) highlighted that field demonstrations provide tangible evidence of the benefits of new practices, making it easier for growers to adopt innovative pest management strategies. The use of UAVs for spray applications and the integration of beneficial insects were particularly noted as promising areas for future implementation.

Changes in knowledge, attitude, skills, aspiration, and practice

The project documented participants' responses to improved knowledge, attitudes, skills, aspirations, and practices regarding sustainable and integrated FAW management. Growers reported an improved understanding of FAW biology, insecticide resistance, and the role of natural enemies. This enhanced knowledge translated into better FAW identification skills, increased use of effective insecticides, and a stronger commitment to IPM practices. Similarly, the participatory research and extension approach to managing Diamondback Moth (mid-1980's) and Helicoverpa (the mid-1990s) successfully led to the adoption of Integrated Pest Management (IPM) practices and the roles of growers, consultants, researchers, and extension officers in improving communication and boosting confidence in IPM approaches were highly valued (Christiansen and Dalton 2002; Deuter 2024). The shift towards more sustainable pest management practices is crucial in mitigating the risks associated with heavy insecticide use, such as resistance development and harm to non-target organisms (Desneux et al. 2007; Gutierrez-Moreno et al. 2019). Reports on the decrease in the use of ineffective chemistries like synthetic pyrethroids and organophosphates align with global findings on FAW resistance (Duong et al. 2021; Bird et al. 2022).

National communication and impact

The FAW eHub role was vital in disseminating research findings and facilitating national communication among stakeholders. Effective communication channels are essential for the widespread adoption of agriculture technologies (Campenhout et al. 2020). The engagement metrics, with over 5,367 page views and 1,721 unique visitors, indicate a broad reach and substantial interest in FAW management. The eHub effectively served as a platform for sharing updates, providing resources, and fostering discussions, thereby supporting a national approach to FAW management. According to Sobalaje and Adigun (2013), the accessibility of a communication channel is very important in determining its use, and the FAW eHub's success underscores the need for continued investment in digital platforms to support pest management efforts.

Conclusion

The PAR approach demonstrated in this project has proven effective in co-developing and implementing integrated FAW management strategies. The project identified research needs through extensive stakeholder engagement, developed best management options, and facilitated improvements in knowledge, attitudes, skills, aspirations and practices among growers and agronomists.

The project's success in fostering sustainable FAW management practices underscores the value of collaborative research and extension efforts. By bridging the gap between research and practical application, the PAR approach has empowered stakeholders to take ownership of the management strategies, leading to more resilient and sustainable agricultural systems. Moving forward, continued engagement and integration of new knowledge will be essential in adapting to the evolving challenges faced by FAW and other pests.

This project has laid a strong foundation for ongoing collaborative efforts to manage FAW sustainably. The documented changes in KASAP among growers indicate a positive trajectory towards integrated pest management, reducing reliance on chemical controls and enhancing the resilience of the horticultural sector. Future initiatives should build on this momentum, leveraging the established networks and knowledge to address emerging pest management challenges and promote sustainable agricultural practices.

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