The provision of pest and disease information using Information Communication Tools (ICT); an Australian example

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A B S T R A C T

The Australian grains industry relies on growers and agronomists to report endemic pest and disease issues in their crops to their local agriculture department and to also report anything that appears unusual. Previous work conducted by Wright et al., (2016), demonstrated that 70% of growers and 80% of agronomists could identify endemic diseases in crops. However, skills in identifying high priority pests and diseases that can cause major threats were very low. To improve the surveillance and reporting skills of growers and agronomists the use of information communication tools (ICT) was explored. These tools included; webinars, YouTube videos, podcasts and a mobile app.

A survey was conducted with growers and agronomists within the Australian grains industry to determine if they use smartphones or tablets, the Internet and mobile apps. Currently there is a digital divide in Australia as individuals in major cities have better access to Internet services than those in rural regions. In our survey, agronomists accessed the Internet more frequently than growers, and those participants with a university education accessed the Internet more frequently. There was no demographic influence on the usage of apps by participants.

A suite of apps was developed by the Department of Agriculture and Food, Western Australia called MyPestGuide (MPG) suite. In this suite there are a number of different tools, one of them being MPG Reporter. This app was promoted to encourage growers, agronomists and the general public to report anything unusual in their crops, gardens, parks or local bushland. This app was also used during a recent outbreak of Russian Wheat Aphid (Diuraphis noxia (Mordvilko)) (RWA) in South Australia in June 2016. Western Australia asked all growers, agronomists and departmental staff to send in reports of presence and absence of the aphid in crops during their seasonal work via the app. Approximately 500 reports were made, supporting the absence of this pest in Western Australian crops.

Ten webinars were held during the 2015 growing season and 2016 growing season on topical pest and disease issues in Western Australian grain crops. These webinars were converted to YouTube videos that proved to be very successful with agronomists, as they provided a source of readily available information that was up-to-date. The use of podcasts was trialled during the 2016 growing season for those participants in regional areas that have poor Internet access. Information on RWA was provided to growers and agronomists for the first time using webinars and YouTube videos. The YouTube video was the most frequently watched video out of all the videos produced.

Our research has shown, that growers and agronomists are very receptive to the use of ICT as a method to provide immediate and up-to-date information in relation to pest and diseases in crops.

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1. Introduction

1.1. Biosecurity and pest and disease identification

The impact of pests and diseases on the grains industry in
Australia is estimated to be $77 (AUD) per hectare annually. These losses represent 19.5% of the average annual value of the crop production over the last decade (Murray and Brennan, 2009a; b; 2012). Improving the knowledge and skills of growers and agronomists could be important for reducing these losses. However, it is not always easy for growers and agronomists to access training courses due to time commitments, degree of interest and the availability of information and training in a format that is perceived to be useful (Wright, 2017). An alternative to attending a training event is needed that will enable the skills and capacity of growers and agronomists to be increased.

The Australian grains industry relies upon growers and agronomists being aware of pests and diseases in their crops and notifying their local State Agricultural department when they suspect there has been an incursion of a high priority pest (HPP). This is to facilitate the effective management of endemic diseases and pests and to prevent the incursion and establishment of biosecurity threats (Hammond et al., 2016a; b; Wright et al., 2016a). Based on the requirement for accurate identification, a training needs analysis (TNA) was conducted by Wright et al. (2016a) on the ability of growers and agronomists in the Australian grains industry to recognise endemic leaf diseases in their crops. The TNA showed that benchmarks of 70 and 80% for growers and agronomists respectively were met for the identification of endemic leaf diseases in their crops. However, the ability of growers and agronomists to recognise the top four high priority pest threats to the grains industry was well below expectations (Hammond et al., 2016a; Wright et al., 2016a).

Russian Wheat Aphid (Diaphorina noxia (Mordvilko)) was one of the top four high priority pests in the Australian Grains Industry (Plant Health Australia, 2016). This pest was detected and identified in Australia for the first time in June 2016 in the mid-north region of South Australia (PIRSA, 2016). This detection meant that the other States in Australia undertook surveillance of wheat and barley crops and other potential grass hosts to determine the spread of the pest. This new incursion provided the opportunity to test if information communication technology tools (ICT) could be used for providing information in relation to the surveillance and reporting of pests and diseases in crops.

### 1.2. Information Communication Technology tools

Web 2.0 technologies enable online sharing, collaboration and networking to occur throughout the world in both developing and developed countries (Aker, 2011; James, 2009; Rhoades and Aue, 2010). Information communication technology (ICT) tools have enabled and created changes in the way information is transferred to people in developing and developed countries (Aker, 2011; Formiga et al., 2014; James, 2009; Rhoades and Aue, 2010; Wright et al., 2016b). Tools considered in our research paper included the use of webinars, mobile apps, YouTube videos and podcasts. Webinars and YouTube videos allow extension to reach more individuals and provide education over large geographic areas (Johnson and Schumacher, 2016). Webinars are an excellent communication tool as they allow two-way communication and therefore interaction to occur between participants and the presenter (Formiga et al., 2014; James, 2009). The interaction occurs between participants either verbally or by typing questions, and the use of webcams allows participants to see each other. YouTube videos however, do not provide the two-way communication between the presenter and the audience.

Formiga et al. (2014) evaluated the use of webinars in an eOrganic program for the USA and found that they reached a very large audience of farmers, extension educators, agricultural professional, researchers and some students. In the USA many farmers now have access to high speed Internet, and are more likely to access webinars. The use of email newsletters were the best way to inform participants within the industry about webinars whilst social media only generated one percent of their webinar participants (Formiga et al., 2014). In this study, Formiga et al. (2014) found that growers were not interested in research-based webinars; they preferred webinars that provided practical recommendations based on research. When participants were surveyed after the webinars, it was demonstrated that knowledge had increased and some participants had changed their working practices in response to the information in the webinar (Formiga et al., 2014; James, 2009; Johnson and Schumacher, 2016).

Access to ICT has increased with the increase of mobile phone ownership in the last decade regardless of whether they are smart phones or not (Aker, 2011; Walter, 2011). In developing countries such as in sub-Saharan Africa, Asia and Latin America, more than 60% of the population had access to mobile phones (Aker, 2011), and in rural regions of developed countries mobile phone ownership is approximately 90%. In the USA, Walter (2011) showed that 94% of farmers had a mobile phone and 70% of them used it to access the Internet. However, in the USA, Australia and Europe the digital divide still exists between urban and rural areas (Salemink et al., 2012; Willis and Tranter, 2006); access to the Internet is not equal for all. Access to the Internet is generally available through telephone lines, however, cable Internet, fibre optics and mobile broadband are widely available except in rural areas (Salemink et al., 2017). In Australia, although mobile phone coverage is expanding in rural regions, according to the Telstra coverage map (https://www.telstra.com.au/coverage-networks/our-coverage, accessed on the 23rd October 2016) most of the Western Australian wheatbelt only has 3G connectivity and some areas require a 3G external antenna for reception on their mobile devices. Eastern Australia appears to have more 4G device coverage in rural areas however, the majority is still relies on 3G connectivity. Thomas et al. (2016) found that there was a difference among states in Australia in the percentage of households that have access to the Internet; those that live in cities have are more likely to have access compared to those that live in regional Australia. Indeed, 88% of households in major cities have access, 82% of those living in inner regional and 79% of those in outer regional areas Australia, have access respectively (Thomas et al., 2016). Over 50% of people in the regional areas of Australia rate their internet coverage as very poor, and this affects their ability to connect to ICT initiatives, and is therefore reducing their production efficiency (Vidot, 2016).

Mobile apps can be grouped into three categories: a) information delivery; b) collaborative research; and c) decision support tool (Drill, 2012). Information delivery means that the user can access information when they want to (Drill, 2012). The Department of Agriculture and Food, Western Australia (DAFWA) developed the My Pest Guide suite of apps (MPG), as a set of tools that enables two-way collaboration between participants and DAFWA researchers. The apps function on both Apple and android devices and the suite has a selection of information delivery tools (MPG Guides) that contain information on major pests and diseases in crops. There are three MPG guides: a) Crops which contains 202 pests of grain crops; b) Grapes which contains 138 pests and diseases associate with table and wine grapes and c) Diseases which contains common diseases along with high priority pests on grain crops. Another component of MPG is the reporting function (MPG Reporter); photos can be taken and uploaded to a database in DAFWA where it is then reviewed by the relevant entomologist and/or pathologist and an email is sent back to the participant with the identification of the pest and/or disease found in their crop and the information is mapped. When using MPG reporter the participant does not need to be in mobile data range when they make a report. The report
It is very important when using ICT in agricultural extension to:
a) know your audience and use multiple channels to reach them, b) emotionally connect with your audience to build trust, meet their needs and respond to their feedback and c) provide actionable products that can be used by all (Bell, 2015; Formiga et al., 2014; James, 2009; Johnson and Schumacher, 2016; Vignare, 2013).

The goal of this study was to determine if ICT tools would be used by growers and agronomists within the Australian grains industry for information on pest and diseases in crops. This was done by firstly conducting a survey: a) on smart phone or tablet ownership; b) the use of the Internet and c) the influence of the demographic profiles of participants’ usage of ICT. Secondly, webinars were held on topical issues that occurred during the growing season, and these were then converted to YouTube videos and made available to all participants within the Australian grains industry. Podcasts were also developed along with the webinars and YouTube videos in the second year of the trial. Thirdly, the use of MPG as a surveillance tool was trialled in 2016. The success and failures of this research are reported in this paper.

2. Materials and methods

2.1. Surveys on the use of ICT tools

The work reported here is part of a larger project examining the training needs of growers and agronomists within the Australian grains industry in relation to pest and diseases in their crops (Wright, 2017). Two questionnaires were developed assess the training needs of growers and agronomists. One questionnaire targeted growers and the other questionnaire was targeted to agronomists, as their training needs could be quite different. The questionnaires consisted of six sections that examined: A) how they like to obtain information, B) the types of training that they had attended in the previous 12 months, C) pest and diseases in their crops, D) knowledge levels of diseases in crops, E) knowledge level of biosecurity threats and F) demographic information.

The survey was administered using Qualtrics (Qualtrics, Provo, UT) and developed following the principles of Fowler (2009) and Dillman et al. (2009); using questions which were simple and easy to understand and provide reliable and valid measures.

For this study, a grower was defined as a person who works and farms land to produce grain crops. An agronomist was defined as a person employed by grain growers to provide technical information in relation to grain crop production. The information provided by agronomists to growers includes recommendations for fertiliser application, implementation of fungicide, insecticide and herbicide spray programmes and general crop husbandry advice (Wright et al., 2016a).

For this research paper, the results from the following two sections of the questionnaires were analysed and reported:

1) Section A, Questions 2, 3, 4, 5 and 6 (Appendix A) asked growers and agronomists how often they used electronic media when looking for information about farming issues. They were given a list of nine sources and were asked to indicate if they used the source daily, monthly, quarterly, twice a year, once a year or never. Sources included Blogs, chat groups, PestFax, GRDC news feed, podcasts, twitter, and YouTube. Question 3 asked how often they used the Internet to look for information in relation to crops and cropping. Question 4 asked if they owned a smart phone or tablet. Question 5 asked how often they used mobile applications (apps) to help with their day-to-day work and then question 6 asked them to name the top three mobile apps that they used.

PestFax/PestFacts is a state based newsletter service, which operates during the growing season, enabling growers and agronomists to report what they have seen in crops. These reports are verified by an entomologist or pathologist, collated on a weekly basis and distributed to subscribers by email. It is provided as a free service.

GRDC News feed is a service provided by the Grains Research and Development Corporation to all participants within the grains industry. It uses a Rich Site Summary (RSS) feed that participants subscribe to, and new information is automatically downloaded to their smart phone, tablet or computer. There are a number of different electronic newsletters, podcasts offered by GRDC through this service.

2) The final section (Section F) of the questionnaire collected demographic information from the participants (Questions 41, 43, 44, and 47 in Appendix A).

The pretesting and piloting of the questionnaires has been reported in Wright et al. (2016a); Approval for this work was gained from the Human Research Ethics Committee of The University of Western Australia (RA/4/1/6607). The questionnaires were distributed as an on-line questionnaire, and paper-based questionnaire handed out at regional meetings during March 2014, and posted to growers and agronomists from the Birchip Cropping Group. Further details on the distribution of the questionnaires are reported in Wright et al. (2016a).

2.1.1. Provision of Webinars, YouTube videos and podcasts

In June 2015, the use of webinars and YouTube videos was trialled as a method to provide information on pest and disease issues to growers and agronomists in a timely manner. Seven webinars were held from June 2015 until August 2015 and three in June and July 2016 when major pest and disease issues were occurring in crops in the Western Australian wheatbelt. Topics were selected from reports that were highlighted in PestFax as an emerging issue. For example, a webinar on how to identify RWA in crops and grass weeds was held on the 10th June 2016, a week after the report of RWA being detected in South Australia.

Training needed to be provided to the pathologists and entomologists who were giving presentations in the webinars. Because of the reduced Internet access in many regional areas of Western Australia after some discussions with growers it was decided to flip the presentations so that the key messages were given in the first minute.

Participants were notified by email and through the PestFax service that a webinar would be held. They were also advertised using twitter through the Department of Agriculture and Food, Western Australia (DAFWA) account. Webinars were held using GoToWebinar (Citrix Systems, 2015), and recorded using their built-in software. The recordings from the webinars were then converted into YouTube videos using Final Cut Pro (version 10.2.3) before being uploaded to the YouTube Channel “Training Growers” (www.youtube.com/channel/UCGQqkODZkjfqCAwXgnAh-Og). Due to the restrictions imposed on developing digital content in the workplace, the lead author of this paper created an independent YouTube Channel (Training Growers) in 2015.

The availability of the YouTube video was emailed (with a hyperlink) to participants and the hyperlink was also provided in PestFax. Upon demonstrating the success of the YouTube videos developed, these videos previously and subsequent developed were uploaded to the Department’s official YouTube channel in 2016. From reports in Wright et al. (2016a) (www.youtube.com/playlist?list=PLJRsVC3L9GNla2ao6hVx8B8MzIzpCXfbi7y), providing two different channels for the videos to be watched.

In May 2016, six podcasts were trialled as an alternative
information source for growers in regional Western Australia. The 
podcasts were loaded onto the DAFWA website (www.agric.wa.gov. 
au) and more recently onto the Field Crop Disease Community hub 

2.1.2. **MyPestGuide app**

The use of MPG reporter function as a surveillance tool was 
trialled from June 2016 until November 2016. This app was pro-
moted as a tool that could be used to report the presence or absence 
of aphids in crops whilst participants from the grains industry were 
working in cereal crops.

2.2. **Data analysis**

The data from the survey were compiled using Qualtrics soft-
ware, 2013. Statistical Package for the Social Sciences (SPSS) (IBM 
ver. 23) was used to analyse the data using cross tabulation and 
Pearson’s Chi-Square (X²) to determine the influence of occupation, 
age, gender, education level and location on the use of electronic 
media. If Pearson’s Chi-Square failed the assumption that more 
than 20% of the cells had a frequency count of less than 5 then 
Fisher’s exact test was used in its place.

The demographic data formed the following variables used in 
the data analysis: **Age** (<30 years, 31–50 years, >51 years); **Education 
level** (school, vocational education training (VET), University); 
**Occupation** (grower, agronomist); **Location** (Western and 
Eastern Australia) and **Gender** (male, female). A hierarchical Log-
linear analysis was then done to determine if there was an inter-
action between occupations, phone ownership, location and 
Internet usage.

The overall response rate of useable questionnaires was esti-
imated to be 26% because it was not possible to accurately deter-
mine the number of people who received the request to complete 
the survey online (Wright et al., 2016a). Questionnaires with 
complete demographic data (n = 47) such as no postcode were 
not included in the analysis. Due to the low number of returns from 
Queensland, New South Wales, Victoria and South Australia the 
data collected from these states were combined together to form 
“Eastern Australia” (EA) study area which was used in the corre-
sponding cross tabulation and Pearson’s Chi-Square analysis.

The short answer question was coded into themes using an 
inductive approach informed by previous research and developed 
incrementally (Holliman, 2005). Frequency counts were then used 
on these themes to determine the most frequently used mobile 
apps by participants.

Data for the webinars were provided by GoToWebinar statistics 
associated with the software. YouTube and podcast usage infor-
mation were provided by Google analytics.

The MPG Reports on presence or absence of RWA, diseases in 
gains crops, trials and volunteer cereals made during the period 
from 1 June 2016 to 31 October 2016 were summarised using the 
statistical software environment R (version 3.3.0) using the 
reshape2, plyr, and dplyr packages for data analysis, and the 
ggplot2, ggmap and RColorBrewer packages for geocoding data, 
and generating plots and maps of the results (Kahle and Wickham, 
2013; Neuwirth, 2013; R Development Core Team, 2008; Wickham, 

3. **Results**

3.1. **Response rate to survey**

The number of growers within the Australian grains industry is 
estimated to be 31,400, with 5004 farms within the “Eastern 
Australia” (EA) area used for this survey, and 4719 farms within the

area of Western Australia surveyed (WA) (Australian Bureau of Statistics, 2012). The number of agronomists within the EA study 
area is estimated at 548, and 100 within WA (Keogh and Julian, 
2014). The sample size based on the return rate was 1.8% for growers, and 47% for agronomists in Western Australia. For the EA 
study area the sample size was 0.7% for growers and 10.6% for 
agronomists (Wright, 2017).

3.2. **Survey on the use of ICT tools**

3.2.1. **Smart phones and tablet ownership and using the Internet**

Information on the ownership of smart phones or tablets was 
collected along with how much the internet or mobile apps were 
used in day to day work on the farm. There were no significant 
differences between gender and the ownership of smart phones/ 
tables, the use of the Internet and the use of mobile apps.

A Pearson Chi Squared analysis showed that there was a signi-
nificant difference between smart phone/tablet ownership and the 
frequency of use of the Internet; 63.3% of owners used the Internet 
frequently compared to 8.5% who did not use the Internet (X²: (2, 
n = 248), = 17.27, p ≤ 0.001) (Fig. 1).

There was no significant difference between growers and 
agronomists for ownership of smart phones/tablets. However, there was a significant difference between growers and agrono-
mists in the usage of the Internet (Fig. 2A); agronomists (77%) used 
the Internet more frequently than growers (45.2%) (X²: (2, 
n = 248), = 31.10, p ≤ 0.001).

There was no significant differences between smart phone/ 
tablet ownership and education level obtained. There was however, 
a significant difference between education levels and the frequency 
of use of the Internet (Fig. 2B). University educated participants 
(71%) used the Internet on a frequent basis compared to 55% of VET 
educated and 42% of School educated participants (X²: (2, 
n = 248), = 20.384, p ≤ 0.001).

There was a significant difference between the age groups 
and ownership of a smart phone/tablet. Only 70% of those over the 
age of 51 years owned a smart phone/tablet compared to 84% of those 
that were less than 51 years of age (X²: (2, n = 248), = 6.645, 
p ≤ 0.05). There was a significant difference between age groups 
and the usage of the Internet (Fig. 2C); 77% of participants who 
were less than 30 years of age, used the internet on a frequent basis 
compared to 61% of those between 31 and 50 years of age, and 50% 
of those over 51 years of age (X²: (2, n = 248), = 15.3, p ≤ 0.05).

A hierarchical log linear analysis was conducted to determine if 
there was an interaction between Occupation (O, grower/agrono-
mist), Internet usage (I), phone ownership (P) and Location (L, 
Eastern/Western Australia). The hierarchal analysis from the satu-
rated model showed that a four-way interaction (O x I x P x L) was 
not significant. However, a model that included a three-way

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interaction (O x P x L) was significant, \(X^2; (9, n = 241) = 26.081, p \leq 0.05\). This three-way interaction and the two-way interactions and their corresponding Chi Square results are shown in Table 1. The 1-way effects of individual variables are not shown as these are assumed to contribute to the 2-way interactions.

The three-way interaction between occupation, smart phone ownership and location showed that there was a significant difference between percentage of participants in WA and EA that own smartphones or tablets; 82% of participants from WA owned smart phones compared to 76% in EA \(X^2; (9, n = 241) = 26.081, p \leq 0.05\).

3.2.2. The use of mobile apps

The most popular apps used by growers and agronomists are listed in Table 2. Apps were coded into themes using an inductive approach. However, they did not all use the same app by name, as there were three or four different ones under different names that did the same thing. For example, a weather app used is either: a) Bureau of Meteorology (BOM); b) Weatherzone; c) Accuweather; d) Wallyweather; and e) Elders weather. The demographic variables age, education level, occupation and location did not influence \((p > 0.05)\) the use of mobile apps amongst the participants.

3.2.3. Use of electronic media by growers and agronomists

There were no significant differences between growers and agronomists in their usage of chat groups, GRDC news feed, podcasts and other forms of electronic media except PestFax (Fig. 3). All of these options were used infrequently, apart from the GRDC news feed. This tool was used on a regular basis (approx once a month), by over half of the agronomists and growers. Only 4% of growers and agronomists used it frequently (once a week).

There was a significant difference in the usage of PestFax/Pest-Facts by growers and agronomists; 10% of agronomists would use it frequently (once a week) whilst only 1.5% of growers would use it that frequently \((X^2; (2, n = 247), = 26.37, p \leq 0.001)\).

There was a significant difference between agronomists and growers in the use of Facebook and Twitter to solve problems. Facebook (23.6% agronomists compared to 12.6% growers) was used on a regular basis \((X^2; (2, n = 245), = 6.99, p < 0.05)\) and Twitter (14.4% agronomists compared to 6.7% growers) was used on a regular basis \((X^2; (2, n = 246), = 12.014, p < 0.05)\).

There was a significant difference in the usage of YouTube by agronomists (47.3%) compared to growers (29.6%) as an information source on a regular basis \((X^2; (2, n = 246), = 9.054, p < 0.05)\) to solve problems on the farm.

3.3. Provision of Webinars, YouTube videos and podcasts

The use of webinars as an information source for growers and agronomists in Western Australia had very mixed results (Table 3). No growers attended the webinars, however, agronomists did attend. For many of the agronomists, the timing of the webinars was difficult. Feedback suggested that they should be run at 7:30 a.m. on a Monday morning, when all agronomists were generally in the office.

The YouTube videos produced from the webinars as an information source are shown in Table 4. The number of views indicate that the videos were accessed and watched on average for 2–3 min (16–41% of the total length of individual videos were watched); suggesting that the key messages that were given in the first minute of the talk were watched, and then people proceeded to watch the rest if interested or had the time. The videos developed and uploaded in 2015, were still being accessed and watched in 2016 (Table 4), indicating that the key messages are still valid and important to participants within the grains industry.

A greater in depth analysis from Google analytics was done on the RWA webinar statistics. The webinar was watched by 70 people and two regional DAFWA offices provided streaming to multiple participants. YouTube analytics from the DAFWA channel showed that 101 people accessed the video from the link in PestFax, 169 people accessed it from other websites or links, 76 found it through another YouTube related video, 65 found it through YouTube search function. Only 10 people watched it from a twitter link or a Facebook link.

The podcast page on the DAFWA website had 26 clicks from the PestFax newsletter and 185 people viewed the page. The average time spent on the page was 3 min suggesting that one or some of the podcasts had been listened too.

3.4. The use of MPG App

Since 2015 until the end of November 2016, over 18,000 reports had been made using the MPG Reporter app. A survey for RWA in Western Australia using MPG Reporter app ran from 01 July 2016 until the end of the growing season (31 October 2016). Growers, agronomists and DAFWA staff were asked to report detection and absences of all aphids in cereal crops and roadside Poaceae weeds. A total of 508 aphid related reports were received using the MyPestGuide Reporter app between 01 June 2016 and 31 October 2016. Of these reports 379 were absence reports and 129 were reports of other species of aphids occurring on potential hosts of RWA. Categorisation of the clients making reports to an occupation group was based on email addresses, i.e. those with a company address were assigned to the state department or to an agronomy company and the remainder to individuals assumed to be growers. Of the clients that sent reports, 406 (79.9%) were from state department staff, 73 (14.4%) reports were received from 18 agronomists and 29 (5.7%) reports were made from 6 individuals assumed to be growers. A total of 46 diseases in grain crops, trials involving grain crops and on volunteer cereal hosts were made through MPG Reporter app during the same time frame as the RWA reports. Nine DAFWA staff reported 20 times, ten agronomists made 24 reports and there were two reports from two individuals that were assumed to be growers.

4. Discussion

Our research is the first in the peer-reviewed literature focusing on the use of ICT tools for both growers and agronomists in the

![Fig. 1. The frequency of Internet usage by participants who own smart phones. 199 participants own smartphones and/or tablets out of the 248 surveyed \((p \leq 0.001)\). Frequently referred to daily or weekly basis and regularly equalled on a monthly basis.](image-url)
Australian grains industry to provide information and training on pests and diseases in the Australian grains industry. The influence of participants' demographics on the ownership of smart phones and tablets and the use of the Internet is discussed first. The use of ICT tools to provide information on pests and diseases in crops is then discussed.

4.1. Survey on smart phone, and tablet ownership and the use of the Internet

Our research showed that there was no significant difference between growers and agronomists on the ownership of smart phones and tablets, however there was a significant difference in occupation, education level and age on the use of the Internet by participants in the Australian grains industry.

Fig. 2. The influence of the demographics occupation, education level and age on the use of the Internet by participants in the Australian grains Industry. A) Agronomists use the Internet more frequently than growers ($p ≤ 0.001$). B) Participants with a University education level used the Internet more frequently than those who had a lower education level ($p ≤ 0.001$). C) Participants older than 51 years of age used the Internet less frequently than those younger ($p ≤ 0.05$).

Table 2
Frequency of type of mobile app used by participants in the Australian grains industry. Apps were coded into themes using an inductive approach. Apps are listed in order of most popular first choice.

<table>
<thead>
<tr>
<th>Mobile App type</th>
<th>1st Selection (% participants)</th>
<th>2nd Selection (% participants)</th>
<th>3rd Selection (% participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
<td>30.6</td>
<td>16.7</td>
<td>10.9</td>
</tr>
<tr>
<td>Other (all others not allocated to another category)</td>
<td>23.5</td>
<td>32.7</td>
<td>36.7</td>
</tr>
<tr>
<td>Paddock management</td>
<td>16.5</td>
<td>6</td>
<td>7.8</td>
</tr>
<tr>
<td>Pest ID</td>
<td>4.7</td>
<td>6</td>
<td>4.7</td>
</tr>
<tr>
<td>Spray</td>
<td>3.5</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>Soil Maps</td>
<td>3.5</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>National Variety Trials</td>
<td>2.9</td>
<td>3.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Grain marketing</td>
<td>2.9</td>
<td>6.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Ag Companies</td>
<td>2.9</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>Disease ID</td>
<td>2.4</td>
<td>3.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Weed ID</td>
<td>1.8</td>
<td>10.7</td>
<td>9.4</td>
</tr>
<tr>
<td>Australian Pesticides and Veterinary Medicines Authority (AVPMA)</td>
<td>0.6</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>News</td>
<td>0.6</td>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>Grains Research Development Corporation</td>
<td>0</td>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>Nutrient</td>
<td>0</td>
<td>1.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Nozzle size for spraying</td>
<td>0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>Rarely used apps</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Do not use apps</td>
<td>2.9</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Walter (2011) found that 94% of growers in the USA have a smart phone and 33% of the respondents use their smart phone to access the Internet daily. The USA has extended and upgraded its services within regional areas and there are very few that remain on dialup Internet (Formiga et al., 2014). There is no other literature that has compared the usage of smart phones between growers and agronomists within developed countries. The finding in our research showed that there is a difference in usage between growers and agronomists and this was expected because of the digital divide between urban areas and regional areas within Australia and most agronomists are based within the town centres of regional areas that have better Internet access than growers who generally reside further from regional centres (Thomas et al., 2016).

Our research has shown that there is a significant difference between age and ownership of smart phones and the usage of the Internet. This trend is no different to what has been shown in the general population of Australia; people who are under 50 years of age are more likely to own a smart phone than those who are older than 50 years (Sensis, 2015). This report also found that people older than 50 years of age use the Internet less frequently than those younger. Less than 80% of participants older than 50 years accessed the internet daily (Sensis, 2015).

In the 2015 Sensis report, there is a difference between Internet usage in Western Australia and Victoria; 72% of people from WA accessed the Internet daily compared to 82% from Victoria (Sensis, 2015). There is also division between States and the percentage of households that have access to the Internet. Those that live in cities are more likely to have access compared to those that live in regional Australia; 88% of households in major cities have access, 82% for those living in inner regional and 79% for those in outer regional areas Australia (Thomas et al., 2016). Over 50% of people in the regional areas of Australia rate their internet coverage as very poor. This affects their ability to connect to the Internet, and is impacting on their production efficiency (Vidot, 2016).
Australian wheatbelt is amongst the least digitally connected areas of Australia along with the Eyre Peninsula in South Australia, and northern Victoria (Thomas et al., 2016). In contrast, in our research the hierarchical loglinear analysis showed that there was no interaction between occupation, Internet usage and location, and the hierarchical loglinear analysis showed that there was no influence of location on smart phone ownership or on the use of the Internet. This maybe due to the sample size of the survey not being large enough for the differences to be apparent.

Our research showed that the education level of participants influenced the use of the Internet. These results correspond to other reports in the literature. The report on Measuring Australia’s Digital Divide found that people with less than secondary education qualifications such as a Bachelor Degree have a strong influence on Internet use (Thomas et al., 2016; Willis and Schumacher, 2016) they found participants had an increase in knowledge and some changed their behaviour when they participated in webinar programs on financial awareness. In our research we trialled two different methods to survey the participants after the webinars. The first method used GoToWebinar survey function that is built into the program. This function automatically sends out an email when the webinar has finished and requests the participants to complete the survey. Survey monkey was also trialled and the same proportion of responses was received. Most of the feedback from the webinars and YouTube videos occurred via emails or phone calls; and was commonly of the sentiment:

**Table 4**

<table>
<thead>
<tr>
<th>YouTube video</th>
<th>Date</th>
<th>Number views 2015</th>
<th>Number views 2016</th>
<th>Average view duration (minutes)</th>
<th>Length of YouTube video (mins)</th>
<th>Percentage of video watched (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLEM resistance</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; July 2015</td>
<td>65</td>
<td>9</td>
<td>2.08</td>
<td>10.27</td>
<td>20</td>
</tr>
<tr>
<td>Slugs in canola</td>
<td>6&lt;sup&gt;th&lt;/sup&gt; July 2015</td>
<td>56</td>
<td>12</td>
<td>2.10</td>
<td>8.38</td>
<td>25</td>
</tr>
<tr>
<td>Barley leaf rust update</td>
<td>23&lt;sup&gt;rd&lt;/sup&gt; July 2015</td>
<td>162</td>
<td>33</td>
<td>2.17</td>
<td>7.38</td>
<td>29</td>
</tr>
<tr>
<td>Aphids in your crop</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; August 2015</td>
<td>31</td>
<td>45</td>
<td>4.35</td>
<td>10.51</td>
<td>41</td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>23&lt;sup&gt;rd&lt;/sup&gt; August 2015</td>
<td>40</td>
<td>101</td>
<td>3.32</td>
<td>13.58</td>
<td>24</td>
</tr>
<tr>
<td>Powdery Mildew in Wheat</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; August 2015</td>
<td>199</td>
<td>92</td>
<td>8.02</td>
<td>20.05</td>
<td>40</td>
</tr>
<tr>
<td>Wheat Streak Mosaic Virus</td>
<td>16&lt;sup&gt;th&lt;/sup&gt; August 2015</td>
<td>38</td>
<td>43</td>
<td>2.27</td>
<td>10.10</td>
<td>22</td>
</tr>
<tr>
<td>Ruts in your wheat crop</td>
<td>26&lt;sup&gt;th&lt;/sup&gt; August 2015</td>
<td>97</td>
<td>25</td>
<td>4.52</td>
<td>18.50</td>
<td>24</td>
</tr>
<tr>
<td>Rhizoctonia in your paddocks</td>
<td>31&lt;sup&gt;st&lt;/sup&gt; August 2015</td>
<td>80</td>
<td>101</td>
<td>1.30</td>
<td>8.14</td>
<td>16</td>
</tr>
<tr>
<td>Russian Wheat aphid</td>
<td>10&lt;sup&gt;th&lt;/sup&gt; June 2016</td>
<td>103 (377)</td>
<td>103 (377)</td>
<td>3.45 (2.54)</td>
<td>12.04</td>
<td>29</td>
</tr>
<tr>
<td>The implications of Powdery Mildew in wheat for this season 2016</td>
<td>29 (107)</td>
<td>3.46 (3.53)</td>
<td>16.28</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>11&lt;sup&gt;th&lt;/sup&gt; July 2016</td>
<td>58 (152)</td>
<td>5.54 (4.34)</td>
<td>17.52</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Snails Stopping the menace</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; July 2016</td>
<td>5 (43)</td>
<td>(3.25)</td>
<td>9.57</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>768</td>
<td>1335</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The implications of Powdery Mildew in wheat for this season 2016 messages included the main management options, which is what growers want to know (Formiga et al., 2014). The success of rearranging the content meant that those in areas with poor Internet coverage or slow download speeds could access the required information easily. The rest of the presentation described how the pest or disease influenced the crop production and how to manage these issues in greater depth, allowing for those with good Internet access to watch the rest of the YouTube video.

It is important to evaluate the effectiveness and longterm outcomes of webinars. In research conducted by Johnson and Schumacher (2016) they found participants had an increase in knowledge and some changed their behaviour when they participated in webinar programs on financial awareness. In our research we trialled two different methods to survey the participants after the webinars. The first method used GoToWebinar survey function that is built into the program. This function automatically sends out the survey to the participants and provides a report with the responses. Less than 10% of the participants responded to the survey. Survey monkey was also trialled and the same proportion of responses was received. Most of the feedback from the webinars and YouTube videos occurred via emails or phone calls; and was commonly of the sentiment:

4.2. Use of webinars, YouTube videos and podcasts

In June 2015, the use of webinars and YouTube videos to engage with agronomists and growers within Western Australia on emerging pest and disease issues was trialled. Webinar topics were selected from reports that were raised in the weekly electronic newsletter PestFax, so were topical for local growers and agronomists. Agronomists and DAFWA staff report issues they have seen in crops during the week to PestFax, which are then compiled into a weekly newsletter. Feedback from growers and agronomists showed that rearranging the content of the webinars so key messages were given in the first minute was more successful. These key messages included the main management options, which is what growers want to know (Formiga et al., 2014). The success of rearranging the content meant that those in areas with poor Internet coverage or slow download speeds could access the required information easily. The rest of the presentation described how the pest or disease influenced the crop production and how to manage these issues in greater depth, allowing for those with good Internet access to watch the rest of the YouTube video.

It is important to evaluate the effectiveness and longterm outcomes of webinars. In research conducted by Johnson and Schumacher (2016) they found participants had an increase in knowledge and some changed their behaviour when they participated in webinar programs on financial awareness. In our research we trialled two different methods to survey the participants after the webinars. The first method used GoToWebinar survey function that is built into the program. This function automatically sends out the survey to the participants and provides a report with the responses. Less than 10% of the participants responded to the survey. Survey monkey was also trialled and the same proportion of responses was received. Most of the feedback from the webinars and YouTube videos occurred via emails or phone calls; and was commonly of the sentiment:
“Sorry I missed the webinar, when will the YouTube video be ready”
Agronomist 1

“I have just watched the video on Powdery Mildew, it answered 75% of my questions, and I now have only one question to ask you”
Agronomist 2

These comments indicate the value placed by the agronomists on being able to go back to a resource and use it when required. This is further validated by the data that show videos produced in 2015 were still being viewed in 2016 (Table 4).

The most popular webinar and YouTube video was on the identification of Russian Wheat Aphid. This pest was not present in Australia until June 2016 when it was first detected in South Australia. This was the first time a webinar had been used to talk about the incursion of an exotic pest into Australia and what help was required from grain industry participants to survey crops. This webinar and YouTube video explained to growers and agronomists how to scout crops and how to recognise the pest. Western Australia needed all of the grain industry to be aware and report absence of RWA in their crops to provide evidence that the pest was not present in WA. This could only be done, if participants had the necessary skills to recognise aphids and scout crops. The use of the webinar and corresponding YouTube video provided the tools to upskill participants quickly and the availability of the MPG Reporter app provided a tool for reporting. The downside to using webinars and YouTube videos for increasing knowledge and skills remotely, is the lack of immediacy to determine if participants have gained these skills and knowledge. The MPG Reporter app can be used as a tool to monitor the skills and knowledge of the participants; the reporting of the presence or absence of aphids in crops with a corresponding photo provides information that can then be assessed.

It is not possible to draw conclusions from the results of the podcast trials. However, the initial results look promising and the development and release of the podcasts would need to continue for another growing season at least. Easier access will be required through the use of RSS feeds to encourage growers and agronomists to use them, rather than having to look for them on a website.

4.3. The use of MyPestGuide App

This is the first time that the results from using an app for a surveillance tool in Australia has been reported in the literature. The data collected from people using this app when in the field, was used to support the claim of absence status of RWA in Western Australia. The ease of using the app, and the fact that it does not require connectivity when in the field for participants to make the report helped to encourage participants to use this app (pers. comm. R. Emery, 2016). The community is regularly using the app to report insects, weeds and diseases seen in crops, in their gardens, local parks and native bushland by sending in photos. The reports are confirmed and identified by Department experts. The number of reports (>18,000) received in 18 months from the public, and the agricultural industry further validates the success of this app as a passive surveillance-reporting tool.

4.4. The use of ICT for up skilling growers and agronomists

Our research has shown that growers and agronomists are willing to make use of webinars, YouTube videos, and podcasts produced during the growing season. From feedback received, most have found these tools have been very useful in providing up-to-date information on local pest and disease issues. Many of the participants found the information useful and were able to implement management practices where needed. Further work needs to be done to fully determine the extent of improvement in the identification skills of growers and agronomists using these tools. This work would include another TNA to determine if the benchmark 70% of growers and 80% of agronomists can identify endemic diseases in crops, previously set by Wright et al. (2016a) has changed.

The number of reports made by industry in relation to the RWA outbreak using the MPG Reporter app was greater than expected and the data was used to support absence status for Western Australia. This work showed that apps can be used by industry and other people for passive surveillance work. The app allows feedback to occur to the participant using the app, which is very important when building trust and is seen as being responsive to a request (Bell, 2015; Formiga et al., 2014; James, 2009; Johnson and Schumacher, 2016; Vignare, 2013).

It is important when embarking on using ICT to ensure that procedures are in place to develop and deliver the tools in a timely manner. The immediacy of the information delivery, and being able to provide the information in different formats (ie YouTube videos and podcasts) ensures that the information is available to all participants within the grains industry, and again is seen as being responsive to a situation which helps to build trust within the community (Bell, 2015; Formiga et al., 2014; James, 2009; Johnson and Schumacher, 2016; Vignare, 2013).

5. Conclusion

The use of ICT tools to provide information to growers and agronomists within the Australian grains industry can be very successful. These tools provide information immediately, are easily accessed and are user friendly for all. However, it is important to: a) understand which tools the community would prefer to use; b) does everyone have access to these tools and c) will the community trust the information. The work discussed in this study met the needs of the community by rearranging the content of the YouTube videos and webinars, and by the provision of the podcasts for those that cannot access the videos due to the digital divide. The use of multiple media approaches to deliver information that is useable and friendly to participants in rural communities is demonstrated through the use of webinars, YouTube videos, podcasts and apps.

Conflicts of interest

Ms Dominie Wright, Dr Nichole Hammond, Mr Geoff Thomas, are employed by the Department of Agriculture and Food, Western Australia.

Acknowledgements

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The authors would like to acknowledge the work done by Dr Rob Emery, Dr Rosalie McCauley and Dr Laura Fagan in the developing of the MPG suite of tools, and the promotion of these tools, and being allowed to have access to the data to use in this research.

The authors would also like to thank all of the growers and agronomists that responded to the survey, and to all those that helped with piloting the survey.
Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cropro.2017.08.023.

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