Understanding motivational factors for improved spray application on farms

Final Report to CRDC

February 2020

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EXECUTIVE SUMMARY

Spray drift, the off-target movement of herbicides and pesticides, negatively impacts agricultural production across Australia. The problem is particularly acute in mixed cropping regions where a diverse range of chemicals may be applied at any given time. Although industry organisations have developed and implemented an impressive set of technologies, education programs and workshops aimed at improving spray solutions across multiple agriculture sectors, the problem persists.

This project used theory and methods from the behavioural sciences to:

1) Identify the main drivers and barriers to engagement in best-practice spray application at three time points: Before spraying, during spraying and after spraying.
2) Identify the number and nature of grower segments based on their current practices before, during, and after spraying.
3) Identify the main leverage points to initiate and sustain behaviour changes to reduce spray drift.
4) Recommend targeted engagement strategies for segments that are not engaged in best-practice spraying.

Using interviews of key industry stakeholders, and an online grower survey we identified seven behaviours that, if adopted, would produce the greatest reduction in spray drift:

1) Before spraying:
    a. Using online mapping tools to register crop locations
    b. Checking online sources for sensitive areas
    c. Discussing spray plans with neighbours.
2) During spraying:
    a. Driving at recommended speed
    b. Spraying when conditions (Delta-T, low risk of surface inversion, wind speed) were suitable.
3) After spraying:
    a. Decontaminating spray equipment appropriately
    b. Keeping accurate records.

Audience segmentation analyses identified 3 grower segments for the before-spraying behaviours (*Disengaged, Partially engaged* and *Engaged*), 3 grower segments for the during-spray behaviours (*Disengaged, Partially engaged* and *Mostly engaged*) and 2 grower segments for the after-spraying behaviours (*Disengaged* and *Engaged*). Discriminant analysis identified the primary barriers (classified as capabilities, opportunities and motivations) for each of the behavioural segments that were not engaged in best-practice spray behaviours:

1) Before spraying (Not registering or checking online mapping tools):
    a. Not being aware of the mapping tools (capability)
    b. Not having the time to check the online sources (opportunity)
    c. Not knowing anyone else who used the mapping tool (motivation).

2) Before spraying (Not discussing spray plans with neighbours):
    a. Bad relationships between neighbours (capability and motivation)
    b. Growers saw no need to discuss plans (motivation).
3) During spraying (Not driving at recommended speed):
    a. Not enough time when conditions are suitable (opportunity)
    b. Not aware of the link between speed and spray drift (capability)
    c. Need to complete job (motivation)
    d. Field conditions (opportunity)
    e. Perception of reduced efficiency at slower speeds (motivation).
4) During spraying (Not spraying when conditions were suitable):
    a. No flexibility with the contractors /staff resulting in spraying when somebody was available to do so regardless of conditions (opportunity)
    b. Beliefs that their crop production took precedence, getting the job completed was the priority and spray drift was not an important issue (motivation)
    c. Perception that everyone cuts corners and sprays in less than ideal conditions so it was acceptable for them to do so as well (motivation)
    d. Knowledge about when conditions were suitable to spray (capability)
    e. Perception that no-one would know anyway if they did spray in less than ideal conditions (motivation).
5) After spraying (decontaminating spray equipment):
    a. Awareness of the need to decontaminate (capability)
    b. Having the time to perform decontamination (opportunity)
    c. Having a suitable location to decontaminate (opportunity)
    d. Perceiving decontamination as important (motivation).
6) After spraying (keeping accurate records):
    a. Awareness of the need to keep records (capability)
    b. Forgetfulness (capability)
    c. Perception that no-one was going to check anyway (motivation)
    d. Not knowing anyone else who kept records (motivation).

Based on these results, we recommended which behaviour change techniques would be most suitable to remove and circumvent these barriers to achieve maximum on-ground impact. Further research is needed to implement and evaluate behaviour change interventions based on the results from the current research. This implementation and evaluation lies outside of the scope of the present project.

INTRODUCTION

Background

Off-target movement of herbicides and pesticides negatively impacts agricultural production across Australia. The problem is particularly acute in mixed cropping regions where a diverse range of chemicals may be applied at any given time. Cotton crops are susceptible to spray drift from auxin-based herbicides commonly used for fallow weed control over the summer period (particularly with the active ingredient 2,4-D). The CRDC, along with a network of other industry organisations including GRDC and Nufarm (SprayWise) have developed and implemented an impressive set of technologies and recommended best practices. Education programs and workshops aimed at improving spray solutions across multiple agriculture sectors have been delivered for many years. But the problem persists.

Behaviour change

Changing human behaviour, and sustaining these changes over time, is a difficult process. Educating people about the negative impacts of spray drift and providing detailed instructions is rarely enough to initiate and sustain practice change (Hine, McLeod, & Driver, 2019). Social research has shown that these proposed solutions will fail unless people are sufficiently motivated and empowered to change behaviours and adopt new approaches.

Acceptance and implementation of best-practice spray application ranges across a continuum. At one end there are “adopters”, those who always implement best practice spray application and have reduced the negative impact of these chemicals on neighbouring enterprises. At the other end are “non-adopters” who, for a range of reasons, fail to implement best practice, often causing significant negative impacts on and beyond their own properties. The elimination of the negative impacts of spray drift is a complex process that requires on-going participation by a diverse set of people who often possess a range of values, enterprise-interests, and skill sets.

Social psychology and behavioural economics have generated an array of intervention strategies and behaviour change techniques designed to increase audience understanding, engagement and ultimately, adoption of desired behaviours. To assist practitioners, a number of frameworks have been created, offering a methodical approach to develop effective interventions. Hine, McLeod and Driver (2019) have noted that although these frameworks may differ in structure and terminology may vary, most are guided by four main principles (Hine, McLeod & Driver, 2019):

Principle 1: Focus on human behaviour

Step 1: Define the goals in behavioural terms

Before we can begin to understand the factors influencing best practice spray application we first need to systematically unpack the spray drift problem to determine its nature, and what exactly needs to be changed to fix it. In particular, four questions need to be considered:

1) What is the nature of the problem in ecological, economic, social and health terms?
2) Which human behaviours are making the problem worse?
3) Which human behaviours can help resolve the behaviour?
4) Who are the individuals whose behaviour needs to change?

Step 2: Specify the target behaviour(s) needed to achieve the goals

The next step is to define 'best-practice' spray application in precise behavioural terms, and generate a list of these behaviours that can bring a reduction in the spray drift problem. When constructing this list it is important to consider who needs to do what, when, where, how often and with whom (Michie, Atkins, & West, 2014).

Step 3: Select the target behaviour(s)

In complex problems such as the spray drift issue, there are usually many behaviours that have an impact on the problem. Behaviour change interventions often fail if they try and change the wrong behaviours or too many behaviours at once (McKenzie-Mohr, 2011). To assist in selecting the most appropriate behaviours to target, we employed McKenzie-Mohr's (2011) Behaviour Prioritisation Matrix (BPM). The BPM ranks potential target behaviours from most impactful to least impactful based on the effectiveness of the behaviour in reducing negative impacts, the likelihood of adoption of the behaviour by the target population, and the proportion of the target population currently not engaged in the behaviour. To maximise impact, behaviour change interventions should target effective behaviours that have a high probability of being adopted and that are not already being performed by the target audience.

Principle 2: Know your audience

Step 4: Driver and barrier (COM-B) analysis

Having selected the target behaviour(s), the next step is to understand what factors lead individuals to engage in the behaviour (drivers) or prevent them from engaging (barriers), i.e. what are the factors that distinguish between adopters and non-adopters, and to identify what needs to change in order to achieve best-practice spray application. A useful behavioural model to help understand these drivers and barriers is the Capability Opportunity Motivation-Behaviour (COM-B) model (Michie et al., 2014). According to this model behaviour factors determining behaviour can be classified into three groups:

1) Capability - Do individuals have the relevant knowledge, skills, and physical capacity to engage in the target behaviour? Do they know the best management strategies?
2) Opportunity - Are situational conditions present to support the behaviour? Are relevant laws and other support structures in place to support action? Are appropriate technologies readily available?
3) Motivation - Are individuals sufficiently motivated to take action? Are they aware there is a problem in their region? Do they possess the right combination of values, attitudes, and beliefs to inspire action?

Step 5: Audience segmentation analysis

Audience segmentation involves dividing a target population into subgroupings called segments, usually based on some combination of demographics, values or behaviours. The fundamental idea underlying audience segmentation is that the targets of behaviour change interventions are generally not homogenous. Different groups of people will have different driver/barrier (COM-B) profiles. Thus, to maximise impact, interventions can be designed to best match the characteristics of specific segments, a process known as targeting. Messages can also be crafted for specific individuals, as opposed to larger segments. This is referred to as message tailoring, and is becoming increasing common with advances in Internet marketing. The primary goal of tailoring and targeting is to increase the persuasive and behavioural impact of interventions by matching intervention content to audience needs.

Step 6: Identifying main leverage points

Once you have gained an understanding of what needs to change and the audience segments present in the target population, you are ready to identify the main leverage points, in particular three strategic decisions:

1) Who should be targeted? To maximise on-the-ground impact it may be better initially to target a large group of disengaged but receptive audience members, rather than focusing on a smaller group who are not interested, and who would require more time and money to engage.
2) How to best optimise interventions for each audience using their unique COM-B profiles?
3) How to ensure the audiences engage with the intervention? Different audience segments may have their own unique preferences for where they obtain information or who they trust to deliver that information. Not all audiences will perceive certain sources or communicators as credible and trustworthy.

Principle 3: Match intervention to primary cause of behaviour

Step 7: Develop intervention plan

Having identified the main leverage points for initiating and sustaining behaviour change, the next phase is to develop the behaviour change intervention plan to increase the adoption of best practice within each selected target audience group(s). A broad range of behaviour change tools can be applied to facilitate the adoption of best-practice spray application. But, not all tools are equally well suited for all situations. Ensuring that the selected tools match the primary causes of behaviour you are attempting to change will increase efficiency and impact. For example, where the barriers are associated with an individual's Capability, tools that educate, train or enable them to participate are most appropriate, whereas if the barriers are associated with external Opportunities to engage, tools that enable, restrict or restructure the physical or social environment are more appropriate. Where barriers are associated with an individual's Motivation to engage, tools that persuade, educate, model the targeted behaviour, offer incentive or coerce should be used.

Step 8: Assess feasibility and practicality of new intervention plans

Once an intervention plan has been developed it is important to assess its practical feasibility. A first step may be to use the APEASE criteria developed by Michie and her colleagues, which looks at the affordability, practicality, cost effectiveness, acceptability, fairness and potential side effects of the intended intervention. Preliminary testing with audience focus groups or small pilot studies may be another way to ensure that engagement materials are optimally matched for each segment.

Principle 4: Evaluate, review and reflect

Step 9: Evaluation

Evaluation is an important component in any intervention design. The design of an effective evaluation plan should consider, where feasible, randomised field experiments to assess the effectiveness of the interventions. This ensures that any changes in adoption rates can be causally attributed to the intervention, and not to uncontrolled factors. Qualitative interviews can be conducted with a subset of landholders and other stakeholders to determine more precisely what aspects of the intervention were effective and ineffective.

Step 10: Review and reflect

Changing people's behaviour, along with creating new solutions to complex problems such as spray drift, can be challenging. It is important to take a systematic, long-term approach, constantly reviewing and reflecting to identify what worked in what contexts, what did not, and how the process/methodology could be improved in the future. This commitment to continuous learning and improvement is necessary to maximise the effectiveness of human behavioural research.

Project objectives

This project was designed to demonstrate how to accelerate sustainable participation in best practice ground-rig spray application techniques using behavioural science and targeted engagement. More specifically the aims were to:

5) Identify the main drivers and barriers to engagement in ground-rig best practice spray application (Steps 1, 2, 3 and 4 described above),
6) Identify the different audience segments across the sector (Step 5),
7) Identify the main leverage points to initiate and sustain behaviour change (Step 6),
8) Recommend engagement approaches for the different audience segments that are not currently taking action (step 7).

The project's methodology is based on a systematic, integrated framework for developing behaviour change interventions, built around the four guiding principles described above. The project will increase the CRDC's understanding of the drivers of and barriers to best-practice spray application behaviours across mixed cropping landscapes. This understanding will increase the capacity of the cotton and other cropping industries and their funding bodies to develop targeted strategies for increasing participation in best practice spray application. Further research will be required to implement and evaluate possible behaviour change interventions that may be developed from the knowledge gained from this research.

DEFINE BEHAVIOURAL GOALS & SPECIFY BEHAVIOURS (Steps 1 & 2)

Methods

Industry stakeholder interviews

To assist in defining the problem in behavioural terms and identifying all the best-practice spray application behaviours (steps 1 and 2), we interviewed 30 stakeholders, sampled from across the cotton, grain and horticulture industries, and including consultants, educators, spray contractors, as well as representatives from farmer groups, research and government organisations. The interviews followed a semi-structured format (Appendix 1), and were conducted either by phone or face-to-face. Semi-structured interviews were used for two reasons. First, this methodology is well suited explore the perceptions and opinions of respondents regarding complex and sometimes sensitive issues, and enables probing for more information and clarification of answers. Second, the professional, educational and personal histories of the sample group were diverse, which precluded the use of a standardised interview schedule. All interviews, which lasted between 30 to 60 minutes, were recorded (by consent) and later transcribed and summarised for further analysis in NVIVO. This involved coding the responses to identify common themes and patterns to gain an understanding of the spray drift issue and identify relevant goals and behaviours as well as factors that impede or drive best-practice spray application behaviour.

Results

Step 1: Define the goals in behavioural terms

The results from the analysis of the stakeholder interviews for behavioural goals required to solve the problem of spray drift are shown in Table 1. Three distinct behavioural goals were identified: 1) improvement in the planning of spray application, 2) increased adoption of best-practice spray application techniques, and 3) improved record keeping in-line with current regulations and industry best-practice.

Table 1: The behavioural goals required to solve the spray drift problem as identified by the 30 interviewed stakeholders, along with location and who is involved.

What behavioural goals?	Where does it occur?	Who is involved?
1. Improve the planning and decision making around timing and location of ground-rig spray application in line with industry-approved good practice	Rural Australia	Property managers / growers
2. Increase the adoption of industry-approved good practices for the application of sprays	Rural Australia	Chemical spray applicators[1]
3. Increase the adoption of industry-approved good practice for recording of spray application on crops	Rural Australia	Property managers / growers / chemical spray applicators

[1] May include growers, farm staff or contractors

Step 2: Specify the target behaviour(s) needed to achieve the goals

Stakeholder surveys were used to populate a list of 19 candidate target behaviours covering the three identified behavioural goals. These 19 behaviours can be grouped into three general categories:

1) behaviours performed BEFORE a spray event
2) behaviours performed DURING a spray event
3) behaviours performed AFTER a spray event.

These behaviours are listed in Tables 2a, b and c, along with a description of who needs to do what, where, how often and with whom.

Table 2a: Target behaviours performed **before** a spray event to reduce the incidence of spray drift.

What	Goal[1]	Who	Where	How often	With Whom
Develop a Pesticide and Application Management Plan	1	Growers / managers	On their property	Once, but re-evaluate as required	Alone / with adviser or consultant
Register location of sensitive crops (e.g. CottonMap, Satacrop)	1	Growers of these crops	Online	Once	Alone / with adviser or consultant
Ensure spray applicators are accredited	1	Growers / managers	On property	Every time they spray	Alone / with spray applicator
Ensure spray applicators are trained in correct use of equipment	1	Growers / managers	On property	Every time they spray	Alone / with spray applicator
Check online for location of sensitive crops (e.g. CottonMap, Satacrop)	1	Growers / managers	On website	Every time they spray	Alone / with adviser or consultant
Check for location of sensitive areas (e.g. waterways, beehives)	1	Growers / managers	On website	Every time they spray	Alone / with adviser or consultant
Check with neighbours for location of sensitive crops	1	Growers / managers	Website / local info	Every time they spray	Alone / with neighbours

[1]Behavioural goals specified in Table 1

Table 2b: Target behaviours performed **during** a spray event to reduce the incidence of spray drift.

What	Goal[1]	Who	Where	How often	With Whom
Ensure equipment is compliant with chosen chemical as specified by label	1,2	Growers / managers / spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Read the chemical label	1,2	Growers / managers / spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Mix chemicals per the label instructions	2	Spray applicators	On property	Every time they spray	Alone / with grower
Ensure water is suitable as a carrier for chosen chemical	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Use nozzle that produces coarsest spray quality	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Adjust boom height to lowest recommended level	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Drive at recommended slow speed	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Ensure wind conditions are suitable as specified by good practice guidelines	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Ensure Delta-T conditions are suitable as specified by good practice guidelines	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser
Ensure temperature conditions are suitable as specified by good practice guidelines	2	Spray applicators	On property	Every time they spray	Alone / with grower / with adviser

[1]Behavioural goals specified in Table 1

Table 2c: Target behaviours performed **after** a spraying event to reduce the incidence of spray drift.

What	Goal[1]	Who	Where	How often	With Whom
Decontaminate equipment - specified by good practice guidelines	2	Spray applicators	On property	Every time they spray	Alone / with grower
Keep comprehensive spray records as required by legislation	3	Growers / Spray applicators	On property	Every time they spray	Alone / with grower / with adviser

[1]Behavioural goals specified in Table 1

Key Takeaways:

1) *Three distinct behavioural goals were identified to reduce the incidence of spray drift*
2) *19 candidate target behaviours were identified to achieve these goals*
3) *Target behaviours can be divided into those performed before a spray event, those performed during a spray event, and those behaviours performed after a spray event.*

SELECT TARGET BEHAVIOURS (Step 3)

Methods

Industry stakeholder online behaviour impact survey

We asked the 30 industry stakeholders (interviewed for Steps 1 and 2) to rate (using a 10-point scale) the effectiveness of each of the identified behaviours in reducing spray drift. This was completed using a short online survey (Appendix 2). Sixteen of the stakeholders responded to this request.

Industry advisory group and consultation

An industry advisory group was established to provide guidance and technical assistance to the project. Members of this group were Rachel Holloway (People Program Manager - CRDC), Susan Maas (R&D Manager - CRDC) and Vicki Green (Crop Protection Manager - GRDC).

Given the project would ultimately involve surveying all growers across the landscape, not just those growing cotton, it was decided after consultation with advisory group, that the Pesticide and Application Management development behaviour should be refined to address a broader planning discussion between the grower and their adviser / agronomist (including four sub-categories: discussion of appropriate chemicals to use, application equipment, weather constraints and consideration of nearby sensitive areas).

Grower spray application online survey

An online survey of 180 growers / land managers (90% male, average age 47 years) who were undertaking spraying activities, or who employed staff or contractors to undertake spray activities on their properties, was conducted. The survey consisted of questions to collect respondent's self-reported participation and the likelihood of future participation in the final 19 agreed spray-drift-reducing behaviours (broken into three categories - those behaviours performed before spraying, during spraying, and after spraying). Sociodemographic information including age, gender, location, type of crops grown, and total crop area sprayed was also collected from all respondents (Appendix 3).

The respondents were sourced through both CRDC and GRDC member contact lists. They came from eight regions throughout Queensland and New South Wales: Central Qld (n=23), Darling Downs (N=36), South West Qld (N=11), Border / Gwydir (N=35), Namoi (N=15), Macquarie / Lachlan (N=20), Murrumbidgee (N=31), and Murray (N=9). Eighty-six (48%) grew cotton on their properties, with other common crops including wheat (n=159), chickpeas (N=118) and sorghum (N=87). One hundred and three of the respondents (57%) indicated they mainly did their own spraying with a ground-rig, 56 employed staff to conduct spraying with ground-rig, 18 employed a contractor to spray with a ground-rig, and 3 employed a contractor to spray by air. The average crop area grown per respondent was 5944 ha, with the average area sprayed per year 21826 ha (crop area x number of passes).

Results

Spray behaviour impact

Sixteen of the invited industry stakeholders rated the effectiveness of each of the identified behaviours on a 10 point scale (1= not at all effective in reducing incidence of spray drift, 10= extremely effective). Results are shown in Table 3.

Table 3: The effectiveness for each behaviour in reducing the incidence of spray drift as rated by industry stakeholders (Scale: 1=not at all effective, 10=extremely effective).

Behaviour	Mean	Standard deviation	Range
Develop a Pesticide and Application Management plan	7.38	2.45	2 - 10
Growers register their sensitive crops on appropriate websites	6.94	2.02	3 - 10
Check appropriate websites for sensitive crops or other sensitive areas	7.63	1.93	4 - 10
Ensure that any person applying spray on their property is fully trained and accredited	8.50	1.51	5 - 10
Ensure that any equipment used for spraying is compliant with the chemical label requirements	9.13	1.20	7 - 10
Spray applicators mix the chemicals as per label specifications	7.56	1.93	4 - 10
Ensure that the conditions (wind speed, humidity, inversion risk) are suitable for spraying	9.81	0.40	9 - 10
Ensure that the available water source is suitable as a carrier for the chosen chemical	7.06	2.43	2 - 10
Use a spray nozzle that produces coarsest spray quality possible	9.00	1.21	6 - 10
Ensure boom height is at the lowest level possible	8.94	1.18	6 - 10
Ensure suitable application rates (i.e. volume, drive speed and pressure)	8.81	1.38	5 - 10
Decontaminate their equipment after spraying following good practice guidelines	7.75	1.88	3 - 10
Keep comprehensive spray records of each spray event	7.75	2.18	2 - 10
Report any spray drift impacts to the appropriate agency	7.06	2.54	2 - 9

Key Takeaways:

The behaviours rated as the most effective in reducing the incidence of spray drift were:

1) *Ensuring weather conditions were suitable*
2) *Using compliant equipment*
3) *Using the coarsest nozzle size possible.*

Current adoption of spray behaviours

Data on current rates of adoption of the spray-drift-reduction behaviours were collected in the grower online survey. Results are summarised in Figure 1. As the online mapping tool SataCrop had only been released just prior to this survey (2019 / 2020 growing season), only data on the use of CottonMap was considered.

For more detail, growers were asked how often they sprayed at certain times of the day (associated with risk of surface inversions), different Delta-T and wind speed conditions, as well as how fast they drove when spraying. Results are summarised in Figure 2. Growers were also asked about the details they recorded for each spray event. Results are summarised in Figure 3.

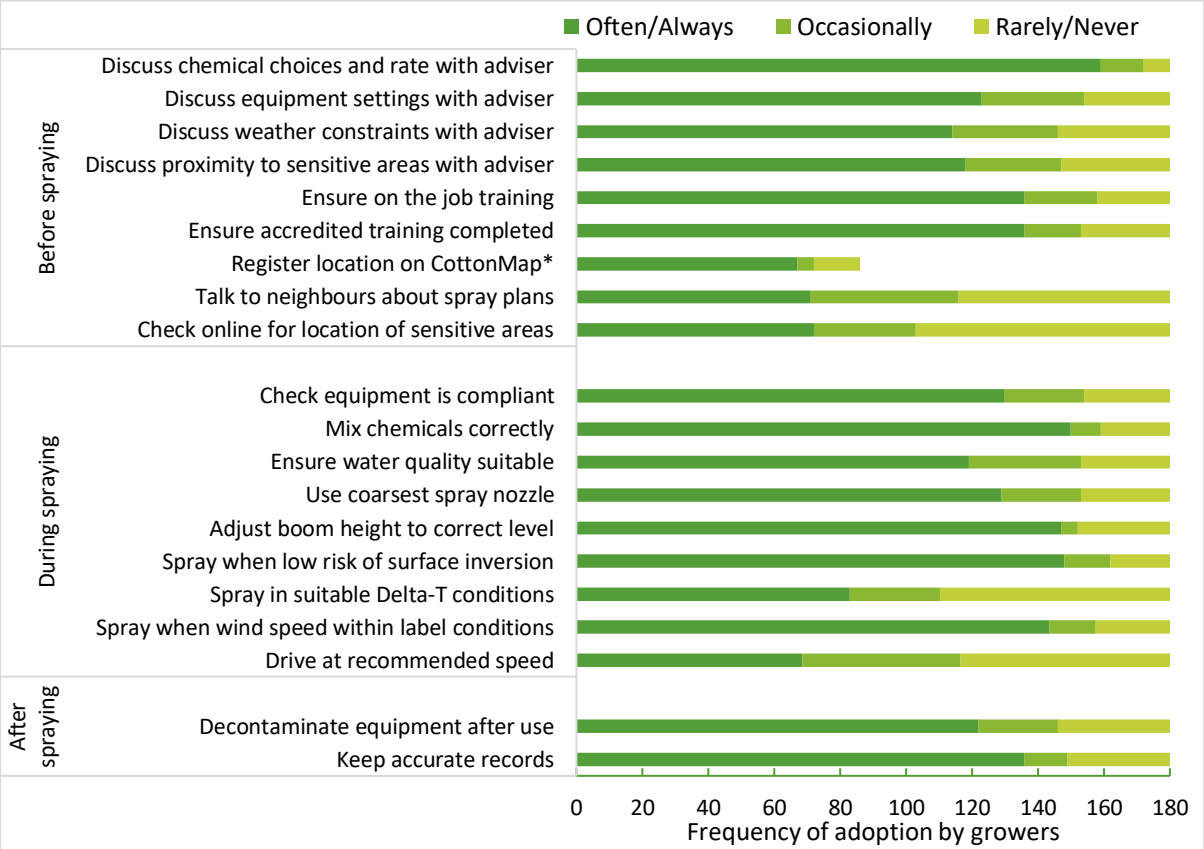

Figure 1: Current adoption of recommended spray-drift-reduction behaviours by surveyed growers (N = 180) (*Only responses from cotton growers (N=86) included for this response).

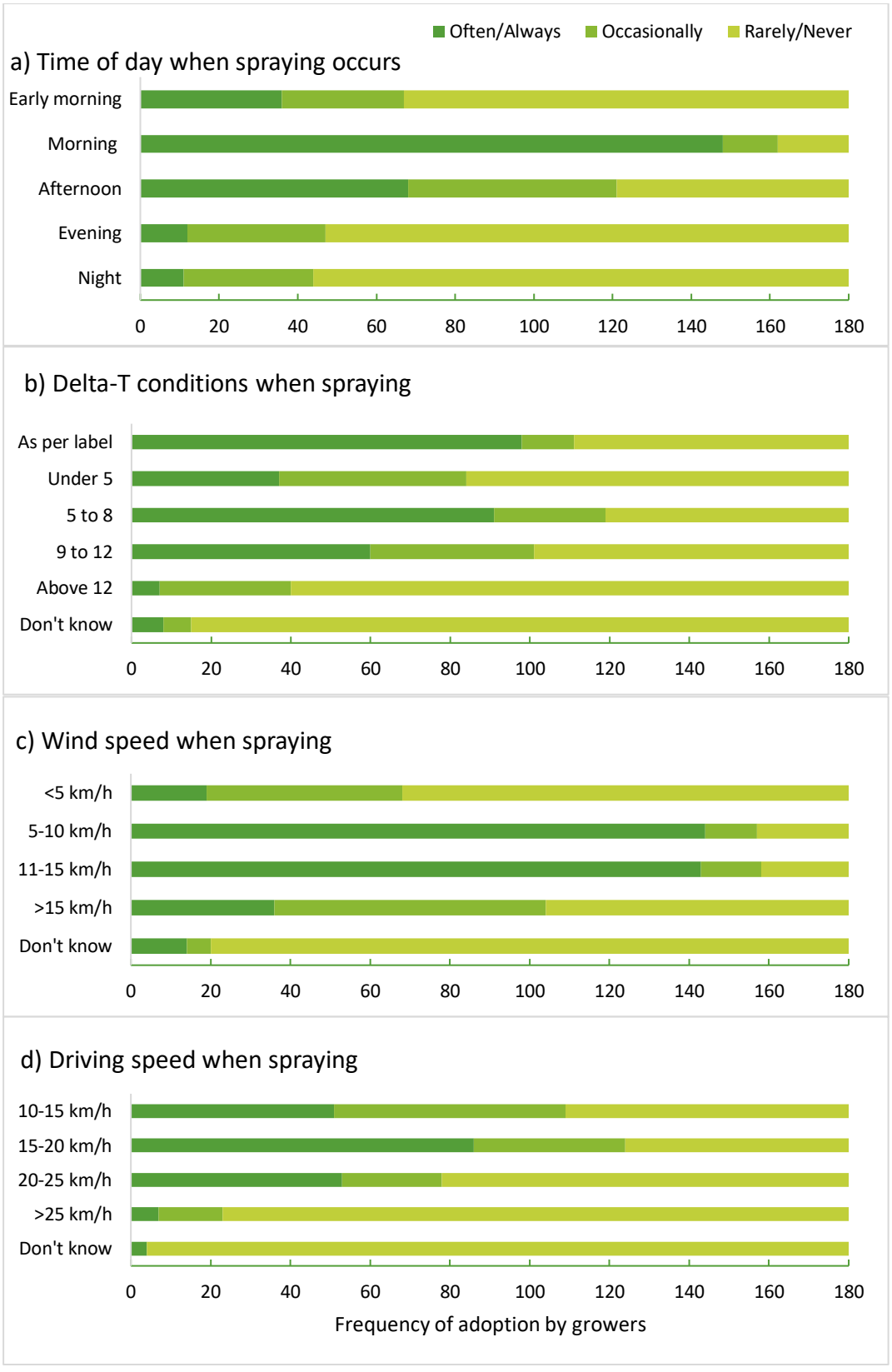

Figure 2: Frequency of growers spraying at: a) certain times of the day, b) different Delta-T conditions, c) different wind speed, and d) different driving speeds. (N = 180).

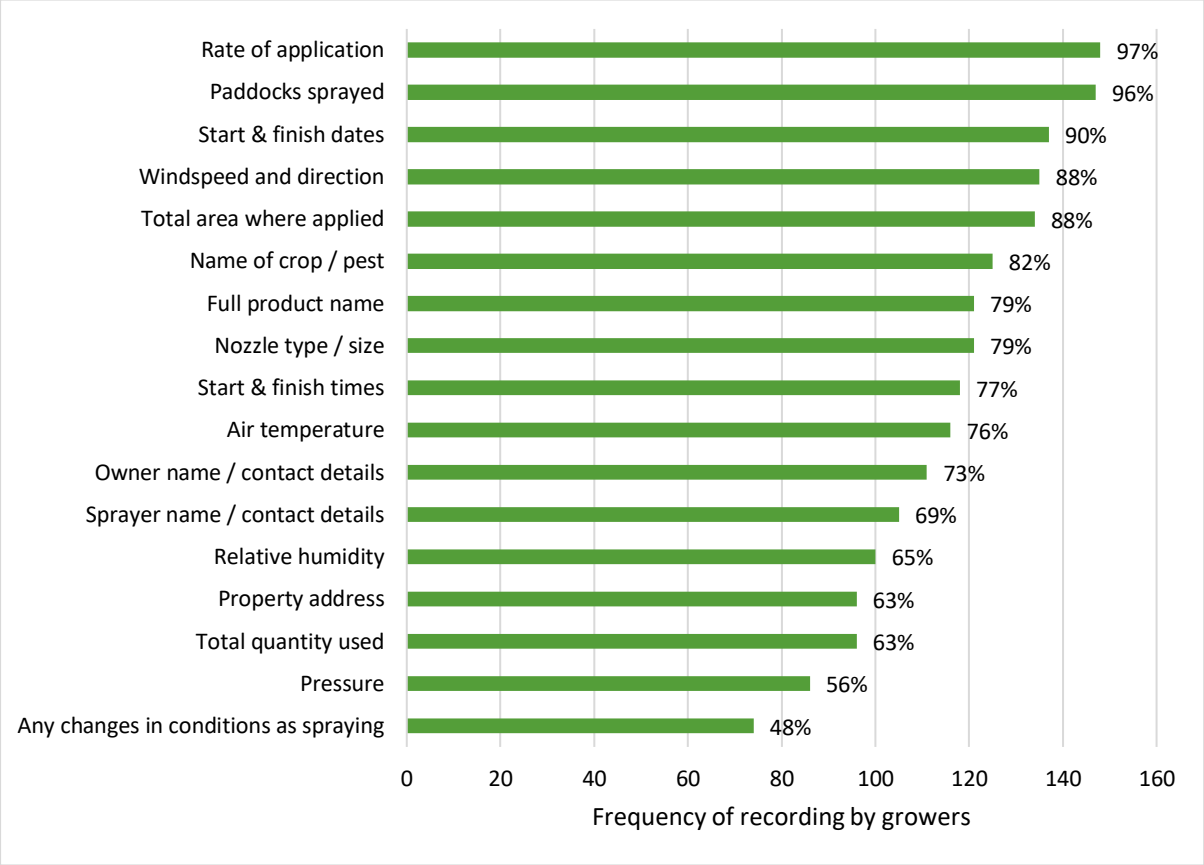

Figure 3: Frequency of recording key spray details by growers (N = 153).

Key Takeaways:

*Behaviours with the lowest current adoption rate **before spraying** were:*

1) *Discussing spray plans with neighbours*
2) *Checking online sources for locations of sensitive areas.*

*Behaviours with the lowest current adoption rate **during spraying** were:*

1) *Driving at recommended speed (around a third of growers drove faster than 20km/h)*
2) *Spraying when suitable Delta-T conditions (8% sprayed when Delta-T was either > 12 or unknown).*

*The behaviour with the lowest current adoption rate **after spraying** was keeping accurate records. There were differences in what was being recorded (97% of growers recorded rate of application, but only 48% recorded changes in conditions when spraying).*

Likelihood of adopting recommended spray behaviours

In addition to current practices, growers were asked to rate the likelihood they would adopt the spray-drift-reduction behaviours in their next crop season. Results are summarised in Figure 4.

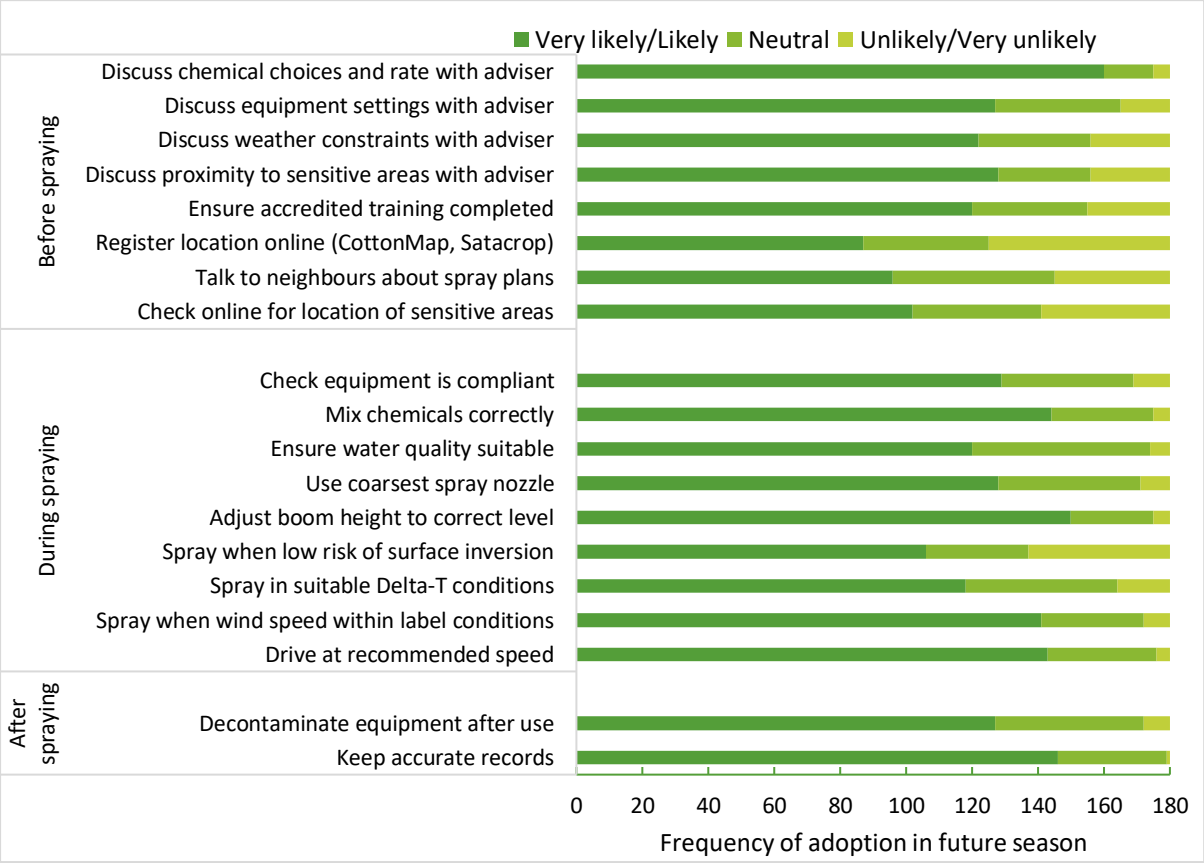

Figure 4: Likelihood of adopting recommended spray-drift-reduction behaviours during next crop season (N = 180).

Key Takeaways:

Behaviours with the highest and lowest likelihood of future adoption were:

1) ***Before spraying**: Highest - discuss chemical choices with their adviser, Lowest - use online mapping tools to register crop locations*

2) ***During spraying**: Highest - adjust boom height to correct level, Lowest - spray when low risk of surface inversion*

3) ***After spraying:** Highest - keep accurate records, Lowest - decontaminate spray equipment appropriately.*

Behaviour prioritisation

The behaviour impact data collected from the industry stakeholders, along with the likelihood of behaviour adoption and current adoption data collected from the growers were used to construct a Behaviour Prioritisation Matrix. The results are shown in Table 4.

Table 4: Behaviour prioritisation matrix ranking spray behaviours from most to least impactful (based on McKenzie-Mohr, 2011).

Behaviour	Current adoption (1-5)	Likelihood of adoption (1-5)	Effectiveness (1-10)	Weighted impact[1]	Group rank
Before spraying					
Register location online at CottonMap or Satacrop	2.02[2]	3.45	6.94	59.4	**1**
Check online for location of sensitive areas	3.06	3.57	7.63	52.9	**2**
Talk to neighbours about spray plans	3.05	3.42	7.63	50.9	**3**
Discuss weather constraints with adviser	3.74	3.89	7.38	36.2	**4**
Discuss equipment settings with adviser	3.82	3.94	7.38	34.2	**5**
Discuss proximity to sensitive areas with adviser	3.85	3.95	7.38	33.5	**6**
Ensure accredited training completed	4.04	3.86	8.50	31.6	**7**
Ensure on the job training	4.11	3.70	8.50	28.1	**8**
Discuss chemical choices and rate with adviser	4.44	4.48	7.38	18.5	**9**
During spraying					
Drive at recommended speed	2.97	4.16	8.81	74.3	**1**
Spray in suitable Delta-T conditions	3.03	3.78	9.81	73.1	**2**
Spray when low risk of surface inversion	2.97	3.60	9.81	71.7	**3**
Spray when wind speed within label conditions	3.74	4.07	9.81	50.3	**4**
Check equipment is compliant	3.99	4.02	9.13	37.2	**5**
Use coarsest spray nozzle	3.97	3.98	9.00	36.8	**6**
Adjust boom height to correct level	4.14	4.23	8.94	32.5	**7**
Ensure water quality suitable	3.89	4.02	7.06	31.6	**8**
Mix chemicals correctly	4.24	4.25	7.56	24.4	**9**
After spraying					
Decontaminate equipment after use	3.73	4.01	7.75	39.5	**1**
Keep accurate records	4.08	4.34	7.75	31.0	**2**

[1] Weighted impact = (5-current practice) x likelihood of adoption x effectiveness; [2] Cotton growers only (N = 86).

Key Takeaways:

*The most impactful behaviours to target **before spraying** are:*

1) *Using online mapping tools to register crop locations*
2) *Checking online sources for sensitive areas*
3) *Discussing spray plans with neighbours.*

*The most impactful behaviours to target **during spraying** are:*

1) *Driving at recommended speed*
2) *Spraying when conditions (Delta-T, low risk of surface inversion, wind speed) are suitable.*

*The most impactful behaviours to target **after spraying** are:*

1) *Decontaminating spray equipment appropriately*
2) *Keeping accurate records.*

COM-B ANALYSIS AND AUDIENCE SEGMENTATION (Steps 4 & 5)

Methods

Grower spray application online survey

The online survey completed by the 180 growers / land managers also assessed potential barriers that may prevent their adoption of spray-drift-reduction behaviours. They were asked to rate their agreement (on a 5-point Likert scale) to pre-identified capability, opportunity, and motivation behavioural (COM-B) barriers to measure the predictability of these factors. These factors had been identified from two main sources:

1) results from the semi-structured interviews of industry stakeholders, and
2) literature review, including previous surveys on spray drift.

The survey questions are presented in Appendix 3.

Respondents were also asked to identify any other factors that may potentially influence participation using open-ended responses.

Data Analysis

Audience segmentation and COM-B analysis

We used Latent Profile Analysis to segment growers and land managers into distinct groups based on their self-reported behaviours before, during and after spraying. We then conducted a series of Discriminant Function Analyses (DFA) to identify which barriers were most pronounced for each behavioural group. Pearson's Chi-squared or one-way ANOVA analyses were used to determine if differences in collected demographics (age, area sprayed, location, whether they grew cotton or not, or whether they sprayed themselves or employed staff or contractors).

Responses to our open-ended barrier questions were initially coded using a grounded-theory methodology which involved coding the themes as they emerged from the data as opposed to applying any pre-conceived themes (Charmaz, 1996). The emerging themes were then classified using the COM-B structure and a quantitative element was added by counting the number of responses within each coded theme.

Results

Before-spraying target behaviour profiles

The results from the profiling analysis applied to the target **before-spraying** behaviours are presented in Figure 5.

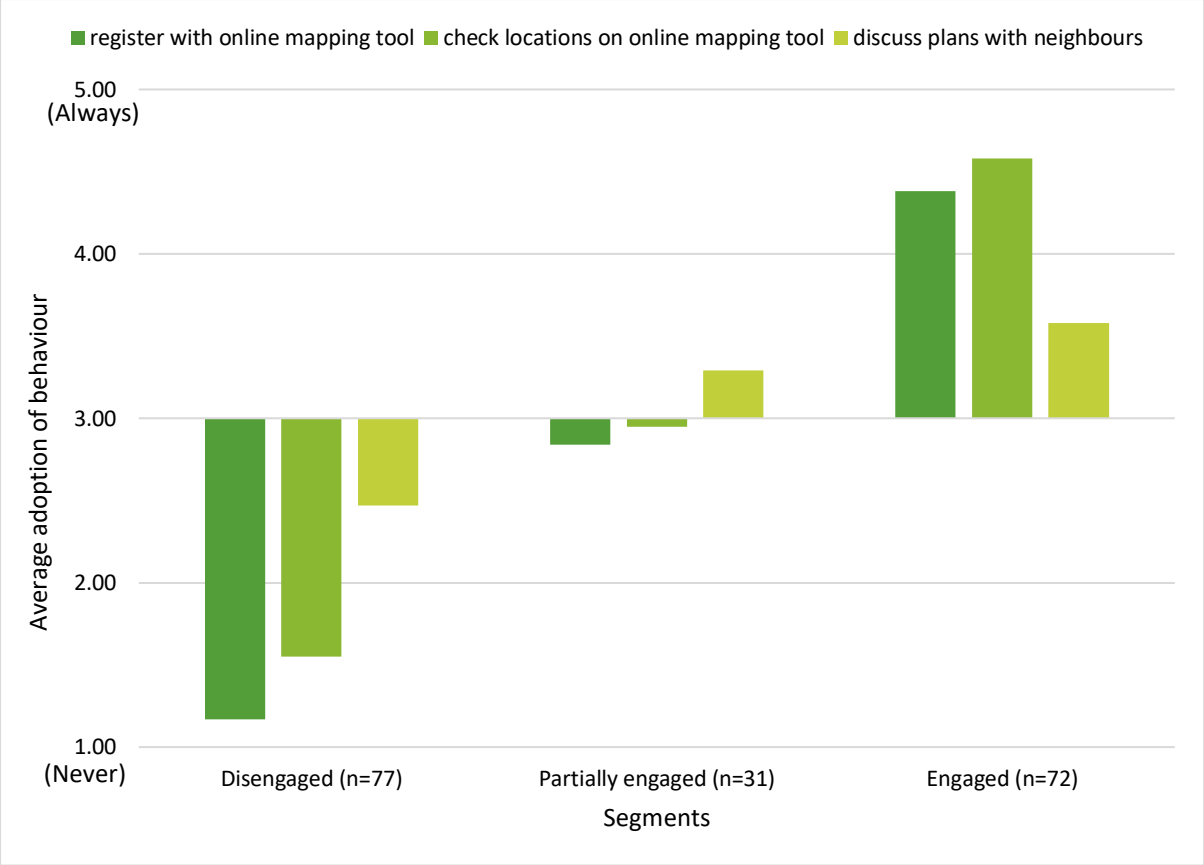

Figure 5: Three grower segments based on adoption of target behaviours **before** spraying (use online mapping tool, discuss plans with neighbours). Behaviour adoption scale: 1=never, 2=rarely, 3=sometimes, 4=often, 5=always.

Key Takeaways:

*The profiling analysis on the target **before**-spraying behaviours produced 3 distinct groups:*

1) *The disengaged group (N=77) rarely used the online mapping tool or discussed their spray plans with neighbours. Members of this group were less likely to be growing cotton, and more likely to be located in the Darling Downs and Murray regions.*

2) *The partially engaged group (N=31) only occasionally used the online mapping tool or discussed their spray plans with neighbours. Members of this group were more likely to be located in Central Queensland.*

3) *The engaged group (N=72) often used the online mapping tool, but less so discussing their spray plans with neighbours. Members of this group were more likely to be growing cotton, and more likely to be located in NW NSW.*

COM-B predictor variables

DFA was used to identify how well the tested COM-B variables could predict adoption of the three target behaviours before spraying within each segment. The results are presented in Table 5. Other barriers suggested by growers in the open-ended responses are detailed in Appendix 4.

Table 5: Correlation with Discriminate Function and means for each segments agreement with COM-B predictors for the target behaviours conducted **before** spraying.

COM-B variable	Correlation with DFA Function	COM-B predictor Means		
		Disengaged	***Partially engaged***	***Engaged***
No-one I know uses the mapping tool	**.87**	3.14[a]	2.42[b]	1.53[c]
No time to check online mapping tool	**.62**	2.94[a]	2.48[b]	1.86[c]
Not aware of online mapping tool	**.47**	2.96[a]	2.74[b]	1.97[c]
Privacy concerns about using the tool	.19	2.65	2.68	2.43
Not important to discuss with neighbours	.11	2.39	2.29	1.97

Correlation >.33 classified as strong (shaded), COM-B agreement: 5=strongly agree, 1=strongly disagree. Means with different subscripts (in rows) differ significantly at $p < 0.05$ Tukey HSD.

Key Takeaways:

Primary barriers to engaging with the online mapping tools (registering and checking) behaviours were:

1) *Not being aware of the mapping tools (capability)*
2) *Not having the time to check the online sources before spraying (opportunity)*
3) *Not knowing anyone else who used the mapping tool (motivation).*

Other strong suggested barriers by the growers were:

4) *The belief that they didn't grow cotton so it was not relevant(motivation)*
5) *They saw no need for it as they relied on their own knowledge of the area (motivation)*
6) *They saw no need as they had no intention of causing drift (motivation).*

During-spraying target behaviour profiles

The results from the profiling analysis applied to the target **during-spraying** behaviours are presented in Figure 6.

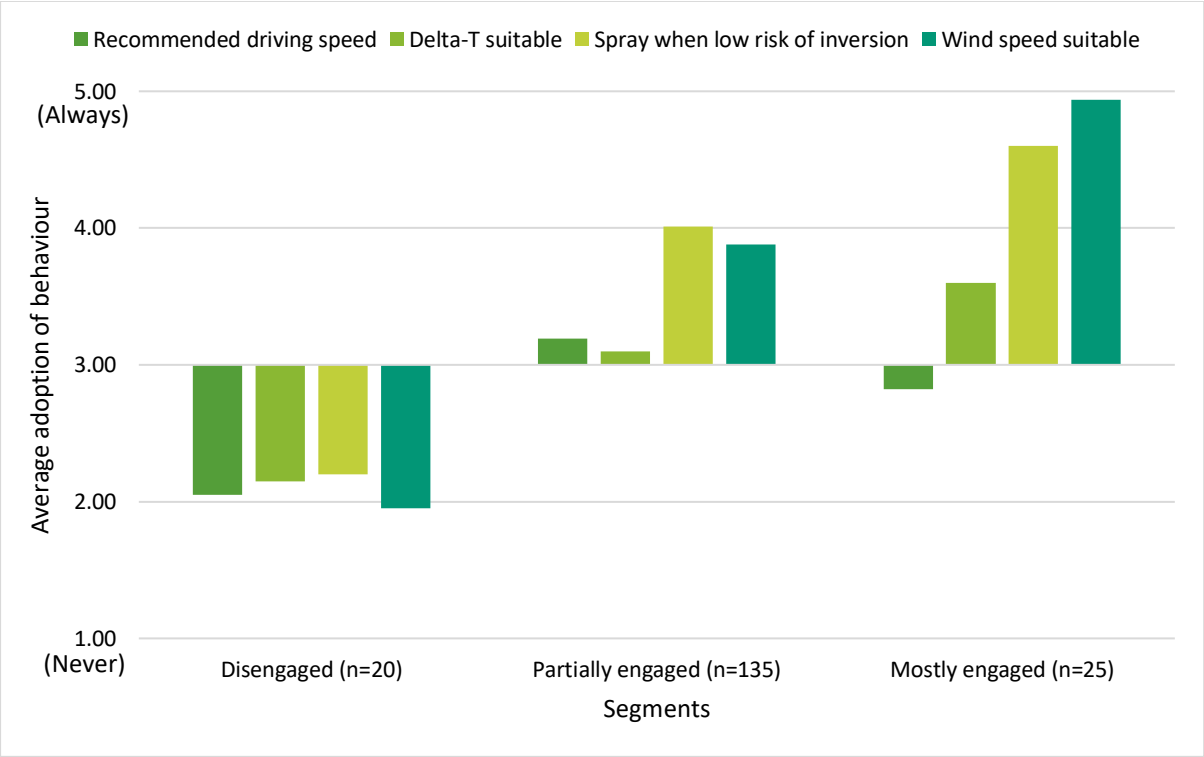

Figure 6: Three grower segments based on adoption of target behaviours **during** spraying (driving at the recommended speed and spraying only when conditions suitable). Behaviour adoption scale: 1=never, 2=rarely, 3=sometimes, 4=often, 5=always.

Key Takeaways:

*The profiling analysis on the **during**-spraying behaviours produced 3 distinct groups:*

1) *The disengaged group (N=20) rarely drove at the recommended speed or sprayed when conditions were suitable.*

2) *The partially engaged group (N=135) only occasionally drove at the recommended speed or sprayed when Delta-T conditions were suitable. Often sprayed when low risk of inversion and wind speed was suitable.*

3) *The mostly engaged group (N=25) always sprayed when low risk of inversion and wind speed was suitable, often sprayed when Delta-T conditions were suitable, but only occasionally drove at the recommended speed.*

There were no statistical differences between these groups and the tested demographic factors (i.e. age, location, area sprayed, crops grown or who did the spraying).

COM-B predictor variables

DFA was used to identify how well the tested COM-B variables could predict adoption of the four target behaviours during spraying within each segment. The results are presented in Table 6. Other barriers suggested by growers in the open-ended responses are detailed in Appendix 4.

Table 6: Correlation with Discriminate Functions and means for each segments' agreement with COM-B predictors for targeted behaviours conducted during spraying.

COM-B variable	Correlation		COM-B predictor Means		
	DFA Function 1	DFA Function 2	Disengaged	Partially engaged	Mostly engaged
My crop production is highest priority	**.87**	-.07	2.90[a]	1.61[b]	1.68[b]
Do it when sprayer available regardless	**.70**	.12	2.90[a]	1.79[b]	1.72[b]
Everyone cuts corners so it's OK for me	**.67**	.32	2.90[a]	1.82[b]	1.60[b]
Spray drift is not an important issue	**.56**	-.08	2.90[a]	1.70[b]	1.80[b]
Getting job done is highest priority	**.41**	.15	3.20[a]	2.41[b]	2.28[b]
Not flexible with staff/contractor needs	**.33**	-.14	2.90[a]	2.26[b]	2.40[b]
Difficult to know when conditions suitable	.52	**.66**	3.00[a]	2.03[a]	1.60[b]
No-one will know if spray at wrong time	.28	**.49**	2.90[a]	2.39[a]	1.92[b]
Difficult to keep up with latest guidelines	.27	.15	3.10	2.57	2.44
Not enough time when conditions suitable	.00	-.04	3.05	3.17	4.00

Correlation >.33 classified as strong (shaded), COM-B agreement: 5=strongly agree, 1=strongly disagree. Means with different subscripts (in rows) differ significantly at $p < 0.05$ Tukey HSD.

Key Takeaways:

*Primary barriers for members in the **Disengaged** segment to spraying only when conditions were suitable:*

1) *No flexibility with the contractors or staff resulting in spraying when somebody was available to do so regardless of conditions (opportunity)*
2) *Beliefs that their crop production took precedence, getting the job completed was the priority and spray drift was not an important issue (motivation)*
3) *Perception that everyone cuts corners and sprays in less than ideal conditions so it was acceptable for them to do so as well (motivation).*

*Barriers for members in the **Partially-engaged** segment (and additional barriers for members in the **Disengaged-**segment) to spraying only when Delta-T conditions were suitable:*

1) *Knowledge about when conditions were suitable to spray (capability)*
2) *Perception that no-one would know anyway if they did spray in less than ideal conditions (motivation).*

An additional factor suggested by the growers was:

3) *Lack of awareness of link between Delta-T and spray drift*

*Members across all three segments (**Disengaged**, **Partially-engaged** and **Mostly engaged**) agreed that there was not enough time when conditions were suitable, suggesting this was a factor preventing all respondents from driving at the recommended speed. Other factors preventing driving at recommended speed that were suggested by the growers were:*

1) *Awareness about the link between speed and spray drift(capability)*
2) *Field conditions (opportunity)*
3) *Perception of reduced efficiency at slower speeds (motivation)*
4) *Need to get the job completed (motivation).*

After-spraying behaviour profiles

The results from the profiling analysis applied to the **after-spraying** behaviours are presented in Figure 7.

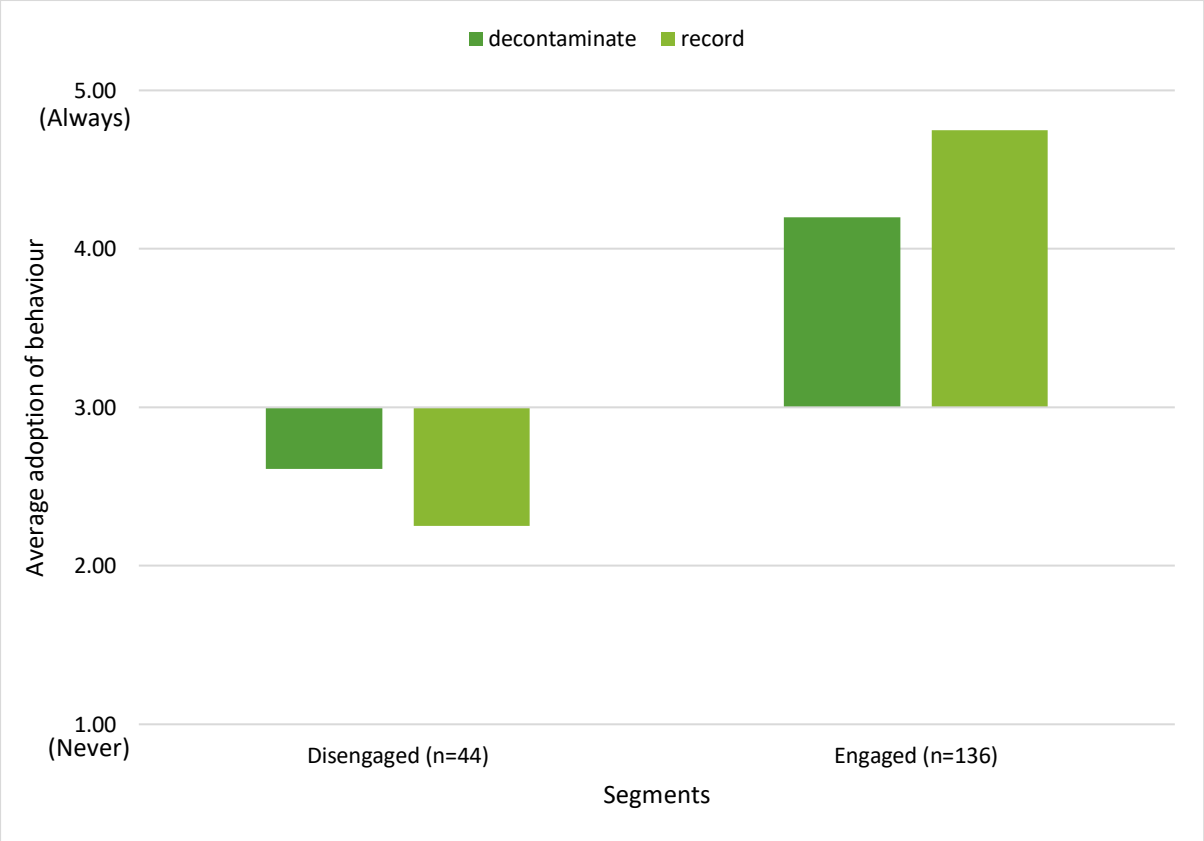

Figure 7: Two grower segments based on adoption of behaviours **after** spraying (decontaminating and record keeping). Behaviour adoption scale: 1=never, 2=rarely, 3=sometimes, 4=often, 5=always.

Key Takeaways:

*The profiling analysis on the **after**-spraying behaviours produced 2 distinct groups:*

1) *The disengaged group (N=44) occasionally decontaminated after spraying but rarely kept records of the spray event. They were more likely to be younger in age (group average age of 43 years).*

2) *The engaged group (N=136) often decontaminated after spraying and always kept records of the spray event. The group's average age was 48 years.*

COM-B predictor variables

DFA was used to identify how well the tested COM-B variables could predict adoption of the two target behaviours after spraying. The results are presented in Table 6. Other barriers suggested by growers in the open-ended responses are detailed in Appendix 4.

Table 7: Correlation with Discriminate Function and means for each segments agreement with COM-B predictors for behaviours conducted after spraying.

COM-B variable	Correlation with DFA Function	COM-B predictor Means	
		Disengaged	***Engaged***
Not aware need to keep records	**.81**	2.73[a]	1.46[b]
No-one checks records anyway	**.72**	3.05[a]	1.75[b]
Forget to keep records	**.58**	3.16[a]	1.98[b]
Don't have time to decontaminate	**.57**	3.00[a]	1.92[b]
Nowhere to decontaminate on property	**.49**	2.80[a]	1.87[b]
No-one I know keeps records	**.49**	3.05[a]	2.07[b]
Decontamination not important	**.41**	2.91[a]	2.04[b]
Not aware need to decontaminate	**.39**	2.82[a]	1.99[b]
Not important to keep records	.30	2.93	2.07
No-one I know cleans their equipment	.27	2.95	2.32

Correlation >.33 classified as strong (shaded), COM-B agreement: 5=strongly agree, 1=strongly disagree. Means with different subscripts (in rows) differ significantly at $p < 0.05$ Tukey HSD.

Key Takeaways:

Primary barriers to decontaminating were:

1) *Having the time to perform decontamination (opportunity)*
2) *Having a suitable location to decontaminate (opportunity)*
3) *Perceiving decontamination as important (motivation)*
4) *Awareness of the need to decontaminate (capability)*

Primary barriers to record keeping were:

1) *Awareness of the need to keep records (capability)*
2) *Forgetfulness (capability)*
3) *Perception that no-one was going to check anyway (motivation)*
4) *Not knowing anyone else who kept records (motivation)*

RECOMMENDATIONS FOR INTERVENTIONS (Steps 6 & 7)

Tackling spray drift is a complex problem - many behaviours contribute to best-practice spray application, and multiple barriers exist to those behaviours. Our results from the previous chapter revealed which behaviours should be targeted for change, and what main barriers need to be overcome. In this chapter we recommend specific behaviour change techniques to overcome these barriers and achieve maximum on-ground impact.

Before-spraying target behaviours

Three key 'before-spraying' behaviours were identified for reducing spray drift:

1) Registering the location of crops using available online mapping tools.
2) Using the mapping tool and other online information sources to check for the location of sensitive areas prior to spraying.
3) Discussing spray plans with neighbours.

Who should be targeted?

More than half (60%) of our survey respondents had not adopted (*Disengaged*) or only occasionally adopted (*Partially Engaged*) these beneficial behaviours. Importantly, because the primary barriers preventing both segments from adopting these behaviours were similar, both segments can be targeted with the same intervention. Respondents located in the Darling Downs, Central Qld and Murray regions, who were not growing cotton could initially be targeted.

Table 8 details recommended intervention designs for discussing spray plans with neighbours, and Table 9 addresses the use of online mapping tools. For more detail on the theory and methods underlying these recommendations, refer to Appendices 5 and 6. Appendix 7 details the breakdown of demographics across each profile.

Table 8: Linking barriers to appropriate behaviour change techniques for discussing spray plans with neighbours.

Barrier	Behaviour change techniques
Bad relationship with neighbour	• Provide training on negotiation and conflict resolution. • Provide case studies based on other growers who have successfully resolved disputes. • Provide trained facilitators to mediate disputes.
Do not see a need	• Frame/reframe messages to ensure relevance to the different grower segments, and highlight benefits of discussing plans. • Recruit key influencers (e.g. respected local growers) to promote community spray-plan discussions. • Provide positive feedback from other growers in community. • Use examples of other growers' experiences to demonstrate benefits.

Table 9: Linking barriers to appropriate behaviour change techniques for promoting the use of online mapping tools.

Barrier	Behaviour change techniques
Not aware of mapping tools	• Promote mapping tools to all grower segments on a variety of platforms (newsletters, social media, face-to-face forums etc). • Disseminate use instructions and information on benefits.
Not having the time to use online tools	• Ensure mapping tools are easy to access (e.g. easy to locate with minimal clicks, usable on a range of devices). • Design mapping tools to be easy to use (e.g. intuitive, user-friendly interface, real-time help available). • Promote to growers at local events. • Run face-to-face training sessions and/or create online tutorials to use online mapping tools.
Not knowing anyone else using the tools	• Provide feedback from other growers in the local area who use the online tools. • Tell other growers' stories of using the online tools, highlighting benefits.
Do not see a need	• Frame/reframe messages to ensure relevance to all grower segments, not just cotton growers. • Promote via trusted messengers (e.g. respected local grower). • Provide positive feedback from other users about benefit. • Offer personal or social reward for using online tools. • Use examples of other growers' experiences to demonstrate use.

During-spraying target behaviours

Four key 'during-spraying' behaviours were identified for reducing spray drift:

1) Driving at the recommended speed.
2) Spraying when Delta-T conditions are suitable.
3) Spraying when there is a low risk of surface inversion.
4) Spraying when wind speed conditions are suitable.

Who should be targeted?

Adoption of recommended driving speeds was poor across all grower segments, in all locations. Therefore, a general intervention targeting the whole audience is advisable. Table 10 lists the recommended intervention designs. For more detail on the theory and methods underlying these recommendations refer to Appendices 5 and 6.

Table 10: Linking barriers to appropriate behaviour change techniques for promoting driving at recommended speeds.

Barrier	Behaviour change techniques
Not aware of the link between driving speed and spray drift	• Provide persuasive information about the importance of driving speed and consequences of not complying. • Demonstrate the link live at field days, or using video posts.
Time constraints and the need to get job completed	• Provide persuasive information about consequences of not driving at the recommended speed. • Obtain commitments from local grower group to keep to speed, and maybe monitor with GPS tracker data that is made available to members of the group. • Offer social and individual reward / acknowledgment for those shown to comply.
Field conditions	• Offer instruction on how to drive efficiently over different terrain. • Provide information on optimising field conditions for spraying events. • Invest in technology and equipment design.
Perceived reduced efficiency at slower speeds	• Provide persuasive information on the efficiency of recommended speeds. • Demonstrate the efficiency of recommended speeds. • Provide feedback from other growers about their experiences.

Table 11: Linking barriers to appropriate behaviour change techniques for encouraging spraying when Delta-T conditions are suitable.

Barrier	Behaviour change techniques
Knowledge about when Delta-T conditions are suitable	• Provide workshops about how to determine suitable Delta-T conditions. • Invest in technologies that allow easy identification of suitable spraying conditions.
Perception that no-one would know	• Provide persuasive information that debunks this perception, including feedback from other growers and their actions. • Obtain public commitment to spraying when Delta-T conditions suitable. • Invest in technologies that identify offenders (such as markers in chemical sprays).
Not aware of the link between Delta-T and spray drift risk	• Provide persuasive information on the link between Delta-T and drift. • Demonstrate the link between Delta-T and drift. • Provide feedback from other growers about their experiences.

More than 85% of the survey respondents rarely or only occasionally adopted spraying when Delta-T conditions were suitable. Table 11 details recommended intervention designs targeting the primary barriers of both these segments (rarely and occasionally).

A small proportion of the survey respondents (11%) were rarely spraying when there was a low risk of inversion and wind speed conditions were suitable. The recommended intervention designs targeting the primary barriers of this segment are shown in Table 12. For more detail on the theory and methods underlying these recommendations refer to Appendices 5 and 6. Appendix 7 details the breakdown of demographics across each profile.

Table 12: Linking barriers to appropriate behaviour change techniques for encouraging spraying when risk of surface inversion is low and wind speed conditions are suitable.

Barrier	Behaviour change techniques
Flexibility in availability of contractor / staff to spray	• Provide instruction to strengthen planning and management skills. • Increase access and availability of contractors at high peak times. • Invest in alternate technologies to reduce the need to spray when conditions are unsuitable.
Belief that crop production is most important	• Frame messages around spraying when conditions are suitable as being beneficial to **their** present and future crop production.
Belief that getting job done is the priority	• Provide persuasive information about the negative consequences of bad spraying practices. • Obtain public commitment to spray only when conditions are suitable, and offer social and individual reward / acknowledgment for those shown to comply. • Invest in alternate technologies to reduce the need for broad-scale spraying when conditions are unsuitable (e.g. detection technology).
Spray drift not important issue	• Provide persuasive information and demonstrate the consequences of spray drift, particularly in the local area. • Tell other growers' stories about their own experiences.
Belief that everyone else does it	• Provide persuasive counter-examples that debunk this perception, including feedback from other growers and their actions.

Note: Persuasive information can be delivered on a mixture of communication channels but particularly: face-to-face, telephone, email, brochure or online learning tool.

After-spraying target behaviours

Two key 'after-spraying' behaviours were investigated:

1) Decontaminating equipment appropriately.
2) Keeping accurate records of the spray event.

Who should be targeted?

Approximately a quarter of the respondents (24%) indicated they were rarely engaging with the two target 'after-spraying' behaviours. These non-adopters tended to be younger in age.

Table 13 details the recommended intervention designs targeting the primary barriers for growers not decontaminating their equipment correctly. Table 14 lists recommended intervention designs for encouraging growers to keep accurate records.

For more detail on the theory and methods underlying these recommendations, refer to Appendices 5 and 6. Appendix 7 details the breakdown of demographics across each profile.

Table 13: Linking barriers to appropriate behaviour change techniques for improving decontamination of equipment after spraying.

Barrier	Behaviour change techniques
Awareness of need / importance of decontamination	• Update available information about the need to decontaminate and how to do it appropriately (e.g. distribute on a variety of platforms, include in face-to-face forums). • Provide instruction on how to decontaminate appropriately. • Use visual tools to demonstrate the consequences of not decontaminating. • Offer farm visits (one-on-one training) to provide support.
Having time to decontaminate	• Develop training guide to demonstrate how to decontaminate efficiently. • Provide feedback from other growers in the local area, and highlight benefits of time spent now versus more time spent rectifying future problems.
Having a suitable location to decontaminate	• Provide information and training about how to set up appropriate location. • Provide physical and / or economic support to set up appropriate area. • Offer reward for having suitable location on property.

Table 14: Linking barriers to behaviour change techniques for encouraging accurate record keeping of spray events.

Barrier	Behaviour change techniques
Awareness of need to keep records	• Provide persuasive information about the need to keep records across a range of platforms (e.g. newsletters, social media, face-to-face forums. Include information on benefits and what needs to be recorded.
Forgetting to keep records	• Cue recording through visible prompts (e.g. on tractor, in farm office). • Create a recording system that makes it easy (e.g. prompts what information needs to be recorded, easily interfaces with automatic recording systems). • Ensure recording is covered in any training courses offered.
Perception that no-one would check anyway	• Provide information that debunks this perception and highlights grower obligations. • Be visible in checking records, and impose punishments for those that don't comply.
Not knowing anyone else who keep records	• Provide feedback from other growers in the local area – tell their record keeping stories and how they overcame barriers.

ACKNOWLEDGEMENTS

We would like to acknowledge Natalie Taylor for her assistance with the stakeholder interviews and analysis of the transcripts.

We would like to thank all of the key stakeholders who took part in our interviews, and offered advice and support throughout the project. In particular we would like to acknowledge the invaluable assistance provided by the members of our advisory group - Rachel Holloway, Vicki Green, and Susan Maas.

Thank you to all the growers who participated in the online survey.

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APPENDICIES

Appendix 1: Semi-structured interview questions for industry stakeholders

Introduction: We (Lynette McLeod or Natalie Taylor) are conducting research into improving spray application on farms to reduce spray drift issues. This project is funded through the CRDC. The aim of our project is to develop a greater understanding of the capacity, opportunity and motivations of agricultural chemical spray users (i.e. farmers and contract sprayers) to engage in best-practice spray application, so we can develop better engagement strategies and messaging to assist you in your task of delivering effective engagement programs. The first step in our approach, which is informed by behavioural sciences, is to identify those specific behaviours and actions which are important for best-practice spray application in your area. Your perspective as a stakeholder in the cotton industry can help us understand the complex behavioural factors associated with this issue.

Before we begin I would like to affirm your consent to participate please (record replies):

Have you read the information contained in the Information Sheet for Participants and any questions asked have been answered to you satisfaction? Yes/No

Do you agree to participate in this activity, realising that you may withdraw at any time? Yes/No

Do you agree that research data gathered may be quoted and published using a pseudonym? Yes/No

Do you agree to having the interview audio recorded and transcribed? Yes/No

Are you older than 18 years of age? Yes/No

Interview questions	Behavioural questions	Prompts/notes	Analysis
1. Tell me about the area in which you work?		Time involved with the cotton industry? Nature of your work? Severity of spray drift problem? What types of chemicals / crops are of the most concern?	Background information, potential segmentation categories
2. What behaviours or actions do you see as important for users of chemical sprays to undertake to reduce spray drift issues in your area?	Before/ during/ after spraying what should users do to reduce spray drift? Are there any actions they should stop doing?	Prompt to uncover behaviours: Attend training, check weather conditions, check chemical use, equipment / nozzle selection, consultation??	Identification of what behaviours underpin the local spray drift issue and who is responsible
3. What factors are preventing users conducting best-practice spray application?	What is preventing users doing the right thing? What is driving incorrect application? What is going through a user's mind when they decide to spray?	Prompt to reflect and uncover drivers and barriers: Awareness, training, knowledge, equipment, chemical, $$, operational time frame, legal or social obligation?	Identification of influential factors that drive or impede spray application behaviour
4. Would do you think would be the best way to engage with those users causing the problem?	What changes to current practice would make the biggest impact	Prompt: e.g. new technologies that remove anonymity such as 'sniffers' chemical finger printing, tougher regulations, improved awareness campaigns	Identify opportunities to engage with unengaged users

Appendix 2: Industry stakeholder online survey to measure behaviour impact

Thank you for taking the time to complete this questionnaire.

Some information about you:

How many years have you been working in your area? _____

Briefly describe your position _____

You will be presented with a range of behaviours that can be undertaken by landholders and spray applicators to reduce spray impacts. As a recognised expert in the field, we would like you to evaluate the effectiveness of each of the listed behaviours in reducing negative spray drift impacts in your area.

We recognise that landholders and spray applicators may need to undertake a combination of the below behaviours to minimise spray drift impacts, however for this exercise we are interested in the effectiveness of each behaviour individually.

Please rate the effectiveness of each behaviour on a 10 point scale (1= not at all effective in reducing impacts, 10= extremely effective in reducing impacts).
When making your effectiveness ratings assume that most landholders adopt the listed behaviour, and use recognised good practice.

Behaviour	Not at all effective 1	2	3	4	5	6	7	8	9	Extremely effective10
Growers develop a Pesticide and Application Management plan at the beginning of each growing season	○	○	○	○	○	○	○	○	○	○
Growers register their sensitive crops on appropriate websites (eg CottonMap)	○	○	○	○	○	○	○	○	○	○
All growers and spray applicators check appropriate websites for sensitive crops or other sensitive areas (eg waterways, beehives)	○	○	○	○	○	○	○	○	○	○
Growers ensure that any person applying spray on their property is fully trained and accredited	○	○	○	○	○	○	○	○	○	○
Spray applicators ensure that any equipment used for spraying is compliant with the chemical label requirements and good practice guidelines	○	○	○	○	○	○	○	○	○	○
Spray applicators mix the chemicals as per label specifications	○	○	○	○	○	○	○	○	○	○
Both growers and spray applicators ensure that the conditions (wind speed, humidity, inversion risk) are suitable for spraying as specified by good practice guidelines	○	○	○	○	○	○	○	○	○	○

Spray applicators ensure that the available water source is suitable as a carrier for the chosen chemical	○	○	○	○	○	○	○	○	○	○
Spray applicators use a spray nozzle that produces coarsest spray quality possible	○	○	○	○	○	○	○	○	○	○
Spray applicators adjust the boom height to the lowest level possible	○	○	○	○	○	○	○	○	○	○
Spray applicators ensure suitable application rates (i.e. volume, speed and pressure) as specified by good practice guidelines	○	○	○	○	○	○	○	○	○	○
Spray applicators decontaminate their equipment after spraying by following good practice guidelines	○	○	○	○	○	○	○	○	○	○
Both growers and spray applicators keep comprehensive spray records of each spray event	○	○	○	○	○	○	○	○	○	○
Growers report any spray drift impacts to the appropriate agency	○	○	○	○	○	○	○	○	○	○
Have we missed anything important? If yes, please add in the text box provided and rate its effectiveness _____	○	○	○	○	○	○	○	○	○	○

Thank you very much for taking the time to fill in this questionnaire. Please click on the next button to ensure your responses are saved correctly and have a great day!

Appendix 3: Online spray application survey

Off-target spray drift can cause considerable ecological and financial harm and is a risk to human health.

To solve the problem, it's important to understand how human behaviour contributes to spray drift. As a first step, we need your help to understand exactly what is happening on-site prior to, during and after spray operations. We will then look to understand the drivers of and barriers to some of these behaviours.

You can help us by being as open and honest as possible to help us solve this problem. All your responses will be completely anonymous and will be used to make general recommendations for reducing spray drift stemming from cotton and grain growers. Your responses cannot be linked back to you or your properties.

This survey should be completed by persons who (1) conduct spraying on properties, OR (2) make decisions about spraying on properties (e.g. what areas get sprayed, with which chemicals, and when). If this is you then please read through the following consent conditions and click on Proceed.

Online Implied Consent for Participants

· I have read the information contained in the Information Sheet for Participants and any questions I have asked have been answered to my satisfaction.

· I agree to participate in this activity, realising that I may withdraw at any time.

· I agree that research data gathered for the study may be published, and my identity will be unidentifiable as explained in the information sheet.

· I am over 18 years of age.

In preservation of anonymity, I understand that no name or signature is required of me to give consent. By activating the proceed button below I am agreeing to participate in this study.

Proceed

End Survey

Q1. Do you mainly....?

Conduct your own spraying using a ground rig

Employ farm staff to conduct spraying using a ground rig

Employ an external contractor to conduct spraying using a ground rig

Employ an external contractor to conduct spraying by air

Other (please specify) _____

Q2. On average, what total area of the property (crop, fallow, pasture) is sprayed per year (in hectares)?_____

Q3. On average, what area of crops is sprayed per year (in hectares)?_____

Q4. On average, how many passes of this crop area would you need to do per year?

Options: Once, Twice, Three, Four or more

Q5. What proportion of this spraying is done using a ground-rig?

	0 10 20 30 40 50 60 70 80 90 100
Slide marker along to indicate proportion of area sprayed using a ground-rig ()	

Q6. What type of crops do you mainly spray?

Q7. What is the nearest town or locality to where you do most of your spraying?_____

Q8. What year were you born?_____

Q9. What is your gender? _____

In this section of the survey we will ask you about common practices that may take place PRIOR to spraying.

We are interested in both what you have done in **past seasons,** and what your intentions are for your **next crop season** (next 12 months).

Q10. Discussing your spray application plan with your adviser / agronomist

Thinking back on **past seasons**, how often did you discuss the following with your adviser / agronomist?

	Never	Rarely	Occasionally	Often	Always
Chemical product choices and rate					
Application equipment settings (e.g. nozzle selection, spray quality, water volume)					
Constraints during application - weather conditions					
Constraints during application - proximity to sensitive areas					

Q11. And how likely is it that you will discuss the following with your adviser / agronomist for your **next crop season**?

	Very unlikely	Unlikely	(3)	Likely	Very likely
Product choices and rate					
Application equipment settings (e.g. nozzle selection, spray quality, water volume)					
Constraints during application - weather conditions					
Constraints during application - proximity of sensitive areas					

Q13. What factors or issues might prevent someone from discussing their spray application plans with an adviser / agronomist? _____

Q14. Training of spray operators on your property

Thinking back on **past seasons**, what level of training have you required of spray operators on your property (this may be you, farm staff or contractors)?

	Never	Rarely	Occasionally	Often	Always
On the job training					
Current accredited training to use pesticides (e.g. ChemCert, TAFE, Spray SMART)					
Other (please specify)					

Q15. In your **next crop season**, how likely is it that you will check that spray operators on your property has current accredited training to use pesticides?

Options: Very unlikely , Unlikely, Neither likely or unlikely, Likely, Very likely

Q16. What factors or issues might prevent someone from checking that spray operators on their property have current accredited training to use pesticides? _____

Q17. Registering the location of your crop, using CottonMap (a website designed to highlight the location of cotton fields). This ensures that neighbouring landholders are aware of what is being grown in the area.

Thinking back on **past seasons**, how often did you register the location of your crop on CottonMap?

Options: Never, Rarely, Occasionally, Often, Always, Not applicable

Q18. How likely is it that you will register the location of your crop on CottonMap and / or Satacrop (a new website introduced in the 2019/20 season) in your **next crop season**?

Options: Very unlikely , Unlikely, Neither likely or unlikely, Likely, Very likely

Q19. What factors or issues might prevent someone from registering the location of their crops on CottonMap or Satacrop? _____

Q20. Checking for the location of sensitive areas before spraying

Thinking back on **past seasons**, before spraying did you....

	Never	Rarely	Occasionally	Often	Always
Discuss your spray plans with your neighbours?					
Check a website such as CottonMap or BeeConnected for sensitive crops / enterprises?					

Q21. In your **next crop season** how likely is it that you will....

	Very unlikely	Unlikely	(3)	Likely	Very likely
Discuss your spray plans with your neighbours?					
Check a website such as Satacrop, CottonMap or BeeConnected for sensitive crops / enterprises?					

Q23. What factors or issues might prevent someone from discussing their plans with their neighbours? _____

Q24. What factors or issues might prevent someone from checking the location of sensitive crops / enterprises? _____

Q25. People give many reasons why they do or do not undertake some of these practices **PRIOR** to spraying. Please rate to what extent you agree or disagree with each of the following statements.

	Strongly disagree	Disagree	(3)	Agree	Strongly agree
I was not aware of the websites to register and check the locations of certain crops					
Finding the time to check websites is hard					
I am concerned about privacy issues regarding people knowing what crops I have planted					
No-one I know uses CottonMap or Satacrop					
It is not important to discuss my spray plans with my neighbours					
It is difficult to check that people have current accredited training to use pesticides					
It is not important that people have current accredited training					
My adviser / agronomist gives sound advice regarding spray application					
I do not have the time to discuss a spray application plan with an adviser / agronomist					
It is very difficult to stick to a spray application plan, there are too many factors that cannot be predicted					

In this section of the survey we will ask you about some common ground rig spraying practices that occur DURING spray applications. If you do not personally apply spray to your crops (i.e. someone else does this on your property) please answer these questions, to the best of your knowledge, on how they conducted the spraying.

Q26. Thinking back on **past seasons**, before spraying do you....

	Never	Rarely	Occasionally	Often	Always
Check your spraying equipment was compliant with the chemical labels?					
Mix the chemicals as per the label specifications?					
Ensure the water quality was suitable as a carrier for the chemical you were applying?					

Q27. At what times of the day is spraying typically done on your property? We appreciate this may not always have been when you wanted it to happen.

	Never	Rarely	Occasionally	Often	Always
Early morning - from sunrise to around an hour after					
Morning - from around an hour after sunrise to midday					
Afternoon - from midday to around an hour before sunset					
Evening - from around an hour before sunset to 10/11pm					
Night - 10/11pm to sunrise					

Q28. At what wind speeds do you typically spray?

	Never	Rarely	Occasionally	Often	Always
< 5 km/h					
5-10 km/h					
11-15 km/h					
>15 km/h					
Don't think about it					

Q29. What Delta-T do you typically spray?

	Never	Rarely	Occasionally	Often	Always	Not applicable
Under 5						
5-8						
9-12						
Above 12						
As per the instructions on the chemical label						
Don't know						

Q30. What speed do you usually drive at when spraying?

	Never	Rarely	Occasionally	Often	Always
10-15 km/h					
15-20 km/h					
20-25 km/h					
> 25 km/h					
Don't know					

Q31. Still thinking about your spraying activities in past seasons....

	Never	Rarely	Occasionally	Often	Always
Did you adjust the spray set up (e.g. nozzles) to achieve the label recommended droplet size?					
Did you adjust your boom height to the correct level?					

Q32. Before you spray in the next crop season, how likely will you do each of the following.

Remember your responses are anonymous. Please respond in terms of what you think you will actually do, NOT what you think you should do.

	Very unlikely	Unlikely	(3)	Likely	Very likely
Check your spray equipment is compliant with the chemical label requirements?					
Mix the chemicals as per the label specifications?					
Ensure the water quality is suitable as a carrier for the chemical being applied?					
Use a spray nozzle that produces the coarsest spray quality recommended for that product?					
Adjust the boom height to the correct level?					
Drive at recommended speed to achieve desired spray quality?					

Q33. **Are there any situations or factors that might prevent or discourage someone from:**
a. Checking spray equipment is compliant with the chemical label requirements? _____

c. b. Mixing the chemicals as per the label specifications? _____

Ensuring the water quality is suitable as a carrier for the chemical? _____

Q34. Are there any situations or factors that might prevent or discourage someone from:
a. Using a spray nozzle that produces the coarsest spray quality recommended for that product? _____

b. Adjusting the boom height to correct level for spray release height? _____

c. Driving at the recommended speed to achieve desired spray quality? _____

Q35. During the **next crop season** how likely are you to consider spraying in the following conditions?

	Very unlikely	Unlikely	(3)	Likely	Very likely
Conditions favourable for surface temperature inversion?					
Windspeed within the label conditions?					
Suitable delta-T conditions?					

Q36. What situations or factors might cause someone to spray in less than ideal conditions (surface temperature inversions, windspeed, suitable delta-T)? _____

Q37. People give many reasons why they do or do not undertake these common ground rig spraying practices during spraying. Please rate to what extent you agree or disagree with each of the following statements.

	Strongly disagree	Disagree	(3)	Agree	Strongly agree
The information given on chemical labels is hard to understand					
I find it difficult to know when conditions are suitable for spraying					
No-one will know if I spray in less ideal conditions					
Getting the job done quickly is the highest priority					
I spray when there is someone to do the job regardless of conditions					
Spray drift is not an important issue					
Guidelines about spraying practices are constantly changing, I find it hard to keep up with the latest information					
I have the flexibility with staff / spray contractors to delay spraying if conditions are not ideal					

My crop production is more important than my neighbours' enterprises
Everyone is cutting corners when it comes to 'best-practice' spraying, so it is OK for me to as well
It is expensive to have the right equipment for all types of chemical product that I use
There are not enough hours in the day when conditions are right (according to best-practice) to get my spraying done

In this section of the survey we will ask you about some common practices conducted **AFTER** spraying has occurred.

Q38. Thinking of **past seasons**, after spraying did you....

	Never	Rarely	Occasionally	Often	Always
Decontaminate your equipment (e.g. clean with appropriate agent)?					
Make an accurate record of the spray event?					

Q39. Please tick which items were recorded

Name and contact details of owner	Rate of application
Name and contact details of person applying product	Total area were applied
Property address	Wind-speed and direction
Blocks or paddocks sprayed	Any significant weather changes during application
Start and finish dates	Nozzle type and size
Start and finish times	Pressure
Full product name	Air temperature - degrees Celcius
Name of crop or pest	Relative humidity
Total quantity used	Other (please specify) _____

Q40. In your **next crop season**, how likely are you to do the following AFTER you spray?

	Very unlikely	Unlikely	(3)	Likely	Very likely
Decontaminate your equipment properly?					
Make an accurate record of the spray event?					

Q41. Are there any situations or factors that might prevent or discourage someone from decontaminating equipment properly? _____

Q42. Are there any situations or factors that might prevent or discourage someone from keeping an accurate record of each spray event? _____

Q43. People give many reasons why they do or do not undertake these practices **AFTER** spraying. Please rate to what extent you agree or disagree with each of the following statements.

	Strongly disagree	Disagree	(3)	Agree	Strongly agree
It is not important to keep an accurate record of every spray event					
I commonly forget to record all the details after I spray					
No-one else I know keeps detailed records of every spray event					
I was not aware that I should keep accurate records after each spray event					
Why bother keeping accurate records, no-one checks anyway					
I did not know I should clean my equipment after every spray event					
There is nowhere to decontaminate my equipment properly					
I do not have the time to clean my equipment after spraying					
It is not important to decontaminate my equipment after spraying					
No-one else I know cleans their equipment after every spray event					

Q44. Are there any other issues around managing spray practices on your property that you would like to mention? _____

That completes the survey. Please click on the next button to ensure your response is recorded.

Once again thank you for your time

Appendix 4: Responses to open-ended barrier questions

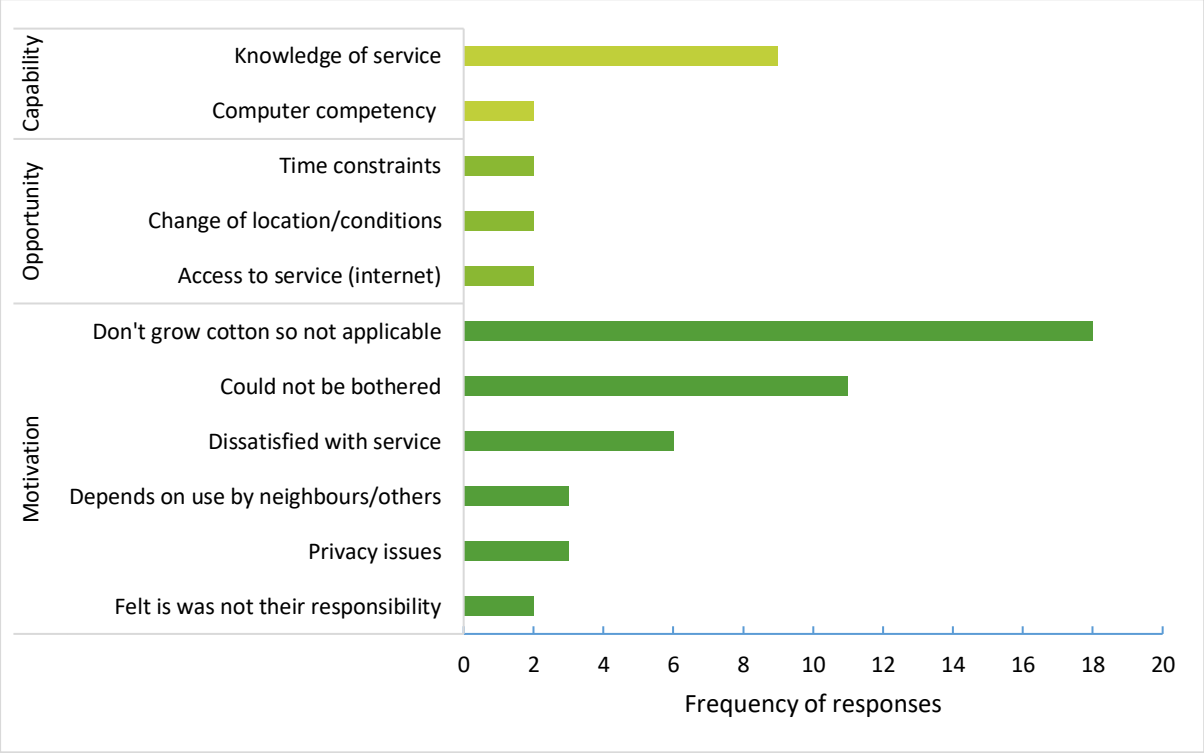

Figure A4-1 Factors as suggested by growers that prevent registration of the location of sensitive crops using online mapping tool (N=54).

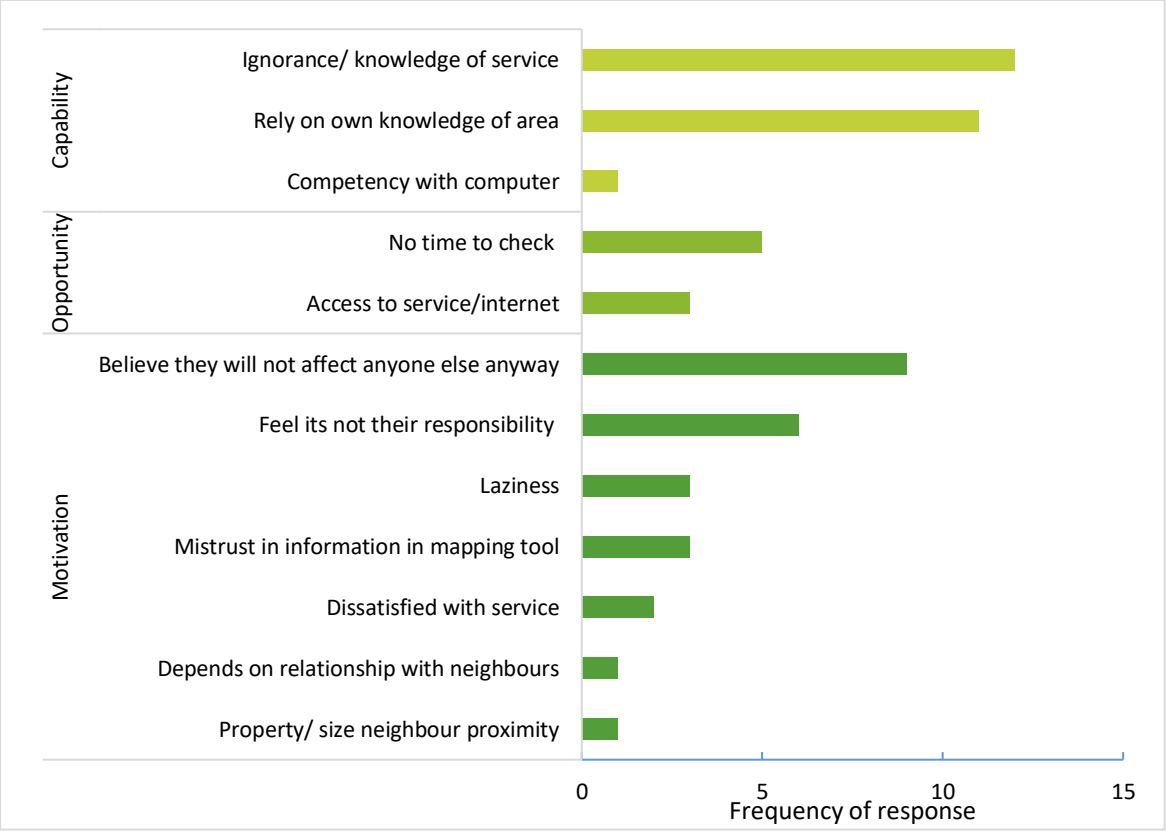

Figure A4-2 Factors as suggested by growers that prevent checking online sources for location of sensitive areas (N=46).

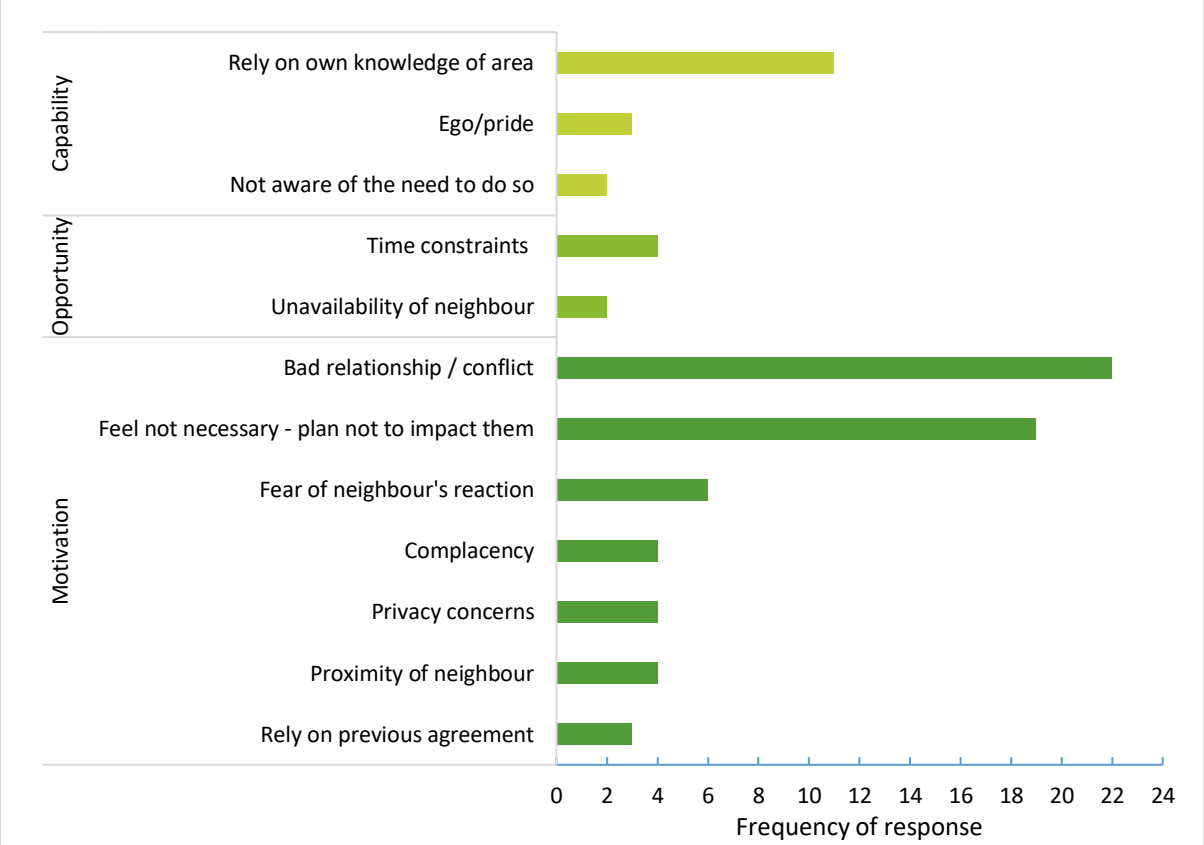

Figure A4-3 Factors as suggested by growers that prevent the discussion of spray plans with neighbours (N=64).

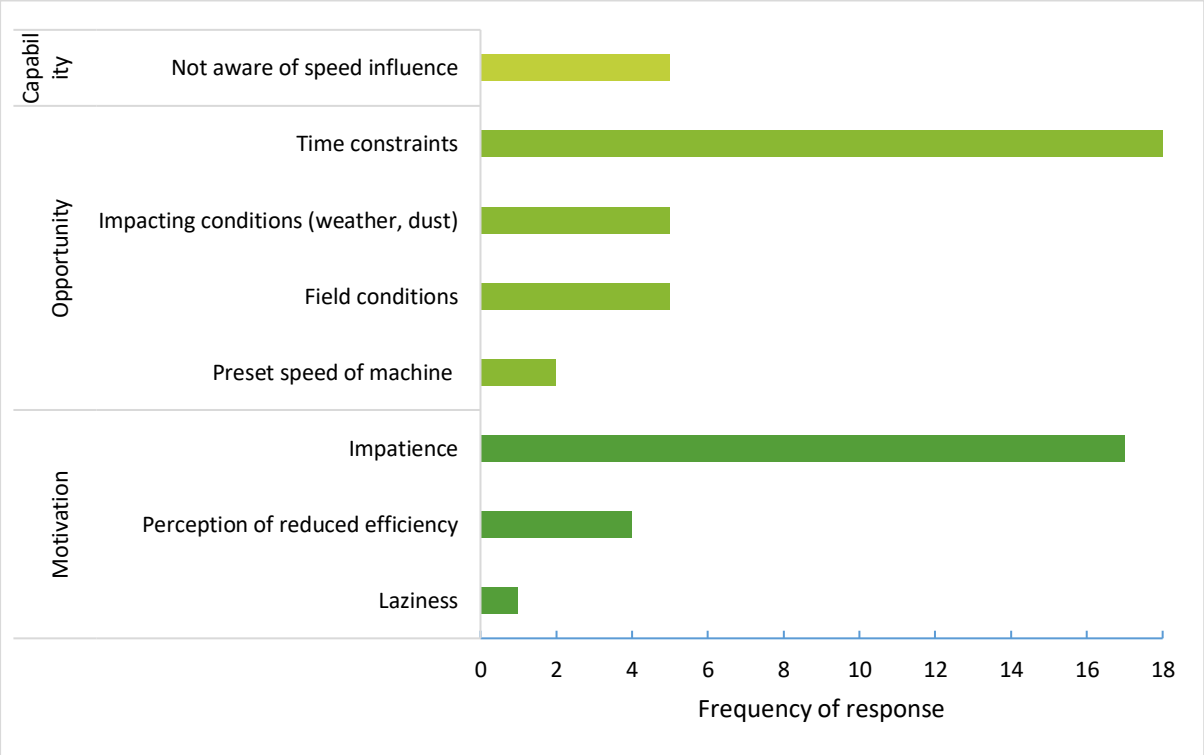

Figure A4-4 Factors as suggested by growers that prevent driving at the recommended speed (N=48).

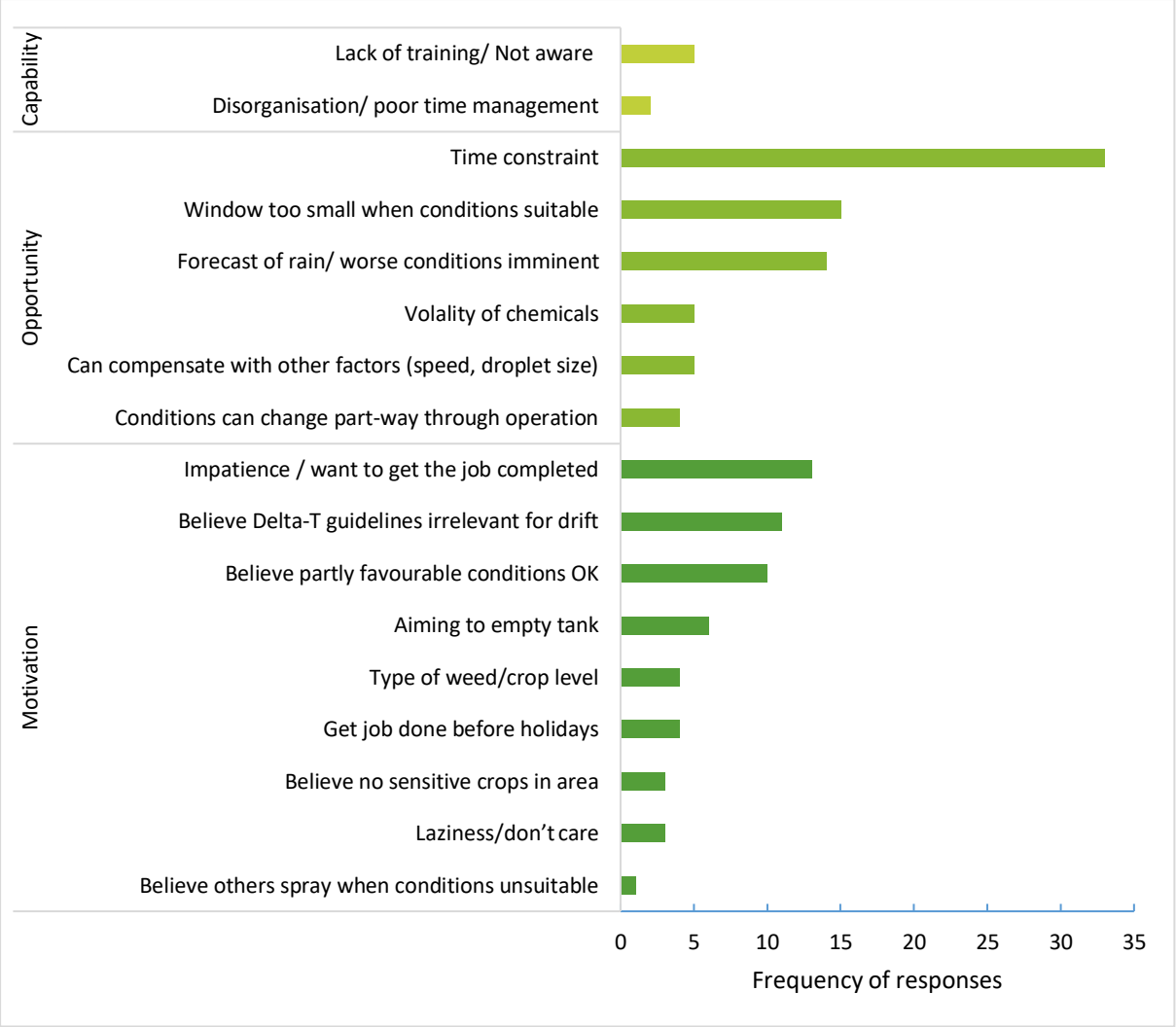

Figure A4-5 Factors as suggested by growers that prevent spraying when weather conditions are suitable (N=81).

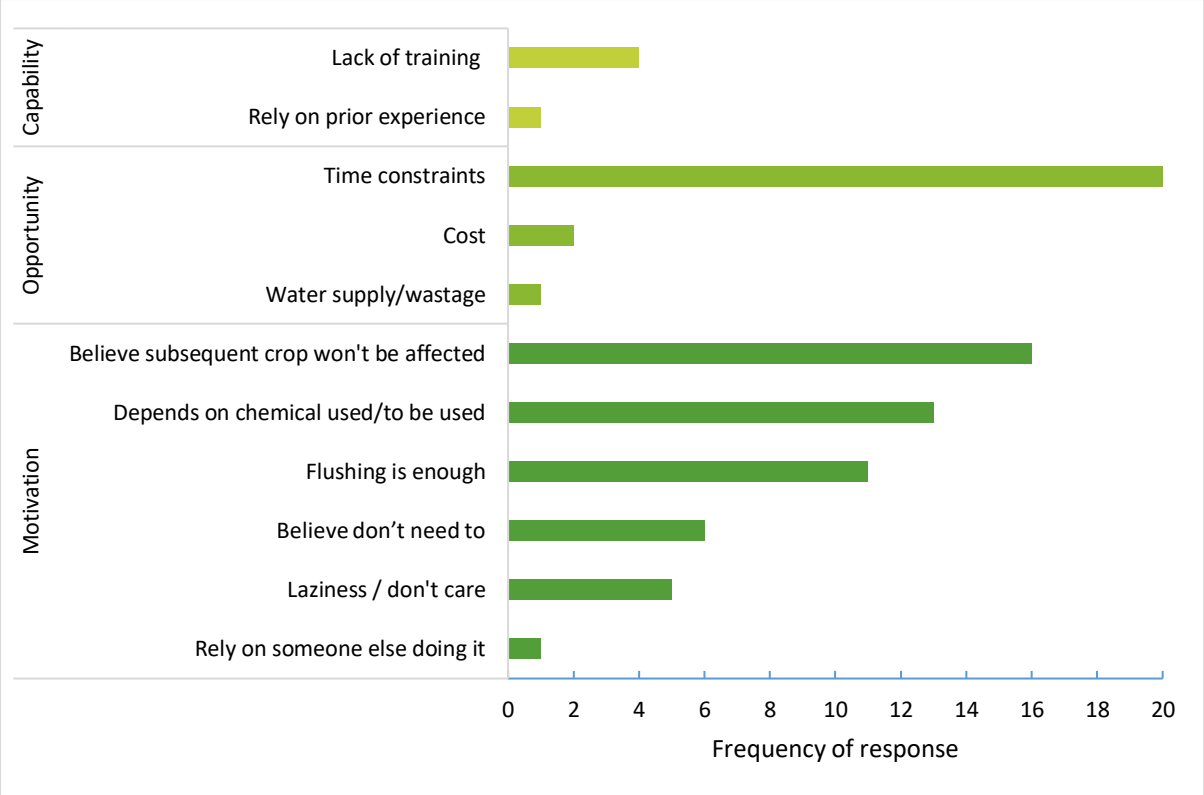

Figure A4-6 Factors as suggested by growers that prevent decontamination of equipment after spraying (N=55).

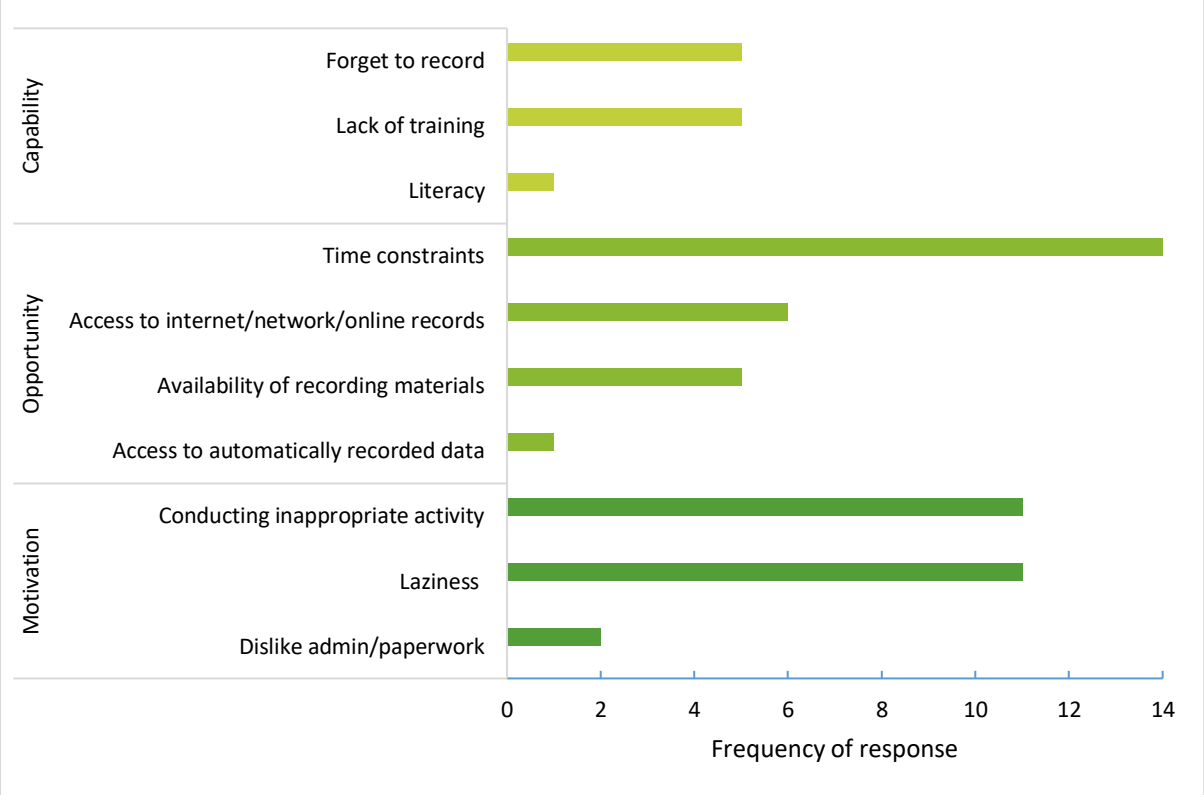

Figure A4-6 Factors as suggested by growers that prevent keeping accurate records of a spraying event (N=48).

Appendix 5: Linking COM-B components to intervention functions

COM-B components	Intervention functions[1]
Influencing capability	
Knowledge	**Educate** about why and how growers can enact the desired behaviour
Skill	**Train** growers in physical, cognitive or social skills required for the desired behaviour
Strength / endurance	**Train** or **enable** growers to develop the strength / endurance required to perform desired behaviour and /or prompt future actions
Influencing opportunity	
Time	**Train** or **restructure the environment** to reduce time demand or competing time demands for desired behaviour.
Resources	**Enable** or **restructure the environment** to increase availability and access to resources that support desired behaviour. Use **restrictions** to limit undesired behaviours.
Physical barriers	**Train**, **enable** or **restructure the environment** to allow for desired behaviour and/or limit undesired behaviour
Interpersonal influences	**Restructure the social environment**, **enable** or use **modelling** or **restriction** to shape grower's ways of thinking
Influencing motivation	
Plans	**Educate**, or **train** to form clearer personal rules / plans and **train** to apply the rules / plans when needed
Evaluations	**Educate** or **persuade** to create more positive beliefs about desired behaviour
Reasons	**Persuade**, **incentivise**, **coerce**, **model** or **enable** to feel positively about desired behaviour and negatively about undesired one
Impulses/inhibition	**Train**, **enable** or **restructure environment** to strengthen habitual adoption of desired behaviour or weaken the undesired one
Responses	**Model** desired behaviour to induce automatic imitation

Based on Michie et al, 2014. [1]Coerce - create expectation of punishment or cost, Educate - increase knowledge and understanding, Enable - increase possibility/means to act, Incentivise - create expectation of reward, Model - provide an example for people to aspire or imitate, Persuade - use communication to induce positive or negative feelings to stimulate action, Restructure environment - change physical or social context, Train - impart skills to act.

Appendix 6: Linking intervention functions to commonly used behaviour change techniques

Intervention function	Behaviour change techniques
Coerce	Impose punishment Remove reward Provide negative feedback
Educate	Provide information about issue Provide information about the consequences of action or inaction Provide information about others' approval Give feedback on behaviour Give feedback on the outcome(s) of behaviour
Enable	Provide physical or social support Goal setting Action planning Improve/reduce access Improve/reduce availability Technological advances Commitment
Incentivise	Individual reward Social reward Commitment
Model	Demonstrate the behaviour
Persuade	Credible source / messenger Framing / reframing Facts vs story-telling Misinformation Information about consequences Feedback on others' behaviour Feedback on outcome(s) of behaviour
Restructure environment	Add objects to the environment Provide prompts / cues Change social norms Remove access to rewards Remove aversive stimulus
Train	Instruct on how to perform the behaviour Provide stimulus to prompt or cue behaviour

Based on Michie et al, 2014, Hine et al, 2019.

Appendix 7: Summary of demographic factors across identified profiles

Before spraying:

Demographic factor	Disengaged (n=77)		Partially engaged (n=31)		Engaged (n=72)		Segment differences	
	mean	SD	mean	SD	mean	SD	*F*	*r*
Age (years)	47.6[a]	11.2	41.2[b]	8.9	48.3[a]	9.7	5.65*	.03
Area sprayed (ha)	11,506	24,330	33,348	113,193	27,902	96,760	1.21	-
	n (%)	Z_{Resid}	n (%)	Z_{Resid}	n (%)	Z_{Resid}	X^2	*r*
Location:							41.9*	.20
Central Qld	8 (10.4)	-.8	9 (29.0)	**3.0**	6 (8.3)	-1.5		
Darling Downs	21 (27.3)	**2.1**	2 (6.5)	**-2.1**	13 (18.1)	-.5		
SW Qld	6 (7.8)	.8	4 (12.9)	1.7	1 (1.4)	**-2.2**		
NW NSW	7 (9.1)	**-3.0**	4 (12.9)	-1.0	24 (33.3)	**3.8**		
Namoi	9 (11.7)	1.4	0 (0.0)	-1.8	6 (8.3)	.0		
Macquarie/Lachlan	8 (10.4)	-.3	6 (19.4)	1.6	6 (8.3)	-1.0		
Murrumbidgee	11 (14.3)	-.9	5 (16.1)	-.2	15 (20.8)	1.0		
Murray	7 (9.1)	**2.2**	1 (3.2)	-.5	1 (1.4)	-1.8		
Sprayer type:							9.05	-
Did own spraying	46 (59.7)	.6	22 (71.0)	1.7	35 (48.6)	-1.9		
Staff did spraying	23 (29.9)	-.3	8 (25.8)	-.7	25 (34.7)	.9		
Contractor	8 (10.4)	.2	1 (3.2)	-1.4	12 (16.7)	1.5		
Grow cotton:							44.06*	.49
Yes	16 (20.8)	**-6.3**	16 (51.6)	.5	54 (75.0)	**6.0**		
No	61 (79.2)	**6.3**	15 (48.4)	-.5	18 (25.0)	**-6.0**		

*$p<.05$; Means with different subscripts (in rows) differ significantly at $p<.05$ Tukey HSD; *r*=Pearson's correlation coefficient; *r*=.10 indicates effect size is small, *r*=.30 is medium, *r*>.50 is large; Z_{Resid}=Adjusted standardised residual, where $Z_{Resid} > |2|$ is significant at $p<.05$

During spraying:

Demographic factor	Disengaged (n=20)		Partially engaged (n=135)		Engaged (n=25)		Segment differences	
	mean	SD	mean	SD	mean	SD	*F*	*r*
Age (years)	43.8	10.6	47.2	10.5	46.9	10.6	.91	-
Area sprayed (ha)	18,800	43,789	21,246	87,488	27,381	43,769	.08	-
	n (%)	Z_{Resid}	n (%)	Z_{Resid}	n (%)	Z_{Resid}	X^2	*r*
Location:							10.14	-
Central Qld	1 (5.0)	-1.1	18 (13.3)	.4	4 (16.0)	.5		
Darling Downs	6 (30.0)	1.2	25 (18.5)	-.9	5 (20.0)	.0		
SW Qld	0 (0.0)	-1.2	9 (6.7)	.5	2 (8.0)	.4		
NW NSW	5 (25.0)	.7	24 (17.8)	-1.0	6 (24.0)	.6		
Namoi	1 (5.0)	-.6	12 (8.9)	.5	2 (8.0)	-.1		
Macquarie/Lachlan	2 (10.0)	-.2	14 (10.4)	-.5	4 (16.0)	.8		
Murrumbidgee	5 (25.0)	1.0	25 (18.5)	.8	1 (4.0)	-1.9		
Murray	0 (0.0)	-1.1	8 (5.9)	1.0	1 (4.0)	-.2		
Sprayer type:							6.34	-
Did own spraying	9 (45.0)	-1.2	76 (56.3)	-.4	18 (72.0)	1.6		
Staff did spraying	8 (40.0)	.9	43 (31.9)	.4	5 (20.0)	-1.3		
Contractor	3 (15.0)	.8	16 (11.8)	-1.3	2 (8.0)	.9		
Grow cotton:							.90	-
Yes	10 (50.0)	.2	62 (45.9)	-.9	14 (56.0)	.9		
No	10 (50.0)	-.2	73 (54.1)	.9	11 (44.0)	-.9		

*p<.05; r=Pearson's correlation coefficient; r=.10 indicates effect size is small, r=.30 is medium, r>.50 is large; Z_{Resid}=Adjusted standardised residual, where Z_{Resid} >|2| is significant at p<.05

After spraying:

Demographic factor	Disengaged (n=44)		Engaged (n=136)		Segment differences	
	mean	SD	mean	SD	*F*	*r*
Age (years)	43.6[a]	11.1	47.8[b]	10.2	5.40*	.20
Property area (ha)	15,224	31,286	23,962	88,796	.41	-
	%	Z_{Resid}	%	Z_{Resid}	X^2	*r*
Location:					7.05	-
Central Qld	7 (15.9)	.7	16 (11.8)	-.7		
Darling Downs	7 (15.9)	-.8	29 (21.3)	.8		
SW Qld	5 (11.4)	1.7	6 (4.4)	-1.7		
NW NSW	8 (18.2)	-.2	27 (19.9)	.2		
Namoi	3 (6.8)	-.4	12 (8.8)	.4		
Macquarie/Lachlan	6 (13.6)	.6	14 (10.3)	-.6		
Murrumbidgee	8 (18.2)	.2	23 (16.9)	-.2		
Murray	0 (0.0)	-1.8	9 (6.2)	1.8		
Sprayer type:					2.61	-
Did own spraying	27 (61.4)	.6	76 (55.9)	-6		
Staff did spraying	11 (25.0)	1.0	45 (33.1)	-1.0		
Contractor	6 (13.6)	.9	15 (11.0)	-.9		
Grow cotton:					.47	-
Yes	23 (52.3)	.7	63 (46.3)	-.7		
No	21 (47.7)	-.7	73 (53.7)	.7		

*p<.05; Means with different subscripts (in rows) differ significantly at p<.05 Tukey HSD; r=Pearson's correlation coefficient; r=.10 indicates effect size is small, r=.30 is medium, r>.50 is large; Z_{Resid}=Adjusted standardised residual, where $Z_{Resid} > |2|$ is significant at p<.05

Appendix 8: Example of the use of persuasive communication elements

From 'Piloting a CBSM-informed strategy for Tropical soda apple control in the Clarence Valley' - Elissa van Oosterhout, NSW DPI 2016.

Important elements used by the cards: 1) use of large motivational images rather than "issue" images, 2) minimal text, 3) use of motivational quotes drawn from the main benefits as described by landholders dealing with the issue, and 4) addressing the four main barriers as identified by landholders dealing with the issue.