Are we going against the grain in training?
Developing a training and information framework for farmers and agronomists in Australia

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Thesis declaration

I, Dominie Gabrielle Wright certify that:

This thesis has been substantially accomplished during enrolment in the degree.

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The research involving human data reported in this thesis was assessed and approved by The University of Western Australia Human Research Ethics Committee. Approval #: RA/4/1/6607.

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This thesis contains published work and/or work prepared for publication, some of which has been co-authored.

Signature: [Redacted]

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Abstract

The Australian grains industry relies on growers and agronomists being able to identify and manage endemic diseases in their crops and being aware of the possible threat of high priority pests (HPPs) becoming established in their crops. However, there is insufficient evidence to judge whether growers and agronomists within the industry have the skills and capacity to meet this expectation. I undertook a training needs analysis to determine the ability of growers and agronomists to identify endemic diseases and to recognise the top four HPPs threats in their crops. A benchmark of 70% for growers and 80% for agronomists was set: this corresponds to 70% of growers being able to identify endemic diseases in their crops and 80% of agronomists being able to identify the endemic diseases in crops. This is the first time a benchmark for pest and disease knowledge has been determined in the Australian grains industry. Both growers and agronomists met the benchmarks for identification of endemic diseases in crops. However, their knowledge of the top four HPPs was well below this benchmark. Thus, it would appear that providing information through knowledge transfer is insufficient to increase the knowledge of growers and agronomists and enable them to alert industry to a possible incursion of an HPP. Therefore, surveys were conducted to examine growers’ and agronomists’ preferences regarding the types and sources of information they preferred to use. The types of general information used were community-, training- or technical-based. To solve specific pest and disease problems, growers either used an agronomist or sourced publicly available information. Agronomists’ preferences were based on content and whether the information had a general, regional or a local focus.

A survey was conducted with growers and agronomists within the grains industry to determine what types of training activities they liked to attend, why they liked to attend them, and what barriers prevented them from attending. Occupation, gender, location and education influenced the number of field days attended. Participants found field days to be informative, interactive, and visual and an important opportunity to network with other farmers, colleagues and professional research officers. Agronomists preferred to attend formal workshops on agronomy and crop production issues such as herbicide application, pests and diseases. Workshops were valued because they were informative, interactive and local. Growers liked belonging to grower groups because they were local, interactive and informative and supported networking. Participants’ age and location influenced their membership of grower groups.

Field days and workshops were evaluated to determine if knowledge levels increased after they had been attended. Participants’ knowledge levels increased after the events...
but demographic variables such as occupation and education level influenced knowledge levels before the event.

Because it is difficult for many participants from rural communities to attend training events, the use of information technology communication tools to provide timely information was evaluated by testing the use of webinars, YouTube videos, and podcasts during two growing seasons in Western Australia. Outcomes varied depending on the event evaluated and the participants involved. Agronomists preferred using the webinars and YouTube videos as the information was provided in a timely manner allowing management strategies to be implemented. Podcasts were developed during the second season following feedback from growers.

This research demonstrated that it is important to provide information and learning opportunities to rural communities, growers and agronomists in different formats. Effective training requires that there is time for participants to reflect, and interact at training events, and that post-event information is provided in different formats. Short webinars, and YouTube videos can be used to provide succinct and pertinent information to growers and agronomists.

The theoretical framework developed indicates that significant interactions occur between growers and agronomists, and how and where they seek information and attending training. The use of information communication tools can facilitate the interaction between information and training as well as the grower and agronomists. Further research is required to fully understand these interactions and how to optimise the information developed so that it can be incorporated into an informal or non-formal training activity.
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<tr>
<td>ASA</td>
<td>American Society of Agronomy</td>
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<tr>
<td>ASPAC</td>
<td>Australasian Soil and Plant Analysis Council</td>
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<tr>
<td>CCA</td>
<td>Certified Crop Advisor</td>
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<tr>
<td>CES</td>
<td>Cooperative Extension System</td>
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<td>CEU</td>
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<td>COGGO</td>
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<tr>
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<td>DEDJTR</td>
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<td>EA</td>
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<td>EPP</td>
<td>Emergency Plant Pest</td>
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<td>EPPRD</td>
<td>Emergency Plant Pest Response Deed</td>
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<td>FAO</td>
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<td>GRDC</td>
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<td>HPPs</td>
<td>High Priority Pest</td>
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<td>ICTs</td>
<td>Information Communication Tools</td>
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<td>IPPC</td>
<td>International Plant Protection Convention</td>
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<td>KSU</td>
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<td>Abbreviation</td>
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<td>NSW</td>
<td>New South Wales</td>
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<td>NVivo</td>
<td>Qualitative Data Analysis Software</td>
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<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
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<td>PCA</td>
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### Authorship Declaration: Co-Authored Publications

This thesis contains work that has been published and/or prepared for publication.

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<td>I organised and ran the webinars. Trained the pathologists and entomologist to use the software. I recorded the webinars and then converted them to videos using Final Cut Pro. I did all of the interviews for the podcasts. I uploaded all of the videos to YouTube and drafted the manuscript. Estimated 90% of the work.</td>
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I, Lynette Abbott certify that the student statements regarding their contribution to each of the works listed above are correct

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Chapter 1. Introduction

I embarked on this journey after wondering for many years whether those involved in the agricultural industry provide the correct training for growers and agronomists. I am a Plant Pathologist; for 16 years I ran a diagnostic service for growers and agronomists in the Department of Agriculture and Food, Western Australia before starting this PhD. Having noticed that quite a few of the growers and agronomists in the grains industry and state agricultural staff either did not know what diseases there were in crops, or were guessing, I started a training course in the identification of diseases in broadacre (grain and legume) crops. For the first few years it was hard work; there was no funding to support the course and there were many scathing remarks from agronomists, and growers, such as “we don’t need training” or “you can’t teach us how to do this – we have been doing this far longer than you”. The course is now run annually, and fills within a week of being advertised. Two agribusiness companies regularly send their new agronomists to the course. The manager of one company says, “as it provides a wonderful basis for them to start” (B. Moore pers. comm 2014). It is still difficult to get growers to attend training, due to the many competing demands on their time, and the majority employ an agronomist to help with management of pests and diseases in their crops. Therefore, I started this research to answer the question: how does industry effectively enable growers and agronomists to access and use information? To answer this I needed to know: a) Does the information provided by the grains industry make sense to the growers and agronomists and can they use it? and b) is there is a better way to teach members of the agricultural industry about biosecurity and pest and diseases?

A review of the literature has shown that there is very little published on the ability of growers and agronomists to identify pest and diseases in crops, or on their ability to recognise biosecurity threats to their crops. There is considerable information on the ability of farmers, veterinarians and others in the animal industry on their skills and abilities to identify diseases in their stock. Therefore there is a gap in the information on the plant industry. For my research, I used the Australian grains industry, as my case study because the value of Australia’s grain exports exceeded $10 billion in 2013/2014\(^1\). This included three major crops: wheat ($6 billion), canola ($2 billion) and barley ($2 billion) (Australian Export Grains Innovation Centre, 2015). Annually, this represents approximately 24% of the gross value of farm production, depending on seasonal conditions (Keogh & Julian, 2014b). As the majority of Australian grain crops are exported, the Australian grains industry must remain competitive in the international

\(^{1}\text{Values are given in Australian dollars throughout the thesis}\)
market. For this to happen, capacity building within the grains industry must be an ongoing activity, which is constantly assessed and re-assessed for necessary improvements and changes that are needed to occur.

The aim of this research was to examine current methods used for capacity building and to develop a framework for the provision of information and the training of growers and agronomists in the Australian grains industry. There is considerable information on capacity building of growers in the literature and virtually none on the capacity building of agronomists, which is another gap addressed by my research.

In this thesis, a grower is defined as someone who lives and farms land to produce crops for human and animal consumption. An agronomist provides technical information to the grower in relation to crop production on the farm. This information can include fertiliser regimes, fungicides and herbicides spray programs and even financial information. The grower usually pays the agronomist for this information.

The agricultural industry is changing rapidly with the introduction of new technology, varieties, and crops and these changes bring new challenges for the agronomist and growers. For Australian agriculture to remain competitive both nationally and internationally it is important that participants in the industry keep up with the changes and challenges (Keogh & Julian, 2014b). Where do growers and agronomists obtain the information to cope with these challenges and how do they continue to maintain their skills and abilities to remain competitive? In this research, the following questions were examined as part of the objectives:

- How do growers and agronomists from the Australian grains industry like to learn?
- What types of information do they use to increase knowledge and what types of training events do they like to attend?
- How do we keep the Australian grains industry informed of biosecurity risks to their crops and increase the capacity and skills of those in the industry to recognise and manage the risks?
- Will the demographics (age, education level, occupation, and location) of the growers and agronomists influence the answers to these questions?
Chapter 1. Introduction

1.1 Principle objectives

The ability of growers and agronomists to identify diseases and pests within their crops was one of the main objectives of this research. A training needs analysis questionnaire was designed to provide a benchmark on the growers’ and agronomists’ ability to recognise endemic diseases and biosecurity threats to their crops (Chapter 4). Once a benchmark has been determined it is then possible to reassess how information and training are presented to participants within the grains industry. However, before redesigning the information and training framework, it is important to understand where and how growers and agronomists access information and if this information accessed is the same for general or specific problems.

The second objective was to determine key issues within the industry in relation to capacity building. This objective was split into two parts; a) where and how growers and agronomists access information, and b) what training events do they prefer to attend. This was done using a questionnaire that examined different sources, types and content of information used for solving general problems and solving pest and disease issues in crops (Chapter 5). The second part also used a questionnaire, to determine: a) what training growers and agronomists preferred to attend; b) how often they attended training; and c) what were the barriers to attending training events (Chapter 6).

The results from Chapter 6 then guided the research into the third objective which was to examine if the preferred training events actually provided effective knowledge transfer strategies for growers and agronomists within the Australian grains industry (Chapter 7). This was done by attending the training events, interviewing participants and using a questionnaire to examine changes in knowledge levels.

The grains industry in Australia had started using information communication technology tools (ICT) to provide information to growers and agronomists through the Grains Research Development Corporation (GRDC) more frequently during the first year of my research. This provided the motivation for objective four to be investigated. In Chapter 8 the use of ICT is investigated as a means for providing information to the industry in relation to pest and diseases in crops.

All of the results from the investigation of the objectives above were combined to answer the final research objective; the provision of a training and information framework (Chapter 9).
1.2 Structure of the thesis

This thesis is presented as a mixed thesis combining traditional chapters such as a review of the literature and a methodology chapter with research chapters presented as manuscripts. The methodology chapter is essential in explaining the mixed methods approach used for this research, as I have combined my love of plant pathology, teaching growers and agronomists about plant diseases into a practical theoretical research project. The research Chapters 4 to 8 address each of the principal objectives determined as part of my research proposal.

Chapter 4 examines the ability of farmers and agronomists to identify endemic diseases in crops and the four main biosecurity threats within Australian grains. This was achieved by using a training needs analysis questionnaire specifically developed for this purpose.

Chapter 5 determines where growers and agronomists look for information when solving a general problem and a specific problem on farm. The paper in this chapter proposes how growers and agronomists can be grouped according to their preferences and how this can be used to guide the targeting of information ensuring that the information is available to all participants within the industry.

Chapter 6 addresses the second part of the research objective determining the preference of training events and what are the barriers to attending these events.

Chapter 7 then evaluates these training events to determine if participants’ knowledge levels were changed following attendance at these events and if they were going to use this new knowledge.

The last paper (Chapter 8) examines the use of information communication technology tools to provide up-to-date pest and disease information to growers and agronomists within the grains industry.

In the Discussion (Chapter 9), I have integrated the main findings to propose a theoretical framework to increase the knowledge and capacity of growers and agronomists in the grains industry to manage pest and disease issues in crops.
Chapter 2. A review of extension and capacity building in Australian agriculture

2.1 Introduction

This chapter examines extension and capacity building in Australian agriculture, using the Australian grains industry as an example. The first half of this chapter provides background information on agriculture in Australia, the Australian grains industry and its participants.

I then discuss extension in Australia, focussing on capacity building and the provision of information to the participants within the grains industry. This then leads into how is extension evaluated in Australia and what frameworks are used. While examining capacity building the role of adult education is raised and this is further reinforced when examining the types of evaluation used in Australia. Therefore the role of adult education is discussed and how this is connected to extension. The gaps in this review of the literature are then identified and form the objectives of my research project.

2.2 Agriculture in Australia

Australia has a very diverse agricultural sector that incorporates a large range of commodities including crops (broadacre and horticultural) and animal production including sheep, cattle (beef and dairy), pigs and poultry. In 2011/2012, 405 million hectares of land were used for agriculture in Australia, with 32 million hectares being planted for crops (Australian Bureau of Statistics, 2012). In 2012, there were approximately 121,000 farm businesses, 99% of which were owned by Australian families (Australian Bureau of Statistics, 2012). Approximately 20% (25,000) of these businesses grew broadacre crops including oilseeds (Keogh & Julian, 2014b). In general crops in Australia are planted in autumn (April/May) and are grown in the winter and spring months (June–November) and then harvested from October to January. The crops include the major grains: wheat, barley, oats, lupins, canola, and triticale. Chickpeas, lentils, faba beans and field peas are also grown but are considered to be minor crops.

There are three major agro-ecological regions in Australia: Northern, Southern and Western (Figure 2.1). The Northern region refers to Queensland and northern New South Wales (NSW). This region has high rainfall that generally occurs in the summer months.
Figure 2.1. Australian agro-ecological zones showing the seasonal rainfall zones (Courtesy of P. Goulding and D. Stephens, AEGIC)
This region is able to grow both summer and winter crops including corn, sorghum and tropical pulses, as well as wheat, barley, winter pulses and oilseeds (Keogh & Julian, 2014b; O'Keefe, 2015). The production of winter crops relies on the retention of soil moisture from the summer rainfall.

The Southern region includes central and southern NSW, Victoria, Tasmania and South Australia. Rainfall generally occurs during the autumn and spring and winter cereals are grown (GRDC, 2016). As the majority of respondents in the eastern Australia group came from Victoria, I shall focus on Victoria. Victoria has approximately 3,500 ha under crop each year and in 2011/2012 produced 7,000 kt of grain (Keogh & Julian, 2014b). Two distinct areas in Victoria grow broadacre crops: the Mallee (North Western) and Wimmera (Western) areas. In the Mallee, the crops grown include wheat, barley, vetch, oats and canola. Beef is the dominant livestock industry but livestock production is in decline, due to low rainfall, increase in grain prices and the increase in the use of minimum tillage for crop production. Most of this area is under irrigation, so the industries tend to be more dairy or vineyards than agriculture (DEDJTR, 2016). In the Wimmera area, broadacre crops include all cereals (mainly wheat and barley), pulses (field peas, chickpeas, lentils, faba beans, broad beans, vetch and lupins) and canola. The southern section of this region has dry land livestock grazing, generally sheep and some beef (DEDJTR, 2016).

The Western region comprises Western Australia (WA), where rainfall occurs during winter and spring. Yields are much lower in this region but are compensated by the large scale of farms in this region. The area under cropping is approximately 8,000 ha each year, producing nearly 16,000 kt of grain. Since early 2000’s the average area under crop on farms in WA has grown from 1000 ha under crop to 3500 ha, whilst in the other states the areas under crop have grown at a much smaller rate (average size is approximately 1000 ha) (Keogh & Julian, 2014b)

Agriculture is the second largest industry in Australia. However, it is also very diverse. This research focuses on the grains industry, therefore it is necessary to consider what is known about the industry, in particular the demographics of the participants.

### 2.2.1 Participants in the Australian grains industry

The grains industry has a wide range of participants from growers, agronomists, bulk handlers, chemical resellers, consultants, Natural Resource Management agencies, state agricultural departments, researchers, extension people, breeder companies,
fertilisers companies, bankers, grain traders, and other research agencies. It is a large complex industry. In this thesis, I focus on the growers and agronomists in the industry.

**Growers**
A Grains Research Development Corporation (GRDC) survey of grain growers in 2014 showed that 54% were between 40-59 years old, and 29% being more than 60 years of age (Watson & Watson, 2014). The average age of growers was 56 years (Keogh & Julian, 2014b). Farming in Australia is male-dominated; between 7% (Watson & Watson, 2014) and 28% (Keogh & Julian, 2014b) of growers identify as female. Since the 1980s there has been no increase in the number of females in agriculture while in the total Australian workforce there has been an increase of 47% (Keogh & Julian, 2014b). The discrepancy between the data on the number of females in farming reported by Watson and Watson (2014) and Keogh and Julian (2014b) is due to the small sample size (n=1200) in the 2014 GRDC survey conducted by Watson and Watson (2014). Data from the Australian Bureau of Statistics census was used by Keogh and Julian (2014b) which is a much larger sample, therefore providing a more realistic result.

More than 60% of the farming population has no post-secondary school education, which is broadly similar to the whole Australian population (Australian Bureau of Statistics, 2012). Nearly 20% of farmers have a post secondary school certificate; less than 10% has a university diploma or first degree, and less than 5% has a postgraduate degree (Keogh & Julian, 2014b). Research by Tucker and Napier (2002) and Ford and Babb (1989) showed the education level of growers was very important when developing information systems.

**Agronomists**
Information on the demographics of agronomists in Australia is sparse. Keogh and Julian (2014a) have the most up-to-date information. They have estimated from a number of sources of data that there are approximately 2300 agronomists working in Australia both in the retail and private sector. Two-thirds of the agronomists employed in Australia work for agribusiness chemical companies, seed companies and fertiliser companies (Keogh & Julian, 2014a). As with farming, the profession is male-dominated with only 7% of agronomists identifying as female (Keogh & Julian, 2014a). There are 548 agronomists in Victoria, with 183 of being private agronomists in the industry, the rest work for retail companies (Keogh & Julian, 2014a). In Western Australia, there are 40 working for retail companies and 60 working as private agronomists (Keogh & Julian, 2014a).
Education levels of agronomists are very different to those of the growers in the industry. The majority of agronomists have a Bachelors degree from university, with very few (5%) having just a high school certificate (Keogh & Julian, 2014a). In the survey conducted by Keogh and Julian (2014a), the age distribution was from 20 to 64 plus years with the nearly 20% of the agronomists falling in the 35 -39 age group. Keogh and Julian (2014a) found that over 30% of the agronomists surveyed had been working for less than 10 years and 24% had been working for 11-15 years. The larger retail companies tend to employ younger and new graduates and older agronomists tend to be self-employed. Those who are in the middle age group, from about 35 to 50 years of age, tend to become independent agronomists working for a small company that is not attached to retail (Keogh & Julian, 2014a).

Agronomists generally provide advice to the grower on all cropping aspects. As farm sizes have increased and cropping systems have diversified, many challenges are faced by the industry. One of the main challenges is pest and diseases in crops and readily accessible information for agronomists and growers.

### 2.2.2 The challenge of pests and diseases in crops

A major challenge for growing grain crops is the introduction of pests and diseases, how to prevent the introduction and then the subsequent management. Therefore accurate and rapid diagnosis of pest and diseases is required for the effective management of endemic diseases and pests and to prevent the incursion of pests and the establishment of biosecurity threats to the Australian grains industry. Early detection requires growers and agronomists to be aware of and to be able to identify symptoms and signs associated with endemic and emergency plant pathogens and pests.

In Australia, the Emergency Plant Pest Response deed (EPPRD) covers the management and funding of responses to emergency plant pest (EPP) incidents. Plant Health Australia (PHA) is the custodian of this document. PHA, a not-for-profit company, is the national co-ordinator of the government-industry partnership for plant biosecurity in Australia (Plant Health Australia, 2015). The EPPRD has increased Australia’s capacity to respond to incursions by supporting rapid, efficient and effective responses (Plant Health Australia, 2015).

An EPP is either: a) a known exotic plant pest; b) a variant form of an endemic plant pest; c) a previously unknown pest; or d) an officially controlled pest. These pests have a significant environmental or economic impact nationally (Plant Health Australia,
2015). The EPPRD lists three EPPs for the grains industry: a) *Tilletia indica* Mitra 1931 (Karnal bunt); b) *Trogoderma granarium* Everts 1899 (Khapra beetle); and c) *Diuraphis noxia* Kurdjumov 1913 (Russian wheat aphid) (Plant Health Australia, 2015). The pathogen that causes barley stripe rust (*Puccinia striiformis* f. sp. *hordei* Eriksson 1894) is not on the list of EPPs, but is listed as a high priority pest (HPP) for the grains industry in Australia. These four pests and pathogens will collectively be referred to as high priority pests (HPPs) in this thesis.

Pests and diseases cause considerable loss of value to Australian crops. The estimated annual loss is $76.64 per hectare in the Australian wheat industry (G. M. Murray & Brennan, 2009b). These losses represent 19.5% of the average annual value of wheat crop production since 2000. Similar losses are reported in barley and canola crops (G. M. Murray & Brennan, 2009a, 2012). Eradication is facilitated by early detection (Plant Health Australia, 2015). Therefore, it is necessary to improve the knowledge and skills of growers and agronomists to increase the likelihood of early detection.

**Early detection**

Different types of surveillance can be used to facilitate the early detection of pests and diseases in crops. Surveillance is defined by the International Plant Protection Convention (IPPC) as an official process that collects and records data on pest or pathogen absence or occurrence by survey, monitoring or other procedures (FAO, 2011; Hammond, 2010). Surveillance has two main parts; a) specific surveillance or b) general surveillance and both can be done by using surveys, monitoring crops or other procedures (FAO, 2011; Hammond, 2010; Hammond, Hardie, Hauser, & Reid, 2016a, 2016b). Specific surveys are considered active and are conducted during a set period at a set time on a specific crop for a specific pest or disease (FAO, 2011; Hammond, 2010). General surveillance uses data collected from other sources such as government agencies and is considered to be passive as the data is collected during other activities (FAO, 2011; Hammond, 2010). These other activities can include; a) routine diagnostic samples that are sent to either a government agency or diagnostic laboratory, b) reports from the general public and growers, and c) community-based surveys (FAO, 2011; Hammond et al., 2016b; Mangano et al., 2011).

These activities are an important contributor to the early detection of a possible HPP (FAO, 2011; Hammond et al., 2016b). The ability of community groups to detect exotic pests or HPPs (both disease and insects) was tested by Mangano et al. (2011) in a simulated exercise using three fictitious pests (two insects and one disease). Success
in detection of the pests was correlated with both participants' age and professional experience. In a previous survey by Hammond et al. (2016a), knowledge of the symptoms and signs associated with the top four HPPs of the grain industry was tested among growers and agronomists in Western Australia (WA). Participants had greater knowledge of the symptoms and signs associated with the pathogens causing Karnal bunt and barley stripe rust than of the two insect pests Khapra beetle and Russian wheat aphid.

The probability of a grower detecting a disease in their crop directly influences the sensitivity of general surveillance for that disease (Hammond, 2010). That is, the higher the probability of detection by the grower, the greater the sensitivity of the surveillance. When knowledge and awareness are low, this is likely to have an impact on the ability of growers and agronomists to report suspected HPPs. The animal and plant industries have considered this issue using scenario tree analysis based on probabilistic modelling (Hadorn & Stärk, 2008; Hammond, 2010; Martin, Cameron, & Greiner, 2007). For example, the sensitivity of general surveillance for the detection of foot and mouth disease in animal production areas of Australia varied according to a number of factors, including the attitudes, behaviours, knowledge and understanding of this disease by farmers and livestock inspectors. In this model (Martin et al., 2015), disease awareness was broken down into three main components: a) the probability of clinical signs being observed in the animals, b) the probability that the farmer recognised these clinical signs as being a problem and c) the probability that a veterinary officer was notified of the problem. It follows then, the earlier that growers and agronomists recognise symptoms associated with HPPs in grain crops, the greater the probability that a HPP will be reported early, supporting a more effective response.

There is little published literature concerning how to increase the ability of growers and agronomists to identify plant pests and diseases, although Levy (2005), Bagamba et al. (2006) and Yang et al. (2008) indicate that the awareness of growers and industry increased when information was provided during a biosecurity campaign. There are more data from the animal industry examining the skills of farmers, veterinarians and other professionals in identifying and being aware of exotic diseases and to determining what capacity building is required (Kunda, Rudovic, & Godfrey, 2008; Martin et al., 2015; Musa, Aderibigbe, Salaudeen, Oluwole, & Samuel, 2010). The data from the animal industry cannot be extrapolated to the plant industry but the methods used to obtain the data provide a good basis to start examining the skills and abilities of growers and agronomists in the Australian grains industry. Hammond (2010), Hammond et al. (2016b) and Wright, MacLeod, Hammond, and Longnecker (2016)
were the first authors to examine the knowledge levels of growers and agronomists on HPPs in the Australian grains industry. The knowledge level of growers in the Australian horticultural industry on their HPPs has not been reported in the literature. The work of Hammond et al. (2016b) and Wright et al. (2016) has provided a benchmark for the grains industry and demonstrates that capacity building is required to improve the skills of both growers and agronomists in the identification of HPPs in their crops.

2.3 Agricultural extension

Extension was first described in the mid-nineteenth century in the United Kingdom, when the universities of Cambridge and Oxford sought to extend university teaching beyond their campuses to serve the educational needs of the rapidly expanding populations of industrial towns and cities. The concept was so successful that similar activities occurred in the USA, and the land-grant\(^2\) universities became involved in the needs of farming families (Jones & Garforth, 1998). The exchange of information involved in extension is basically about promoting learning, the building of skills and knowledge and stimulating change in a community (Coutts & Roberts, 2011; Fulton et al., 2003; Jones & Garforth, 1998; Keogh & Julian, 2014b; J. Pretty et al., 2010; J. N. Pretty, 1995; Primary Industries Standing Committee, 2011; Röling, 1996; Röling & de Jong, 1998).

Agricultural extension is primarily concerned with the communication of information to farming communities. Traditionally, extension aimed to increase agricultural productivity; more recently, it has contributed to improved agricultural sustainability (Keogh & Julian, 2014b; J. N. Pretty, 1995; Röling, 1996; Röling & de Jong, 1998). The tools and delivery mechanisms used for extension can be very diverse, and the choice depends on the desired final outcome (Primary Industries Standing Committee, 2011). Extension methods include broadcast electronic and print media, field days, specific advice, focus farms, demonstrations, subject-specific videos, and general and specific publications. Regardless of the method, information needs to be synthesized and processed, and delivered to learners in a format that is based on their needs (Fulton et al., 2003; Jones & Garforth, 1998).

Different models of extension are used around the world. The USA still uses the Cooperative Extension System (CES), which was established in 1914, as part of the

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\(^2\) A land-grant university is a higher education institution in the United States designated by the state to receive benefits of the Morrill Acts of 1862 and 1890.
land-grant universities (Franz & Townson, 2008). Currently there are 108 colleges and universities in the land-grant system, which are responsible for extension to their surrounding communities. Their mission is to supply research-based information and education to help people improve their lives and includes programs in food and nutrition, agriculture, community, natural resources, and youth development (Franz & Townson, 2008). The accountability and funding of the CES is complex and varies among states. The majority of the funding comes from the US Department of Agriculture as a non-competitive grant (Roush, 2014) CES extension educators are responsible for coordinating needs assessments and program development in their community and subject area. This system provides a strong link between university research and extension (Roush, 2014).

The main differences between Australian extension and USA extension are a) the wide range of subject areas covered under the agricultural portfolio of the CES (Franz & Townson, 2008; Roush, 2014) and b) that the CES recruits and trains thousands of volunteers a year to help with their extension services (Franz & Townson, 2008).

### 2.3.1 Agricultural extension in Australia

The development of extension in Australia has changed over time. Figure 2.2 provides a very simple historical model of extension (Jennings, Packham, & Woodside, 2011). In the 1960’s, most extension relied on a top-down approach, where information was provided to the participants, and they were expected to use this information to make changes on their farm (Cristovao et al., 2009). Different publications use different names for this top-down approach: technology transfer, linear model, or training and visit system (Coutts & Roberts, 2011; Cristovao et al., 2009; Keogh & Julian, 2014b; Rogers, 2003) but all rely on the transfer of knowledge from the extension agent to the grower and the diffusion of knowledge among growers (Coutts & Roberts, 2011; Cristovao et al., 2009; Rogers, 2003). This has been described as a ‘persuasive mode of extension’ that can be paternalistic in its style (Coutts & Roberts, 2011, p. 22).

In the 1970’s, extension developed the farming systems research model, in which research priorities were aligned with the needs of farmers and presented in a farming context (Coutts & Roberts, 2011). This approach aimed to ensure that extension was practical and relevant (Coutts & Roberts, 2011). In the 1980’s, systems thinking influenced the way extension was delivered. This involved a more holistic approach and further developed the participatory model of research. Adult education principles and action learning were major influences on this model.
Chapter 2. Literature Review

Figure 2.2. The historical development of extension in Australia since the 1960’s. From (Jennings et al., 2011, p. 10); reproduced with permission (October 2016).
By using these principles, farmers were able to understand their situation and make relevant decisions to improve the situation (Coutts & Roberts, 2011). During the 1990’s in Australia, a broad range of theories and methods were used in extension, with a strong emphasis on adult learning principles and participation by stakeholders (Coutts & Roberts, 2011; Keogh & Julian, 2014b; Marsh & Pannell, 2000). These were not the only changes to occur. During this time extension moved from being a government-provided service to a private service in Australia (as indeed throughout the world). This move was a reflection of changing agricultural economics; farming had become more specialised, and growers required more sophisticated, technical and targeted information on all aspects of farming (Cristovao et al., 2009; Jones & Garforth, 1998; Marsh & Pannell, 2000). However, because state agencies were still providers of research information they remained responsible for the dissemination of such information to primary extension agents such as agronomists (Marsh & Pannell, 2000).

Since the early 2000’s, extension has focused on capacity building. There is a larger range of stakeholders and providers of extension (Coutts & Roberts, 2011). Agribusinesses, such as fertiliser companies and chemical companies, now also provide extension services to growers. These companies employ agronomists who are responsible for trial work, plus the provision of advice to growers (Marsh & Pannell, 2000). In Western Australia (WA), agronomists have used the Department of Agriculture and Food, Western Australia (DAFWA) for training in specific issues such as disease identification. Many private agronomist companies in WA now send their agronomists to DAFWA for training in disease identification (Geoff Thomas pers. comm. 2015).

In addition, the changes in extension to focusing on capacity building led to changes in delivery method. Instead of one-to-one exchanges, there has been a major requirement for grower groups to be used (Marsh & Pannell, 2000). The one-to-one method involved an extension officer discussing and solving a problem with a grower. In the past, extension officers from government departments spent their days visiting people to help them. This has changed through the use of grower groups, in which extension is provided from on a one-to-many process. One-to-one extension is viewed as a private good (helping a single grower) whereas providing extension to a group is seen as a public good. As the Research and Development Corporations (RDCs) have taken on a larger role in the provision of information and ensuring that extension is a major component of projects, they are also pushing for the information to reach a wider audience and asking that the researchers are responsible for this (Coutts & Roberts, 2011). To enable this to happen, the requirement for grower groups to be used in
extension delivery continues, with the risk that larger groups will be targeted. The larger the group, the lower the interaction level will be and therefore the less knowledge will be constructed (Hare, 1952; Jaques, 2000; Print, 1993). There is also the risk of ‘social loafing’ occurring, which is when individuals reduce their input into a group (North, Linley, & Hargreaves, 2000).

In an extensive report into Agriculture Extension, Learning and Change for the Rural Industries Research Development Corporation (RIRDC), Fulton et al. (2003) considered the different processes used in Australia to facilitate learning and change on the farm. Woods, Moll, Coutts, Clark, and Ivin (1993) recommended that on-going groups had a great potential to support learning and change if a participatory approach or action learning were used. With the increase in the use of groups and action learning evaluation Fulton et al. (2003), demonstrated significant learning occurring among the participants. However, Fulton et al. (2003) found that major questions in relation to group work still remained, including: a) what were the best techniques used when evaluating the effectiveness of groups; b) who participated in the groups and c) which group processes were appropriate for which circumstances. Marsh and Pannell (2000) also commented on the lack of studies that examined the effectiveness of the variety of extension methodologies currently in use in Australia. There are considerable amounts of qualitative data supporting the use of groups, demonstrating that there is better participation and better learning, but, there is a lack of quantitative data demonstrating that practice-change is implemented as a consequence of group work (Fulton et al., 2003; Marsh & Pannell, 2000; Petheram & Clark, 1998).

2.4 Capacity building in Australian agriculture

In 2011, Australian growers stated that they wanted capacity building, which included improving skills training and education in agriculture (Primary Industries Standing Committee, 2011). Capacity building defined by FAO; increasing knowledge, skills and understanding of participants within an agricultural industry through education and training to enable change (Srinivas, 2016). This corresponds with my personal experience of dealing with growers in my 15 years with the diagnostic service. However, prioritising capacity building does not address how to do it or what skill training and education growers are actually seeking.
2.4.1 Capacity building of growers

In the capacity building and community engagement paradigm of agricultural extension in Australia, Coutts and Roberts (2011) identified five delivery models for extension projects: (i) Group facilitation and empowerment; (ii) Training; (iii) Technological development; (iv) Information access; and (v) Individual consultant/mentor. These five models are complementary and should work together to ensure that capacity building needs in the agricultural sector are met. The interactions among the five delivery models are illustrated in the three-legged capacity building ladder shown in Figure 2.3. Three delivery models (information access, group facilitation and empowerment, and technological development) can be visualised as the three ‘legs’ of the ladder, which enable participants to move up the ‘rungs’ of capacity building through ongoing training and education products, and interactions with consultants and mentors.

![Image of the capacity building ladder in Australia’s extension system.](Image)

Figure 2.3. The capacity building ladder in Australia’s extension system. From Coutts and Roberts (2011, p. 25), reproduced with permission.

The facilitation and empowerment model focuses on the development of skills in participants. It is a facilitative model that is based on action learning and works best with a facilitator who has strong facilitator skills and is supportive (Coutts & Roberts,
2011). As the group decides on the planning, decision making, how to solve problems what their education and training needs, this model has similarities to action learning. The group will also undergo a reflection process so that continuous improvement can occur (Coutts & Roberts, 2011). Outcomes from this model are local and quite specific.

The technological development model is about individuals working together to develop specific management practices, decision system support tools or new technology that is then available to all in the industry. This work involves local trials, demonstrations, and field days. This model is based on participatory methods to encourage change. The availability of technology developed is generally through the training or the information access leg of the capacity building model (Coutts & Roberts, 2011). The information access leg of the ladder is discussed in detail in Section 2.6.

The consultant/mentor model is about building relationships with individuals and communities and improving their managerial, social, and technology skills. Now that extension is not solely provided by government agencies, and that agribusinesses and private agronomists are providing more advice, this model is becoming more important, as farms become larger and more complex (Coutts & Roberts, 2011).

The training model is about training programs specifically designed at increasing skills and understanding for participants in the agricultural industry. In general these programs have set curricula and learning objectives and meet the standards required under the National Qualifications Framework in Australia, and are part of the Vocational Education and Training (VET) system. This allows participants to gain accreditation for their learning (Coutts & Roberts, 2011). It is essential therefore that there is extensive consultation done with the industry and community before resources are used to develop a training program. This can happen through the group facilitation and empowerment model where groups may seek out suitable and relevant learning opportunities (Coutts & Roberts, 2011).

### 2.4.2 Capacity building of agronomists

Most literature focuses on capacity building from the perspective of the grower; there is little work on the capacity building of agronomists. Long (2013) ran a project funded by GRDC that focused on developing agronomists’ understanding of growers’ decision-making process and their skills for speaking to growers about science in a practical way. Through this process agronomists developed skills in working with growers as peer mentors. Agronomists were able to implement actions such as the use of social media, tailoring messages to different personality types, learning styles and the use of
a planning and evaluation process and they reported an increased rate of technology adoption by their clients.

Unlike in Australia, crop advisers, consultants and agronomists in the USA, are generally certified (Certified Crop Adviser, CCA and Certified Professional Agronomist CPAg). The American Society of Agronomy (ASA) runs the certification programs. These certifications were established in 1992 to provide a benchmark in the USA and Canada (CCA, 2016) and to protect both the public and the profession. Farmers and employers prefer to work with CCA or CPAg-certified professionals, because they have demonstrated a commitment to education, expertise and experience in their roles (CCA, 2016). Participants are required to pass two comprehensive exams (international and local board). They are then required to demonstrate that they have a bachelor’s degree in Agronomy, five years’ experience and five references approved by the board of the ASA. Once certified, participants are required to undertake 40 hours of continuing education units (CEUs) every two years. Organisers of training events (field days, workshops) register with the local board the number of credits that a participant can earn by attending the event. This is based on how structured the event is, the amount of time the participants are exposed to a qualified instructor and the topic covered. The ASA organisation is very specific in what it will cover and not cover. When participants register to attend the event, they will be notified the number of CEUs that will be given for attending that event (CCA, 2016).

The CEUs are designed to encourage agronomists to continue to learn by attending training events and provide proof of attendance; they are then able to demonstrate to their employers or to growers that they have attended training. There is the option to do some online learning, but, this is restricted to 20 CEUs every two years. The online learning modules have quizzes at the end of each unit that participants need to pass (CCA, 2016). However, there are no follow-up surveys or knowledge testing to determine if the agronomists who registered to obtain their CEUs from field day events actually learned something and how they will use this new knowledge.

### 2.5 Information access in agriculture

Based on the Coutts and Roberts (2011) capacity building model (Section 2.4, Figure 2.3), information access is a critical component of all agricultural extension. Individuals and groups have the information that they need in a form that suits them, at a time that they need it, in order to move to a higher ‘rung’ on the capacity building ladder. As individual and group capacity increases, information needs change and evolve.
Further, the types and providers of information that are sought and used by individuals are very diverse.

Clearly, the utility of ‘information’ in serving capacity building requires further elaboration. In the following sections, I break down the general category of ‘information’ for extension into its component parts, and review the major influences on the providers, types and content of information used by different groups in the agricultural sector.

Research in the USA and Australia has examined the sources of information used or sought by growers for their economic value, marketing and usefulness in decision-making. When a grower or agronomist must make a decision, the amount of external and internal information used will vary from decision to decision and from person to person (Diekmann, Loibl, & Batte, 2009; Ford & Babb, 1989; Gloy, Akridge, & Whipker, 2000; Patrick & Ullerich, 1996; Schnitkey, Batte, Jones, & Botomogno, 1992).

A graphical representation of the individual decision-making process for growers and agronomists is shown in Figure 2.4 This simplified diagram illustrates that a person relies on both internally- (such as personal experience and knowledge) and externally sourced information before making a decision (Errington, 1986; Fulton et al., 2003; Jones & Garforth, 1998). External information can be further classified into source (i.e., who has provided the information), type and content. Although the link between information and decision-making has not changed over time, the sources and types of information have (Errington, 1986; Kilpatrick & Rosenblatt, 1998; Tucker & Napier, 2002). Changes that have occurred since the 1990s, such as the growth in use of Internet sources and social media since the early 2000s, have not been fully investigated in relation to the farming community.

Government agencies, private industries and the community are external sources of information, which can be grouped by type and content. The type of information refers to whether the information delivery is community-, training- or technical-based (Figure 2.5a). Errington (1986) and Solano, Leon, Perez, and Herrero (2003) divided information into two types; general information and specialised information. General information is useful for a variety of activities on the farm, while specific information is focused on a small section or limited portion of the farm.

Content signifies whether the information is general or specific in nature, and consequently the spatial scale of delivery, for example at a national, state, regional or local community or individual farm level (Figure 2.5b).
Figure 2.4. Graphical representation of how a growers’ decision is based on a combination of experience, the source, type and content of the information received.

Figures 2.5 a, b and Figure 2.6 represent a simplified structure of a reality that can be very complex and is further confused by the lack of consistency in the use of terminology in the literature. Information sources can be targeted either at an individual or at a group of people (Ford & Babb, 1989). The content also includes the mode of delivery; whether it is a direct observation, verbal communication or a written document (Fulton et al., 2003; Jones & Garforth, 1998).

2.5.1 Type of information

The literature concentrates on growers and the types of information that they use. There is nothing about the types of information that agronomists use in the literature.

Growers generally prefer personal to written information (Diekmann et al., 2009). Sutherland et al. (1996) found only one-third of respondents used written information compared to personal or technical information (Figure 2.5a). Technical information refers to specific information as advice from a specialist, or specific information in print (Ford & Babb, 1989; Sutherland et al., 1996)

Farm size and enterprise type also influence the types of information used (Ford & Babb, 1989). In the USA, Ford and Babb (1989) and Gloy et al. (2000) found growers that owned small farms often use farm magazines as a type of information, and that less experienced growers rely on commercial newsletters and commodity brokers to a
Figure 2.5. Graphical representation categorising information into: a) types and b) locus. Developed from (Errington, 1986; Fulton et al., 2003; Jones & Garforth, 1998; Kilpatrick & Rosenblatt, 1998; Tucker & Napier, 2002)
greater extent than more experienced growers. They also found a difference between crop growers and livestock growers. Livestock growers use a broader range of information types, most likely due to the volatility in both the input costs and output costs for production, compared to crop growers who tend to only use a small number of different types of information (Ford & Babb, 1989).

2.5.2 Locus of information

In terms of locus, information can be divided into two types; general information and specific (or specialised) information (Sutherland et al., 1996). General information is useful for a variety of on-farm activities (such as nutrient and soil management), and is appropriate at a state or national level while specific information is focused on a small section or limited portion of farm (for example, controlling a leaf disease in a wheat crop), is designed to be specific at a regional, local community or entirely for a single farm. The provision of information in a single format is unlikely to be suitable for both general and specific problems.

For content delivery, growers generally prefer personal or verbal information to written information Diekmann et al. (2009). Growers perceive the written information to be inaccurate; in some cases it is too general and often arrives after the event (Ford & Babb, 1989; Hunt & Coutts, 2009; Solano et al., 2003).

2.5.3 Source of information

The experience of growers and age of growers influences the sources of information used (Ford & Babb, 1989). More experienced growers relied on public co-operative information produced by the universities (Figure 2.6) while the less experienced preferred commercially produced newsletters, and the advice of commodity brokers (public companies and private) (Figure 2.6 (Ford & Babb, 1989; Gloy et al., 2000; Tucker & Napier, 2002). In the livestock industry, (Ford & Babb, 1989; Gloy et al., 2000; Tucker & Napier, 2002) found that the use of USDA news services and private firms increased with experience, while the less experienced still relied on family and friends for information (Figure 2.5a).

Ford and Babb (1989) demonstrated family and friends were the primary source of information across all commodities, regions and years of experience in their survey of growers in Indiana, Iowa, Illinois and the Southeast of the USA. The secondary
sources of information used included other growers, private firms, and the Cooperative Extension Service of the USA. Among farmers in Edinburgh, Scotland, growers considered other growers, agricultural advisors and consultants an important source of information Ford and Babb (1989). Sutherland et al. (1996) found that growers valued participating in groups and that personal gains were from networking, and the sharing of knowledge. Agricultural advisors (non-family) were trusted because of their objectiveness and independence, and were highly valued by growers Hunt and Coutts (2009). However, self-reporting of performance by other growers was not a trusted source of information (Ingram, 2008; Sutherland et al., 1996).

While much research has focused on the information needs of growers, very little has been published on how agronomists access and use information in their work. Radhakrishna and Thomson (1996) examined extension agents’ (agronomists) use of information sources. They concluded that the demographic characteristics of the participants influenced the information sources used. However, close examination of the data showed that the participants’ demographic profiles actually determined in which roles those extension officers were employed, and this role determined where they sought information. Marshall (2002) surveyed agronomists in the UK to determine the environmental information required to help growers under the Pesticide Voluntary Initiative. Echoing Coutts and Roberts (2011) delivery model of information access for growers, Marshall (2002) recommended that training schemes for agronomists need to be supported by knowledge and information resources, and that there needs to be a range of methods available to access these information resources.
Figure 2.6. Graphical representation of categorising information into sources. The external sources are then further broken down into smaller categories. Developed from (Errington, 1986; Fulton et al., 2003; Jones & Garforth, 1998; Kilpatrick & Rosenblatt, 1998; Tucker & Napier, 2002)
Understanding the sources of information, the flow of the information and the relevance of the information are very important. This is because the types of information available and the sources used have changed with the development of the Internet, and the increased use of social media. Therefore, as part of my research I plan to compare the sources, types and content of information that growers and agronomists use to determine if the format of delivery needs to be the same or different.

2.6 Evaluation of extension activities

Over the years, the evaluation of extension activities in agriculture has taken on many different forms. Roberts and Coutts (2011) provide a very comprehensive overview of how evaluation has changed from the 1930s to the 2000’s but there appears to be no single model that fits all approaches to evaluation. In 2011, PISC (Primary Industries Standing Committee, 2011) published a document on the key principles and best practice for evaluation of research, development and extension programs; essentially that the evaluation process should facilitate learning and program improvement. It should be an integral part of the program and not something that is added on at the end (Primary Industries Standing Committee, 2011).

Evaluation can be categorised by the function of the evaluation (Roberts & Coutts, 2011): summative evaluation is completed at the end of the project/program and provides evidence that outcomes have been met, whereas formative evaluation is conducted alongside the project and examines how the program/project can be improved and what were the perceptions of the participants (Print, 1993; Roberts & Coutts, 2011). Formative evaluation must be built into the project and started before the project begins. These evaluations can be designed before the program to help set the priorities and the resources required, or after the program to assess the impact (Keogh & Julian, 2014b; Maredia, 2009)

2.6.1 Approaches used for evaluation

There are many different approaches to evaluation of extension activities, Roberts and Coutts (2011) described six different types of approaches that can be used for evaluation: (i) experimental; (ii) goal orientated; (iii) decision focused; (iv) user orientated; (v) stakeholder approach and (vi) responsive. These are quite general.
Experimental
The experimental approach was designed to address accountability, and observed effects from the program. In general, the differences between treated and untreated are observed and recorded to demonstrate impact of training (Roberts & Coutts, 2011).

Goal-orientated approaches
A goal-orientated approach is based on Bloom’s (1956) and Gagné’s (1985) work on objective centred evaluation to measure impact (Roberts & Coutts, 2011). Bloom’s taxonomy examines changes in knowledge, values and skills of participants, while Gagné’s work focused on rote learning, and the ability to identify and discriminate between objects (Driscoll, 2005b; Krathwohl, 2002; Roberts & Coutts, 2011).

Decision focussed approaches
Decision focussed approach evaluates the input, context, process and the product individually in a program. This is very similar to what is done in Bennett’s hierarchy framework (discussed in further detail below). The components are assessed individually and then as a whole for the evaluation process (Roberts & Coutts, 2011).

User focussed approaches
A user focussed approach is based on Patton’s (1990) work that suggested that those that had funded the work should be involved in the evaluation process, so that the process would deliver outcomes and have useful results (Patton, 2002; Roberts & Coutts, 2011). This type of evaluation is strategic in its approach, and requires engagement by the users to clearly define the priorities (which can be conflicting when there is more than one funder or policy maker (Murray 2000).

Stakeholders approaches
The stakeholders approach involves stakeholders from the beginning in the design and collection of the data. In this type of evaluation it is very important to have a wide range of opinions, which will increase the level of objectivity (Roberts & Coutts, 2011). Roberts and Coutts (2011) suggest extending this further, so that all perspectives are represented (the positive and negatives) ensures that nothing is minimised or lost.

Responsive and participatory approaches
A responsive and participatory approach is based on the action research model used in education; planning for action, taking action, observation and then reflection (McNiff & Whitehead, 2009; Roberts & Coutts, 2011). This approach has a code of engagement that ensures all individuals are equal, and bring value to the project with their skills (Roberts & Coutts, 2011). P. Murray (2000) notes that this type of approach can
appear vague to funding providers and policy makers, and needs a different criteria to those used with a ‘top-down’ approach to extension. The purpose of the evaluation needs to be clear and concise. A participatory approach is not necessarily about the level of adoption (P. Murray, 2000). Predetermined measures and outcomes are not compatible with participatory approaches because of the cyclical nature of the evaluation (P. Murray, 2000).

The evaluation approach is dependent on the outcome and the reporting mechanisms required by the funding body and other parties involved in the research. The difficulty is defining the outcomes that are to be achieved, especially when there are multiple outcomes (Keogh & Julian, 2014b; Labarthe, 2005; Maredia, 2009). Frameworks such as those described above have been developed to help with the design of evaluations.

### 2.6.2 Types of frameworks used in evaluating Australian extension

The three main frameworks used for evaluating extension in Australian agriculture are; (i) Bennett’s hierarchy, (ii) Wissemann’s six steps, and (iii) the monitoring, evaluation, reporting and improving (MERI) framework (Keogh & Julian, 2014b; Roberts & Coutts, 2011).

**Bennett’s hierarchy**

Bennett’s hierarchy is used extensively in Australia in the evaluation of large extension project/programs (Bennett, 1975; Keogh & Julian, 2014b; Roberts & Coutts, 2011). It provides both qualitative and quantitative data that can be triangulated to strengthen the data and the conclusions. Bennett’s is a summative approach, with seven steps (Roberts & Coutts, 2011):

1. Inputs; resources required for the project
2. Activities; how many and what types of activities will be undertaken in the project
3. Participation; how many participants attend each activity
4. Reactions; the reaction of the participants to the activities
5. Change in knowledge, attitude, skills, aspirations
6. Practice change; examination of participants to determine if there has been a change in their behaviour after the training event
7. End results; measure of overall impact

The seven steps listed above, are related and as each step is evaluated its relationship with the next step is also evaluated (Roberts & Coutts, 2011). Steps 5, 6 and 7 need to
be measured at a set time after the completion of the project. However, to do this, a measure of baseline data is needed before the project so that the amount of change can be evaluated. Behavioural change may occur immediately with some participants, however to fully measure the impact of a project, observations on practice change, and change in knowledge need to be measured every 12 months (Roberts & Coutts, 2011). (Llewellyn, Pannell, Lindner, & Powles, 2006) noted evaluation after 12 months is a short time for measuring adoption. This may be because the farmers’ post training perceptions are still being formed with the other information and the seasonal conditions maybe unfavourable thus a change from previous practices is not warranted (Llewellyn et al., 2006). These 12 month time frames or longer are not always suitable for funding bodies, and it may be difficult to access the participants over long time frames (Llewellyn et al., 2006).

**Wissemann’s six steps**

Wissemann’s framework uses six steps that lead to the development of a logical framework (Roberts & Coutts, 2011). The six steps are: (i) clarify the evaluation request; (ii) determine the scope and key questions to focus the evaluation; (iii) identify the information that needs to be collected; (iv) identify information sources and data; (v) determine methods of analysis and reporting procedures and (vi) sequence evaluation activities and produce a plan (Keogh & Julian, 2014b; Roberts & Coutts, 2011).

There are negative aspects of this logic framework; it assumes that there is a linear flow from the projects beginning to its end (Roberts & Coutts, 2011). This is not always the case, and by including the context of the project, assumptions, and a risk assessment into the framework can help (Roberts & Coutts, 2011).

**MERI framework**

The monitoring, evaluation, reporting and improvement (MERI) framework was developed in 2003, and is widely used (Roberts & Coutts, 2011). It was originally developed to for natural resource management programs to improve communications with funding bodies, staff, and the stakeholders (Keogh & Julian, 2014b; Roberts & Coutts, 2011).

The MERI framework is built into the design of the extension program, and represents a continuous improvement cycle. Thus the reporting and improvement part of the framework must be part of the program and not left until the end (Keogh & Julian, 2014b). It is important when using this framework that the questions used for the monitoring and evaluation part are appropriate for the objectives (Keogh & Julian, 2014b).
The success of these frameworks described above is dependent on the types of data collected; quantitative and/or quantitative and the quality of the data collected by those responsible for the evaluation.

As I am not focussing on the evaluation of a whole extension program, the examples of frameworks provided above will not be used.

### 2.6.3 Alternative framework – Kirkpatrick model

None of the approaches described above are really suitable when evaluating an event such as a field day or a workshop held in a rural community; these events are usually seen as a form of informal training. Kirkpatrick (1970) developed a framework to evaluate training that is commonly used in workplaces and can be used with informal training events such as field days (Kirkpatrick, 1970, 1979). In this framework, there are 4 steps (Kirkpatrick, 1970, 1979):

1. Reaction: did the participants like or dislike all or part of the program?
2. Learning: what principles, facts and techniques did the participants learn?
3. Behaviour: what changes in job behaviour have resulted from the program?
4. Results: what were the tangible results in terms of outputs and outcomes?

There are concerns about the Kirkpatrick framework. Alliger and Janak (1989) note that a) it is assumed that the four steps are arranged in ascending order of importance, b) that there is a positive correlation between the steps and c) that these steps are causally linked (Alliger & Janak, 1989; Bates, 2004). Steps three and four are similar to those in Bennett’s hierarchy model in that these changes become more apparent after the training course or project has finished, and need to be measured after the training has been completed. Bates (2004) also notes that the model does not consider the contextual and individual influences; characteristics of the organisation and work environment are crucial factors. Steps 1 and 2 are also administered after a training activity, but usually immediately after the event. There are problems with measuring these two steps together. For example, a trainer might have been very funny but the participants did not learn anything or the participants might have felt very negative about the course but still learned what was required (Alliger & Janak, 1989; Bates, 2004). Holton (1996) does not include reactions in his models, as this is the variable that influences the participants’ motivation to learn or not to learn (Alvarez, Salas, & Garofano, 2004; Holton, 1996). In the model used by Holton (1996), learning is related to transfer and transfer is related to results (Alvarez et al., 2004). However, using a methodological approach to measure learning outcomes provides a micro-view of the
training results. These training results then contribute to the benefits for the individual in terms of learning and on-the-job performance (Alvarez et al., 2004). When evaluating the effectiveness of a training program, this then focuses on a macro-view of the training outcomes (Alvarez et al., 2004). The variables that influence the outcomes of the program are measured before, during and after the event but the evaluation still looks at whether the individuals learned or did not learn, and how this benefits the organisation (Alvarez et al., 2004).

2.7 Adult education and adult learning

Education is about changing skills, knowledge and attitudes in individuals, groups or communities. In education, the focus is on the teacher or facilitator bringing about the change (Boyd, 1980; Knowles, Holton, & Swanson, 2012). Learning is about the processes used to create change in expertise, skills, knowledge, behaviour and attitudes (Boyd, 1980; Knowles et al., 2012); the focus is on the participant.

In most adult education scenarios it is important that training is learner-centred, not teacher-centred (Burns, 1995). Learner-centred requires the engagement, and active participation, of adults in their learning, rather than a teacher transmitting knowledge to an empty vessel (Barraket, 2005; Burns, 1995). Learners are responsible for their own learning and the facilitator is responsible for creating an environment for this to happen (Barraket, 2005; Passfield & Billett, 1995).

Given that the grower and agronomist communities comprise adults, it is appropriate to consider theories of andragogy; the science of adult education (Burns, 1995). These include Vygotsky’s social constructivist theory (Bonk & Cunningham, 1998; Scales, Senior, & Briddon, 2013), Kolb’s experiential learning cycle (Knowles et al., 2012; A. Y. Kolb & Kolb, 2005; D. A. Kolb & Lewis, 1986), and Bruner’s theory of learning (Scales et al., 2013).

Constructivism is based on Piaget’s model and describes the process in which knowledge and learning is constructed between an individual and their environment (Barraket, 2005; Burns, 1995). Piaget’s model of constructivism was first described by Jean Piaget; people construct knowledge from active engagement and through the process of assimilation and accommodation (Fulton et al., 2003; Jones & Garforth, 1998). In this model, the work of Jerome Bruner is now included. Bruner developed the theory of learning and theory of instruction (Scales et al., 2013), based on the idea that learners construct new knowledge through communicative interaction. The knowledge
is formed from a body of knowledge, but it is a process of intellectual development and problem solving (Scales et al., 2013). The theory of learning is: a) acquisition of new knowledge based on Piaget’s assimilation and accommodation; b) transformation of the knowledge and c) evaluation of the new knowledge (Scales et al., 2013). Vygotsky is closely associated with social constructivism; in his model learning is not an individual process but happens through social interaction and dialogue (Scales et al., 2013). Kolb’s experiential learning theory draws on all of these theories and puts them into a holistic model associated with multi-linear model of adult development (A. Y. Kolb & Kolb, 2005; D. A. Kolb & Lewis, 1986). Basically, it is a constructivist model; learning is where knowledge is created through the transformation of an experience. The model is a cyclical model that allows the learner to experience, reflect, think and act (A. Y. Kolb & Kolb, 2005; D. A. Kolb & Lewis, 1986).

The main difference between andragogy (adult) and pedagogy (child) is related to assumptions about to what extent the participant is independent and self-directed in their learning (Knowles et al., 2012). The adult learner is described as (Knowles et al., 2012; Merriam, 2001):

1. Self directed, has the ability to direct their own learning
2. Rich resource for learning, usually have rich life experiences that can be used as a resource
3. Problem-centred, is interested in the immediate application of knowledge to solve problems
4. Learning needs that are related to social capital or social roles
5. Self motivated, they do not require external factors to motivate them for learning

Adults have a range of experiences that can be used during their learning, where as a child is unlikely to have a similar range of experiences. Another assumption is that adults want to only learn what is applicable now and useful now, whereas, a child is happy to learn a skill or knowledge that can be used later (Hogan, 2009; Knowles et al., 2012; Merriam, 2001).

There are many critics of the assumptions listed above about adult learners, because many children can be self-directed, and do have a range of experiences that they like to share (Barraket, 2005; Hogan, 2009; Scales et al., 2013). Therefore, the main difference becomes how the learning experience is designed that is, the instructional theory. Learning theory is the link between the conditions in which learning occurs and what has been learnt (Merriam, 2001). Instructional theory involves the deliberate
arrangement of learning conditions that allows specific learning goals to be attained (Driscoll, 2005b). Instructional theory is prescriptive in providing principles to facilitators or teachers so that the learning goals can be achieved.

The links between learning theory, instructional methods and instructional theory are shown in Figure 2.7. This has been adapted from (Driscoll, 2005b) and includes an example from my work teaching plant disease identification to growers and agronomists. By understanding the theories and the links, it becomes easier to design a framework that is able to take into account the different learning styles between learners and enables the environment to be created for this to happen (Driscoll, 2005b).

The model in Figure 2.7 implies that when designing training, it is important to consider the learner, the task (learning outcomes), the learning environment (instructional methods and learning conditions) and the context in which the learning occurs (Barraket, 2005), which is all very similar to Gagne’s theory of learning (Driscoll, 2005b). Gagne’s theory has three major components: a) taxonomy of learning outcomes; b) specific learning conditions to obtain those outcomes (internal and external events) and c) nine events of instruction (Driscoll, 2005b). The taxonomy of learning outcomes includes: a) verbal information; b) intellectual skills; c) cognitive skills; d) motor skills and e) attitudes (Driscoll, 2005b). However, there is no one-way to learn since learning will depend on the instructional task, the materials, the criterion of learning, and the characteristics of the individual who is learning. As Voss (1987, p. 609) notes: ‘The answer to the issue of how best to teach a particular subject matter to a particular group of students becomes “It depends.”’

Gagne’s theory is the complete opposite to the constructivist model for learning; direct instruction tends to happen when following Gagne’s theory, as opposed to constructing the learning/knowledge through experiences (Driscoll, 2005a).

Throughout the literature on adult education, lifelong learning is discussed in relation to improving the economic performance of nations, and in some cases rural regions and farm businesses (Driscoll, 2005b). Lifelong learning refers to the fact that people continue to learn throughout their life, even after they have left the formal education system (Candy, Crebert, & O'leary, 1994; Kilpatrick & Johns, 2003).

All life experiences are learning experiences (Candy et al., 1994; Kilpatrick & Johns, 2003). Merriam (2001) states that lifelong learning is a normal activity such as breathing. The learning can be unconscious, and incidental (Candy et al., 1994).
Lifelong learning can also be deliberate, planned and self-managed. Investing in learning is investing in capacity building for businesses (both private and public), communities (including rural) and other production settings. It encourages innovation and provides an ability to manage change (Candy et al., 1994; Merriam, 2001).

Many governments have policies on lifelong learning, as do supra-governmental bodies such as such as the European Union (EU), and the Organisation for Economic Co-operation and Development (OECD). However, lifelong learning is not an explicit component in the Australian government policy on education and training (Kilpatrick & Johns, 2003). This does not mean it is not supported; it is implied because the educational framework in Australia is very open and does not discriminate on age (Clemans, Newton, Guevara, & Thompson, 2012; Karmel, 2004). The government places an emphasis on workforce education and training designed to meet changing workforce demands (Karmel, 2004). Workforce education and training includes informal, formal, non-formal and incidental learning. However, there is a lack of agreement on the definitions of these terms (Clemans et al., 2012) and the boundaries tend to be blurred (Malcolm, Hodkinson, & Colley, 2003; Merriam, 2001). Informal learning: a) includes learning through everyday work practices; b) is intentional but
unstructured; c) tends to occur in a non-educational setting and d) the control of the learning is the responsibility of the learner (Malcolm et al., 2003). Examples of informal learning include, networking, coaching, mentoring, field days, families, groups, electronic media, print and other social settings (Malcolm et al., 2003; Marsick & Watkins, 2001; Merriam, 2001). Formal education usually occurs in educational institutions, and is highly structured (Kilpatrick & Johns, 2003; Marsick & Watkins, 2001). Non-formal learning is defined as all education that occurs outside of the school system (Malcolm et al., 2003; Marsick & Watkins, 2001; Merriam, 2001). This type of learning is considered organised and can have learning objective compared to informal or incidental learning (Kyndt, Dochy, & Nijs, 2009). Capacity building projects in agriculture that use participatory methods or action learning would be an example of non-formal learning using the definition given above. Incidental learning can be tacit and generally is unconscious for example, learning from mistakes, the process of trial and error (Kyndt et al., 2009).

In the agricultural community, Marsick and Watkins (2001) noted that formal education and training was not something that farmers perceived as being essential, nor did they have the time for formal professional development (Oreszczyn, Lane, & Carr, 2010). Many growers are unwilling to lose income while attending formal training, and they feel that many of the courses do not meet the needs of the industry (Kilpatrick & Johns, 2003; Oreszczyn et al., 2010). Furthermore, Kilpatrick and Johns (2003) noted that formal education qualifications alone are an inadequate measure of growers’ skills and knowledge. Growers use a range of sources for information and a variety of informal learning, non-formal learning and training sources to educate themselves and increase their capacity and skills (Kilpatrick & Johns, 2003).

One of the sources available for informal training and learning are Web 2.0 technologies (Kilpatrick & Johns, 2003). Web 2.0 was introduced in 2003-04, encompasses a wide range of constantly changing technologies (Selwyn, 2007). These new technologies have enabled online sharing, online learning and collaboration, information exchange and networking to occur throughout the world in both developing and developed countries (Cormode & Krishnamurthy, 2008). The development of Web 2.0 technologies has increased the amount of information communication tools that are now available, including webinars, podcasts, blogs, Facebook™, and Twitter™ (Aker, 2011; James, 2009; Rhoades & Aue, 2010). Online learning supports adult education extremely well, as self-directed learning is the main model used when developing courses. Courses can be richly resourced, problem-based, and provide a social context.
for learning (Aker, 2011; James, 2009; R. Mason, 2006) and be based on Kolb’s experiential learning cycle (Maloney, 2007; R. Mason, 2006).

Web 2.0 technologies have changed extension methodologies used in agriculture (R. Mason, 2006). These technologies are similar to the old methods used in that they can provide either one-way communication or two-way communication (Aker, 2011; James, 2009). The use of webinars (web conferencing) and social media sites allow for two-way communication between the agricultural community and extension and research officers while the use of a web page, SMS messaging or emails tend to be viewed as one-way communication coming from the research or extension officers to the agricultural community (James, 2009).

### 2.8 Linking adult learning and extension

As discussed in Section 2.4 (above) discussion of extension in the farming community is largely based on different models of how to transfer knowledge, which is highly dependent on whether the extension officer is working with an individual or with a group of people. Only more recently have the theories of adult education and extension have been linked (James, 2009; Kilpatrick & Fulton, 2003; Kilpatrick, Johns, Murray-Prior, & Hart, 1999; Vanclay, 2004) and used when providing extension. However, Röling and Pretty were discussing the role of constructivism and communicative rationality within agricultural science since 1995 as well as promoting the participatory approach (J. N. Pretty, 1995; Röling, 1996). The social principles of adult learning need to be taken into account when providing extension/education to farmers in Australia stressing that: “farmers construct their own knowledge” (Vanclay, 2004, p. 216). That is, farmers’ knowledge is created via their own experiences of the world, and any information that is provided to them through extension is evaluated against other information, knowledge and beliefs (Vanclay, 2004).

Many extension strategies are actually based on theories of adult education. For example, Coutts and Roberts capacity building ladder (Section 2.5 Figure 2.3) represents scaffolding, which is the main focus of the work done by Vygotsky. Thus it is important that courses developed for growers and agronomists are grounded in a social constructivist approach, which recognises this (J. N. Pretty, 1995; Röling, 1996; Röling & de Jong, 1998). Evaluation of the effectiveness of training programs for farmers shows that those taught in the classroom do not learn as effectively as those that are taught in the field or through hands-on experiences (Vanclay, 2004). The literature has also shown that it is much harder to teach complex ideas such as
integrated pest management in the classroom (van de Berg & Jiggins, 2007; Yang et al., 2008) than in the field using a participatory approach.

2.9 Discussion

This literature review has shown that the grains industry in Australia is diverse, and to remain competitive in the world market, capacity building has to occur for participants in the industry. Australian growers are keen for education and training to occur, however, there is no single solution. In contrast to the animal industry in Australia the grains industry has no benchmarks established. The animal industry in their capacity building programs have organised benchmarks to demonstrate that knowledge and skill levels have increased through their training and extension programs. There is very little evidence of benchmarking in the Australian grains industry. Therefore, in determining if capacity building of growers and agronomist in the identification of pests and diseases is required, the following questions arose:

1. What is the existing knowledge level of grain growers and agronomists on endemic diseases in their crops?
2. What is the existing knowledge level of grain growers and agronomists on biosecurity threats in their crops?
3. Where do grain growers and agronomists learn about these biosecurity threats?
4. Do they attend training, or do they actively look for information?
5. What type of training do growers and agronomists like to attend or value?

The following questions arose from a review of the literature on information sources, types and content:

1. Do growers and agronomists use the same types or sources of information when trying to solve problems on farm?
2. Are these sources and types of information the same for solving general problems and specific problems on farm?
3. How does the introduction of Web 2.0 technology change the information needs of growers and agronomists in the grains industry?
4. Does this use of Web 2.0 technology affect the sources and types of information used by growers and agronomists?
5. Do the providers of information need to change the sources and types of information produced?

6. Do we need to take into account their age, education and location when developing the types and sources of information?

Another area that needs further examination is the linking of the information leg and the training rungs in the capacity building ladder proposed by Coutts and Roberts (2011). The availability of having an information repository for growers does not necessarily mean that they will access this information, so there is a need to look at how growers and agronomists access information and training.

By making use of adult education theories to underpin agricultural extension, the range of training activities that can be used for capacity building increases, as well as the ability to use different evaluation methods. Many evaluation methods used in extension have as their final outcome behaviour change in the participants. However, this is very difficult to measure over a short period of time. One of the outcomes in the evaluation process needs to determine if there has been a change in knowledge levels and if the participants intend to use this new knowledge. The range of training events used in capacity building can then incorporate formal, informal, non-formal and incidental learning. There is very little in the literature about the training or capacity building of agronomists and if they need the same training as growers. Do agronomists fit into the groups on the capacity building ladder suggest by Coutts and Roberts (2011) (Section 2.4, Figure 2.3) or do agronomists need a different model?

In Figure 2.8, I have drawn a diagram displaying how the main sections of the literature are linked together. The main gaps in the literature are identified by the question marks on the arrows. For example, there is a large gap in the literature on capacity building of agronomists within agriculture. I then show the linkages between the literature, the gaps in the published literature and how these link into the objectives of my research (Figure 2.8).
Figure 2.8. Diagram showing: a) the linking of sections of the literature review; b) the gaps in the literature; and c) how the gaps link with the objectives of my research.
Having established the gaps in the literature and a list of questions that I had, the following five objectives were determined to guide my research:

1. To determine the existing knowledge levels on pest and diseases and biosecurity issues in Australian grains industry (Chapter 4).
2. To determine if there are key issues or concerns that growers and agronomists have in relation to training currently provided for capacity building in Australian grains industry (Chapter 5 and Chapter 6).
3. To determine the most effective knowledge transfer strategies available and required for growers and agronomists in the Australian grains industry (Chapter 7).
4. To determine if information technology tools can be part of this effective knowledge transfer strategy (Chapter 8).
5. To propose a theoretical framework that incorporates training and information as effective knowledge transfer strategies. (Chapter 9).

Therefore, in my research I will be using the growers and agronomists within the Australian grains industry as my case study. This case study will include the growers’ and agronomists’ skills and ability to identify pest and diseases in crops. The results obtained during my research will then be used to develop a theoretical framework for capacity building using training and information as the two main components.
Chapter 3. Methodology

3.1 Introduction

This chapter introduces the methods used to collect data during the research study and explains how the data were analysed. Different techniques were used to collect the data depending on the objectives of the study.

The data collected included both qualitative and quantitative and a mixed methods approach was used for the analysis. Mixed methods approach allows for the qualitative and quantitative data to be collected and used in tandem. This approach strengthens the results compared to quantitative or qualitative studies on their own (Creswell, 2009, 2012).

There were three main strategies used to answer the research aims of this project: a) Training needs analysis was used in the Australian grains industry. This provided quantitative data and qualitative data; b) Participants at workshops and field days in Australia and the USA were surveyed and interviewed. This work provided both quantitative and qualitative data; and c) The use of webinars, YouTube videos and podcasts were trialled as a method to provide information to the industry. This provided quantitative data.

3.2 Research paradigm

The researcher’s worldview or research philosophy creates a set of beliefs that guides their research action (Creswell, 2009, 2012; Patton, 2002). My background as a research scientist provides me with strong quantitative analytical skills, and my exploration into the world of adult education and extension has given me the ability to understand and use qualitative methods. Used separately, both of these models have disadvantages in terms of hypothesis setting, collecting data and being able to interact with participants in rural communities (Creswell, 2009, 2012; Patton, 2002). Therefore a mixed methods approach (Creswell, 2009, 2012), which uses both quantitative and qualitative methods, is highly appropriate (see Section 3.2.1 below). The mixed methods approach fits into the paradigm of pragmatism. In this worldview of pragmatism; a) I have the ability to focus on the problem, and b) I also have the freedom to use a range of approaches to collect all the data needed to fully understand the problem (Creswell, 2009, 2012; Patton, 2002) and the flexibility to determine solutions to the problems (Creswell, 2009).
In my research, I have five main objectives (Section 2.10) concerning the skills of growers and agronomists in the Australian grains industry to identify pest and disease issues in crops and what training will best improve their skills. In such work, there is no point determining a solution that will not be used by the growers and agronomists. Therefore, it is important that the growers and agronomists are an integral part of the research, which required me to seek and understand the context of the situation by visiting and participating and gathering information first-hand from current training events.

### 3.2.1 Mixed methods

A mixed methods approach was determined to be the most suitable method to use for collecting data based on the objectives of my research. The quantitative data to be collected were determined from gaps in the literature review. The qualitative data to be collected were determined to enable a richer perspective of growers and agronomists to be included in the research. Using the mixed methods approach enables: a) greater validity through variation of the data collection methods used; b) provides a variety of perspectives when answering the research questions; c) reduces the gaps in the data; and d) reduces my inherent prejudices (Creswell, 2009, 2012; Patton, 2002). This approach also enables the collection of data in the participants setting, that is rich, deep and detailed and supports a rigorous and detailed analysis (Ivankova, Creswell, & Stick, 2006; Patton, 2002). The downside to mixed methods is the extensive data collected, and the time consuming nature of analysing both numerical and textual data (Creswell, 2009, 2012).

The quantitative data collected provides numeric data that is analysed using statistical methods. The qualitative data collected is usually textual, and analysed using thematic coding. Collecting and analysing quantitative data can be straightforward if using parametric statistics but it is important to check data for discrepancies when collecting; if priorities are unequal, it can result in unequal evidence (Creswell, 2009, 2012).

The mixed methods approach enables quantitative data to be collected via questionnaires, and the usage statistics on the success of webinars, YouTube videos and podcasts as a communication tool. The qualitative data collected includes the short answer questions that were on the questionnaires, the interviews conducted with participants at training events and observations made at these events.

I used a sequential explanatory research design, that involves first collecting and analysing quantitative data, then collecting and analysing qualitative data (Ivankova et
al., 2006). Use of this approach means that the qualitative data can support, explain and be used to interpret the quantitative data. Specifically, I used a concurrent embedded design (Creswell, 2009), in which both quantitative and qualitative data were collected at the second stage. This allowed different perspectives to be obtained at the same time, as well as reducing the time spent collecting data. For example, I handed out a one-page questionnaire at field days and interviewed participants at the same field day. From the interviews, I was able to find out information from the participants to supplement the observation evidence (Patton, 2002).

3.2.2 Reliability and validity

A mixed methods approach requires that the instruments used to collect the data need to provide scores that are reliable and valid (Creswell, 2012). Reliability is defined as the measure of consistency (Henson, 2007). For example, a question in a questionnaire produces nearly the same result each time regardless of when it is administered. This means that if an individual answers a question one way, that person will always answer that question the same way (Creswell, 2012). Validity is defined as the development of sound evidence to demonstrate that the interpretation of the results from the instrument used matches the designed purpose (Creswell, 2012).

Validity in using qualitative research is quite different in its approach from that used in a quantitative research. In quantitative research, the emphasis is on reliability; the extent to which the same result would be found if you repeated the experiment (Jensen & Holliman, 2009). The use of statistical methods is heavily represented when reporting the results (Creswell, 2012; Jensen & Holliman, 2009). In qualitative research, the emphasis is on validity. This is the degree to which the sample data authentically represents the concept under study (Jensen & Holliman, 2009, p. 59). Validity is established based on the researchers', participants' and reviewers' views and the employment of certain procedures such as detailed field notes, recording of interviews using a recording device, and the use of participants quotes (Lather, 2007). It is also important that the researcher’s approach is consistent across the different groups researched, and that there is an active search for discrepant data (Creswell, 2009; Creswell & Miller, 2000; Lather, 2007).

One method used for determining validity is triangulation (Creswell, 2009; Creswell & Miller, 2000). Triangulation of the data allows for convergence between different sources of data to form themes in the research (Creswell, 2009; Creswell & Miller, 2000). For example, the open-ended questions used in the questionnaires and in the
interviews can be examined together to establish support or contradiction. Triangulation increases validity because multiple forms of evidence are used rather than a single incident or data point in the research (Creswell & Miller, 2000). In my research, I collected data from 14 training events. Another method for establishing validity in qualitative studies is the use of rich thick descriptions that enable the reader to be transported into the setting (Creswell & Miller, 2000). A thin description is one that lacks details and reports facts and does not enable the reader to be transported to the setting (Creswell & Miller, 2000). During the collection of data at field days, I wrote down observations at the end of the day, and recorded parts of the field day using a video recorder, to remind me about the setting that I was observing.

The next major aspect that has to be addressed when doing research that involves the use of people is the ethics associated with this type of work.

### 3.3 Ethics

As this research project involved conducting surveys, and interviews with participants from Australia and the USA, an ethics application was made to the University for permission to proceed. Approval for this work was gained from the Human Research Ethics Committee of The University of Western Australia (RA/4/1/6607).

The following research practices were addressed when applying for permission from the ethics committee:

1) The questions asked during the survey and the interviews did not contain any content that would cause embarrassment or economic loss to the participants. All questionnaires and interview questions were sent to the ethics committee for approval.

2) All personal information would be kept strictly confidential and not released to any third party.

3) Data were stored according to the UWA Code of Conduct for Responsible Practice. All electronic data were kept on a password-protected laptop and on an external hard drive. The data were also backed up onto the Science Communication Folder on the Science Faculty Server. Each personal folder is password protected. The data will be held for five years after publication.

4) Participants were asked if they were happy to be interviewed, and given an information sheet and a permission sheet to sign (Appendix C and D). I also explained why I was visiting the field day and my work in Australia. An
interview protocol was developed and submitted to the ethics committee for approval (Appendix E).

5) All interviews were conducted in person, and recorded on a digital voice recorder. The recordings were then downloaded on to a password-protected computer. Either I transcribed the interviews verbatim into MS Word documents, or I paid someone to transcribe the interviews, due to time restrictions. There were no personal details about the participant on the recordings apart from their first name. The transcriber was not able to collect any details, and received all recording labelled by date of the interview and a number.

6) These transcribed interviews were kept in a password-protected folder on my password-protected laptop. The interviews were filed according to the date and the training event.

7) Participants were assigned codes to their names to protect their anonymity. Codes were based on the training event that was held and the number of participants surveyed at that event.

8) As I was collecting data in the USA and Australia from field days and workshops, I checked before travelling to the USA if I needed ethics approval. Both USA universities (Washington State University, (WSU) and Kansas State University (KSU) were happy that I had approval from UWA and therefore I did not require further approval.

9) Before handing out questionnaires and interviewing participants at field days and workshops I asked for permission from the person in charge of these events. The questionnaires were given to the person in charge to examine and comment on the questions asked before the event. This was really important in the USA, as there quite a few language barriers and certain words had to be changed including names of occupations. These questionnaires are in Appendix F.

10) Participants did not have to fill in the questionnaire if they did not want to and anonymity was assured (that is, no names were collected) on the questionnaires.
3.4 Quantitative methods

In this section, I describe the instruments used to collect the data, the types of data collected and the statistical methods used for analysis. Table 3.1 provides a summary of the instruments used and the data collected against each of the aims for the thesis.

3.4.1. Questionnaires

The first objective of my research was to determine the knowledge levels of pest and diseases and biosecurity issues in the Australian grains industry. To do this, a training needs analysis (TNA) was conducted to determine the capacity of growers and agronomists to identify diseases and biosecurity threats in crops. I used a cross-sectional survey designed approach that enabled a wide cross section of the grains community to be covered at the same time, to determine their current attitudes and perceptions about training. Questionnaires are an effective instrument to use in a survey design, They have been used frequently in the literature when examining knowledge levels on quarantine issues in the animal and plant industry (Bagamba et al., 2006; Hammond et al., 2016a; Kunda et al., 2008; Musa et al., 2010) and they are used within educational research when examining the effectiveness of training programs (Barrett, Bolding, & Munsell, 2012; Escalada & Heong, 2004; Print, 1993). Using a cross-sectional design also allows for groups to be compared (such as growers and agronomists) in their attitudes, opinions and practices (Creswell, 2012). The questionnaire enabled me to determine the key issues or concerns that growers and agronomists have in relation to delivery methods and technical content that are currently used for increasing knowledge and capacity building in rural Australia (the second objective of the research). To determine the third objective, development of effective knowledge transfer strategies, another one-page questionnaire was developed and used at field days and workshops.

3.4.2 Development of the questionnaires

Two questionnaires were developed to examine the aims mentioned above (these will be known as the TNA questionnaires). The Australian grains industry includes both growers and agronomists. For this research, a grower was defined as a person who 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.
Table 3.1. Methodology matrix with the research questions showing how data were collected and analysed.

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Method</th>
<th>Data type and phase of research</th>
<th>Data source</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the baseline knowledge levels on pest and diseases and biosecurity issues in the Australian grains industry?</td>
<td>Online and paper-based questionnaire in Western Australia, Victoria and Queensland</td>
<td>Quantitative data, 1st phase</td>
<td>Growers and Agronomists in Western Australia (100 – 200) Growers and agronomists in Queensland and Victoria (50 per state minimum)</td>
<td>Statistical analysis on the survey results.</td>
</tr>
<tr>
<td>What are the key issues or concerns that growers and agronomists have in relation to delivery methods and technical content for increasing knowledge and capacity building?</td>
<td>Online and paper-based questionnaire in Western Australia, Victoria and Queensland</td>
<td>Quantitative data 1st phase</td>
<td>Growers and Agronomists in Western Australia (100 – 200) Growers and agronomists in Queensland and Victoria (50 per state minimum)</td>
<td>Statistical analysis on the survey results. Both qualitative and quantitative data analysis methods used. Thematic coding used for short answer questions.</td>
</tr>
<tr>
<td>What are the most effective knowledge transfer strategies required for growers and agronomists in the grains industry?</td>
<td>Examine field days and workshops in Australia and the USA Evaluation questionnaires used to assess knowledge levels Interview participants</td>
<td>Quantitative and qualitative data, 2nd Phase</td>
<td>Back paddock (FertCare Australia workshops) Western Australian field days International: Washington State University field days, Kansas State University field days and workshop</td>
<td>Qualitative analysis – observations and interviews. Interviews thematic coding using NVivo Quantitative analysis – survey, testing methods – non parametric statistical analysis.</td>
</tr>
</tbody>
</table>

Continued on the next page
<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Method</th>
<th>Data type and phase of research</th>
<th>Data source</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can information communication tools be apart of this effective knowledge transfer strategy?</td>
<td>Examine the uptake of webinars, YouTube videos and podcasts</td>
<td>Quantitative data, 3rd phase</td>
<td>Examine apps that are being used by agronomists here in Australia.</td>
<td>Data collection from Google analytics.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Develop webinars and Youtube videos, and podcasts for Western Australian grains industry</td>
<td></td>
</tr>
</tbody>
</table>
The information provided by agronomists to growers includes recommendations for fertiliser application, implementation of fungicide and herbicide spray programmes and general crop husbandry advice.

I assumed that the training needs of the two groups would be quite different, because they have very different roles in the industry, and in general their education levels are quite different, as shown in the reports from (Keogh & Julian, 2014a, 2014b; Watson & Watson, 2014). The questionnaire targeted at growers is in Appendix A; the one for agronomists is in Appendix B. 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 questionnaires were developed following the principles of Fowler (2009) and Dillman, Smyth, and Christian (2009); using questions which were simple and easy to understand and provided reliable and valid measures. This included ensuring that the questions were not too long, they did not ask two questions, and there were no mismatches between the questions and the responses supplied. Most of the questions were closed-ended questions with some open-ended questions used to probe and explore further the responses from participants (Creswell, 2012; Fowler, 2009). I developed the questions for sections a–d of the questionnaire based on my prior knowledge of the industry, having worked in the industry for over 16 years, and having a good understanding of what information was required to answer the objectives for my research. The responses supplied in section a on information sources used by growers and agronomists were based on similar questions asked by Watson and Watson (2014) on their survey of “Information products and Services needs in the grains industry” for GRDC. I also used sources that DAFWA provided to the industry. For section e of the questionnaire, the knowledge level of biosecurity threats, the questions were based on Hammond (2010) thesis. By using the same questions, in the same format, the results between 2008 (when Hammond did her survey) and from my survey in 2014 could be compared to determine if there had been a change in knowledge levels in the industry.

After developing the questions, I asked colleagues in my research group to read and comment on the construction of the questions, to identify whether the questions were ambiguous, if there was more than one question asked and if the responses (answers supplied) matched the questions (Creswell, 2012; Fowler, 2009). After multiple reviews the questionnaires were finally designed for pretesting with growers and agronomists.
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Pre Testing

Ten agronomists and researchers in the Department of Agriculture and Food, Western Australia (DAFWA) tested the agronomists’ questionnaire to ensure that questions were clear. Unclear questions were modified and a pilot run was undertaken at the GRDC Agribusiness Crop Updates held in Ballarat, Victoria in February 2014. A similar process was used for the grain growers’ questionnaire; a test for clarity was conducted with three farmers in Goomalling, WA and then the pilot run was held at the GRDC Grains Research Update for Growers at Lake Bolac, Victoria in February 2014.

To examine the third objective (Table 3.1), another questionnaire was developed to examine if knowledge levels changed after participants attended a training event (Appendix F). Paired single-page questionnaires (pre-workshop and post-workshop) were piloted at a training course held in Victoria in May 2014. However, after the course, I realised that a single-page questionnaire could be used, which was less daunting for participants.

3.4.3 Administering the questionnaires

The questionnaires were administered in two formats; online and paper-based. Using a mixed-mode method helps increase the response rate, by allowing participants to respond in a format that they are comfortable with (Dillman, Smyth, et al., 2009; Fowler, 2009). This enables a larger cross section of the community to be sampled (Dillman, Phelps, et al., 2009; Dillman, Smyth, et al., 2009; Fowler, 2009). Dillman, Smyth, et al. (2009, pp. 302-303) have shown that use of a mixed-mode method reduces the costs, improves the timeliness and reduce coverage error. As I was personally handing out the questionnaires at Crop Update research meetings in Western Australia, I was only sampling a small proportion of growers and agronomists that were present at these meetings. By using an online format, I could target other growers and agronomists who did not attend these meetings, and I could send the questionnaire to other growers and agronomists in other states. Using a mixed-mode method also enabled me to follow up on poor responses and send another format to participants to increase the response rate (Dillman, Smyth, et al., 2009).

Online questionnaires

The online survey was administered using Qualtrics (Qualtrics, Provo, UT, 2014), which is the preferred online survey software provided by The University of Western Australia (UWA). Links to the questionnaires were advertised in grower group newsletters in Western Australia, Queensland, Victoria and New South Wales.
There are benefits and disadvantages to using online surveys which include: a) shorter transmission time compared to posting out a survey; b) lower delivery costs (no postage costs involved); c) more design options; and d) less data entry time as the results are automatically collected (Couper, Traugott, & Lamias, 2001; Fan & Yan, 2010). The disadvantages associated with this approach are: a) non response error which is not all people included in the sample are willing or able to complete the survey; b) coverage error is when there is a mismatch between the target population and the frame population (Couper et al., 2001, p. 467). There will be people in the frame population who do not have email or Internet access and therefore will not be selected.

The benefits of running the questionnaire online for my research project were there were no administrative costs, the data were collected automatically and I could download the data into Microsoft Excel before analysing the results. The other benefit was that I was able to add the data collected from the paper-based questionnaire. This ensured all data collected was kept in the same place using the same format. I was able to set the software so that a participant could not answer the survey twice from the same computer or Internet Protocol (IP) address. However, they could save what they had done and complete it at a later date.

A number of problems were encountered in distributing the questionnaires online:

- a) I had to learn how to use the software. It was not the easiest software to learn to use properly.
- b) Testing the survey online to ensure that it was working correctly was very time consuming; especially when I had questions that jumped to another question depending on what answer the participant used.
- c) In the literature, most authors were able to obtain email addresses to invite targeted participants to complete a survey (Couper et al., 2001; Dillman, Phelps, et al., 2009; Fowler, 2009). I found that most of the grower groups throughout Australia would not provide email addresses due to their privacy laws. The compromise provided by the grower groups was they would advertise the survey in their local newsletter and encourage members to complete the survey by clicking on the link provided, my contact details were also provided. This prevented me from being able to calculate the response rate, as I had no idea how many people had seen or shown interest in the survey. However, the software used for the online survey did record the number of people who started the survey and how many completed it.

Before designing the questionnaires I attended a three-day course run by Dr Pamela Campanelli (October 2013) (Campanelli, 2013) that taught the general principles of question design. Design principles learnt included: a) Setting out the questionnaire; b)
grouping like questions together; c) instructions for each question; d) using multiple choice and tick boxes or radio buttons (on the online questionnaires); and e) restrict the number of short answer questions, so that there is less typing or writing for the participant (Campanelli, 2013; Couper et al., 2001; Dillman, Smyth, et al., 2009; Fowler, 2009).

**Paper-based questionnaires**

The literature reviewed has shown that in general surveys administered via the Internet tend to have a lower response rates than those that are sent out via the mail (Couper, 2000; Dillman, Phelps, et al., 2009; Shih & Fan, 2009). A low response rate introduces non-response bias into the data (Shih & Fan, 2009), and these authors concluded that the response rate on email surveys were 20% lower than mail surveys (Shih & Fan, 2009). This simple fact was the reason that I chose to use paper-based surveys. Phone surveys are costly in terms of time and training of personnel required to do the surveys (Dillman, Smyth, et al., 2009) and at the time of my research I did not have this option available.

The format of the paper-based questionnaire used for the TNA analysis was exactly the same as the online survey. After completing the online survey, I was able to download this into Microsoft Word and then reformat it so that it was appealing and presentable in the paper-based format. Following the guidelines in Dillman, Smyth, et al. (2009) and (Fowler, 2009) the paper-based questionnaires had a cover letter attached (Appendix A and B), explaining a) the goal of the survey, b) funding of the research, c) what the research was trying to achieve, d) who to contact in relation to the project, e) how to complete the survey and f) the terms of the survey including anonymity and confidentiality.

UniPrint at UWA printed the questionnaires with the university logo on the cover page. Each survey had a unique identifier code; this was used when entering the data into Qualtrics.

### 3.4.4 Data collection

**Training needs analysis questionnaires**

The questionnaires for growers and agronomists were distributed in March 2014 as an online questionnaire and as paper-based questionnaires. The online questionnaire was advertised through local grower group newsletters in Western Australia (WA), Queensland (QLD) and Victoria (V). The paper-based questionnaires (400) were distributed with a reply-paid envelope at six regional crop updates in WA. Crop updates and research updates are forums that are held at the beginning of each year around
Australia, to inform growers and agronomists and others of the latest research in the
Australian grains industry. These are popular events attended by growers and
agronomists in the grains industry.

I attended WA grower groups’ research updates: Liebe, Minginew - Irwin (MIG), West
Midlands Group (WMG), Southern DiRT, Fitzgerald Biosphere Group (FBG), Stirlings
to Coast (S2C) and Ravensthorpe, (Figure 3.1). These groups were targeted because
they represented a wide range of cropping regions in the Western Australian wheatbelt
with different rainfalls, and they have a large membership base. I contacted the
organisers beforehand to seek permission to attend and hand out the questionnaires.
The paper questionnaires were distributed by placing them on the chairs during
morning tea or lunch and then the organiser made an announcement asking
participants to fill them in and either return to me that day or use the reply paid
envelope. The grower group newsletters reminded participants about the surveys a
month later and also provided a link to the online survey.

The sampling strategy was to have a minimum of 50 growers from the low, medium
and high rainfall zones in WA and a minimum of 50 growers from QLD and Victoria. A
minimum of 50 agronomists in WA and 50 from QLD and Victoria were also wanted.
These numbers are very small compared to the actual number of growers and
agronomists in Australia. In 2011, there were 157 000 growers in Australia (ABS 2013),
approximately 20% of these growers are in the grains industry (ABS 2013). The
number of farms that were either grain only or grain and livestock were 5004 in
Victoria, 2500 in QLD and 4719 in WA (ABS 2013, Keogh and Julian 2014a). Therefore
the target for number of growers to respond was 1% for Victoria and 3% for WA. This is
a very small sample size, but given that it is hard to get participants in the grains
industry to respond to surveys (Hammond pers. comm.), and as I was the only person
doing the data collection, this seemed an appropriate number to target. Keogh and
Julian (2014b) estimated that the number of agronomists in Victoria were 548, 255 in
QLD and 100 in WA. Over 70% of farms in WA employ an agronomist (Keogh and
Julian 2014b). I was aiming for 6% of the number of agronomists working in Victoria
and QLD and 50% of agronomists in WA. I received a total of 89 (1.9%) and 47 (47%)
valid surveys from growers and agronomists respectively in WA.

Initially I received only seven responses from growers and agronomists from
Queensland and Victoria, which was extremely disappointing. Due to privacy laws, the
grower groups that I contacted would not let me send the questionnaires to their
members directly. However, the CEO of the Birchip Cropping Group (BCG) in Victoria
(Figure 3.1) worked with me to solve this problem. I placed each questionnaire with a
reply paid envelope into another envelope and shipped them to the CEO.
Figure 3.1: Map of Australia showing where grower and agronomists who responded to the training needs analysis survey on endemic diseases and high priority pests (HPPs) in grain crops resided based on postcodes. Figure 1b shows respondents from the Western Australia wheatbelt. Figure 1c shows respondents from Eastern Australia. The size of the symbols correlates to the number of participants who responded and reside in that locality. ▼ Agronomists (1-8), ■ Growers (1-9), ● Town
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One of the administrators working in the group randomly picked 200 growers and 100 agronomists who were members of the group to receive the questionnaire. I received from growers 40 (20%) and from agronomists 58 (58%) valid questionnaires. (A valid survey was one that included their postcode and more than 50% of the questionnaire had been completed.)

The online questionnaire showed a completion rate of 50%. The software recorded 264 participants started the survey and only 132 completed the survey.

The questionnaire was closed on 30th June 2014, three months after the initial distribution of the questionnaires at the regional crop updates in Western Australia. Surprisingly, up to three months later, I would receive a few completed questionnaires from growers that had found them buried on their desks. The data from these questionnaires were not included in any of the analysis.

**Knowledge level questionnaires**

The questionnaire on knowledge levels was handed out to participants at field days, and workshops at lunchtime or during a specific session (for the WA and KSU field days). In the USA, lunchtime at the field days generally consisted of a sit-down meal, which made it very easy to hand out the sheet with a pen or pencil for people to fill in and leave on the table or their chair when they had finished. Participants were not required to fill in the questionnaire if they did not want to. In contrast, lunchtime for the Australian field days is very informal; participants tend to eat a sandwich or a bread roll standing up and talking to colleagues. Because of this format, questionnaires were handed out at specific sessions where participants were sitting down and could fill in the form.

**Limitations of the survey sample**

The limitations associated with the handing out the knowledge-level questionnaire included: a) the reluctance of participants to fill in the questionnaire, b) the lack of literacy that is often found with older farmers (I observed this on a number of occasions) and c) the sampling is skewed because attendance at field day events is highly dependent on the need and interest of the grower and agronomist for information.
3.4.5 Data analysis

The data from the questionnaires were compiled using Qualtrics software, (2013). Statistical Package for the Social Sciences (SPSS) (IBM ver. 22) was used to analyse the data.

Questionnaires with incomplete demographic data, such as no postcode (n=47), were not included in the analysis. Due to low number of questionnaires returned from QLD, the data collected was combined with the data from Victoria as “Eastern Australia” (EA).

The data collected during the questionnaires met two of the assumptions required for non-parametric techniques: i) each person could only be counted once, and ii) their response did not influence the data collected from another person (Pallant, 2013). The samples were not random, as I had targeted grower groups for distributing the questionnaires. However, I could not predict the return rate or who would return the questionnaires.

Descriptive statistics were used to examine the data before using more specific statistical analysis. Pearson’s Chi-Square analysis was chosen because the data collected in the training needs questionnaires were either categorical or from ranked scales. For example, Question 1 in the TNA (Appendix A) asked growers and agronomists how important particular information sources were for solving problems. They could choose from; a) not important, b) slightly important, c) very important and d) extremely important. This test compares two or more variables and their observed frequencies with the expected values of frequencies as if there was no association between the two variables being measured (Pallant, 2013). Pearson’s Chi-Square test using the participants’ demographics determined the significance of demographics on the results.

3.4.6 Specific data analysis

Non-parametric tests were used with specific questions to complete the data analysis. These are shown in Table 3.2.

McNemar’s test was used (see Chapter 4) to determine if there was a difference in the participants’ ability to identify one leaf disease compared to another leaf disease. This test has only two responses for each disease (correct or incorrect in this example) and is used when examining the difference between two related groups, where the data are nominal rather than ordinal (Field, 2013; Pallant, 2013).
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The biosecurity questions (see Chapter 4) were analysed using the same method as Hammond (2010). The results from the two different years, 2008 and 2014, were then compared using the Mann-Whitney U test. The Mann-Whitney U test is the non-parametric equivalent of an independent samples t-test (Field, 2013; Pallant, 2013). This test determines if there are differences between two independent groups, in this case the results from 2008 and 2014. This test converts the scores to ranks across the two groups and then compares the two groups. This removes any bias from the distribution of the scores, and the median results are given (Pallant, 2013).

The sources of information used by growers and agronomists are examined in Chapter 5. The data collected were split into two parts for analysis based on whether the question asked about information sources were used for a general problem or to solve a specific problem such as pest or disease in a crop (see Chapter 5).

Setting benchmarks for growers and agronomists

Benchmark knowledge levels were set to 70% of growers and 80% of agronomists recognised common diseases in their crops. This benchmark was determined by prior knowledge of the industry and in discussion with colleagues working in the industry. It was felt that the benchmark should be achievable and if it was set higher, it would be unachievable within the industry. Benchmarks have not previously been set within the grains industry or other plant industries.
Table 3.2. Summary of statistical tests used to analyse data from the training needs analysis questionnaires. The parametric equivalent is provided along with assumptions that are used when doing the analysis.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Questions from TNA questionnaire</th>
<th>Test</th>
<th>Parametric Equivalent</th>
<th>Reason and Assumptions (Field 2013, Pallant 2013).</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Section D, Questions 32-34. Identification of barley powdery mildew, stripe rust of wheat and blackleg in canola Section C, Question 31. Awareness of diagnostic services</td>
<td>Cross tabulations and Pearson’s Chi-Square test</td>
<td>None</td>
<td>The test is used to see if each variable from the categorical data is independent or if there is an interaction between the variables. Each variable has two or more categories. Minimum cell frequency is five and more than 80% of the cells should have this.</td>
</tr>
<tr>
<td>4</td>
<td>Section D, Questions 32-34 Identification of barley powdery mildew, stripe rust of wheat and blackleg in canola</td>
<td>Frequency data for number of correct and incorrect responses for each endemic leaf disease. McNemar’s test</td>
<td>None</td>
<td>Two categories of response for each disease (correct and incorrect). Used for matched or repeated measures. This test was used to determine the participant’s ability to identify the leaf diseases reliably.</td>
</tr>
<tr>
<td>4</td>
<td>Section E, Questions 35-38. Recognition of High Priority Pests. Comparison of results from Hammond (2010) and this survey</td>
<td>Mann-Whitney U test</td>
<td>Independent samples t – test</td>
<td>Used to test for differences between two independent groups using the same measure. Test compares the median values. Because the scores are converted to ranks, the actual distribution of the scores in not important.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Chapter</th>
<th>Questions from TNA questionnaire</th>
<th>Test</th>
<th>Parametric Equivalent</th>
<th>Reason and Assumptions (Field 2013, Pallant 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Section A, Question 1. Information sources used to solve general problems on farm&lt;br&gt;Section C, Question 26. Information sources used to solve specific pest and disease problems in crops.</td>
<td>Principle component analysis (PCA)&lt;br&gt;Hierarchical agglomerative cluster analysis&lt;br&gt;Log-linear analysis</td>
<td>Same</td>
<td>The PCA allows for clusters of variables to be identified and reduces the set of variables into a smaller set of linear components, and determines how that particular variable contributes to that component. A hierarchical cluster analysis was chosen because it prevents participants being assigned to more than one component (group). Log-linear analysis allows all categorical variables to be included and whereas Pearson’s Chi-Square test only allows two variables to be tested at a time.</td>
</tr>
<tr>
<td>6</td>
<td>Section B, Questions 7, 11, and 20. Types of training events attended by participants.&lt;br&gt;Questions 8 and 14. Barriers to attending training events.</td>
<td>Cross tabulation and Pearson’s Chi-Square test</td>
<td>None</td>
<td>The test is used to see if each variable from the categorical data is independent or if there is an interaction between the variables. Each variable has two or more categories. Minimum cell frequency is five and more than 80% of the cells should have this.</td>
</tr>
<tr>
<td>7</td>
<td>No questions from the training needs analysis were used in this chapter</td>
<td>Thematic coding. Frequency counts</td>
<td>None</td>
<td>An inductive approach used incrementally.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Chapter</th>
<th>Questions from TNA questionnaire</th>
<th>Test</th>
<th>Parametric Equivalent</th>
<th>Reason and Assumptions (Field 2013, Pallant 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Section A, Questions 2-5</td>
<td>Cross tabulation and Pearson’s Chi-Square test</td>
<td>None</td>
<td>The test is used to see if each variable from the categorical data is independent or if there is an interaction between the variables. Each variable has two or more categories. Minimum cell frequency is five and more than 80% of the cells should have this Log-linear analysis allows all categorical variables to be included and whereas Pearson’s Chi-Square test only allows two variables to be tested at a time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Log-linear analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Section A, Question 6</td>
<td>Thematic coding</td>
<td>None</td>
<td>An inductive approach used incrementally</td>
</tr>
</tbody>
</table>
A Principal Component Analysis (PCA) was used to categorise the sources of information and then a cluster analysis was used to group the participants according to information preferences. This is similar to the process that Solano et al. (2003) used in their work that examined the role of personal information sources on the decision-making process of diary farmers in Costa Rica. The PCA allows for clusters of variables to be identified and reduces the set of variables into a smaller set of linear components, and determines how that particular variable contributes to that component (Field, 2013). A hierarchical cluster analysis was used to determine the number of participants that fitted into the sets of components determined by the PCA. This method was chosen because it prevents participants being assigned to more than one component (group) (Mooi & Sarstedt, 2011). Euclidean distance was used as the measure of distance between the participants, as this is the best to method use with categorical data (Mooi & Sarstedt, 2011). The smaller the distance, the more similar are the cases (participants) (Field, 2000). Ward’s method was used as the linkage method between the clusters. The basis of Ward’s method is to join the cases into clusters so that the amount of variance is minimised; that is, the amount of variability in a cluster is reduced (Field, 2000).

Log-linear analysis was conducted to examine the influence of participants’ demographics on the group profiles determined during the cluster analysis. This method of analysis was selected as it allows all categorical variables to be included whereas Pearson’s Chi-Square test only allows two variables to be tested at a time (Field, 2013; Pallant, 2013). The log-linear analysis starts with a saturated model, then removes interaction terms in a hierarchical manner until an interaction or main variable is removed and this affects the fit of the model (Field, 2013). If a three-way interaction was found then a separate Pearson’s Chi-Square test was conducted for each of the variables to determine the significance of the associations (Field, 2013).

The data collected from the knowledge level questionnaire (see Chapter 6) were analysed using SPSS (IBM ver 23). The data were split into groups based on whether they came from workshops or field days and which state and country they were held in. A Wilcoxon Signed Rank test was used to compare participants’ knowledge levels before and after the training event. This test is the non-parametric equivalent of a paired-samples t-test (Field, 2013; Pallant, 2013). The participants’ knowledge levels were measured twice (before and after); therefore this is the most appropriate test. This test does not compare means. The test converts the scores to ranks and then compares them (Pallant, 2013). Median values are then determined by from the descriptive statistics, so that box plots could be drawn.
A Kruskal-Wallace test was used to examine the influence of occupations and length of working on knowledge levels before and after the training event and on the amount of learning participants felt they received from the training event. The equivalent parametric test is one-way analysis of variance (ANOVA) (Field, 2013; Pallant, 2013). This test is used when groups contain independent scores, and allows for differences between groups to be determined. It can be used when there are more than two groups, for example in this work I have more than two occupations that I want to compare. This test does not identify which group is different, and further tests are required to determine this (Field, 2013; Pallant, 2013). If the result from the Kruskal-Wallace test is significant, this is then followed up with a Mann-Whitney U-test to determine if there were any significant differences between the groups (Field, 2013; Pallant, 2013). This test examines the medians of each group and compares two groups at a time. A Bonferonni adjustment has to be done on each Mann-Whitney U-test to reduce the type 1 errors (Field, 2013; Pallant, 2013).

3.5 Qualitative methods

As noted above, qualitative methods allow for the exploration and understanding of individuals and groups by collecting data in the participants’ settings, such as at field days and workshops (Creswell, 2009; Patton, 2002). Using these methods gives greater insight into how participants view their world, what terminology they use, their judgement and perceptions and experiences (Patton, 2002). General themes are inductively built from particulars, and then interpretation of the data occurs (Creswell, 2009).

3.5.1 Interviews and questionnaires

Structured interviews (Appendix E) were held with participants at workshops and field days to determine; a) what they hoped to learn, b) what was most useful and least useful, c) what was the most engaging; and d) how would they use the information they had gleaned that day.

Semi-structured interviews ensure that the same questions are asked of each participant (Patton, 2002) and allow the data collected to be triangulated with results from the questionnaires. Using semi-structured interviews enables the interview to be focused, and ensure that participants’ time is used efficiently (Patton, 2002), and that as the interviewer, I did not stray from the task. The questions asked were
standardised and were designed to gain extra information from the questionnaires used previously with growers and agronomists and those used at the same field days. By using this approach participants could provide opinions, give their perceptions and experiences which are very important when collecting qualitative data (Creswell, 2009; Patton, 2002). Using a structured interview and standard questions enabled the Ethics committee to review and approve the questions.

In the TNA questionnaires, there were questions that were short-answer, open-ended questions (Section 3.4.2. For example, participants were asked to list three ways the training event could be improved (Appendix A and B). The use of short answer open-ended questions in the questionnaires and interviews enables the points of view of the participants to be collected without predetermining the results (Patton, 2002). The limitation to collecting answers to open-ended questions on a questionnaire is determined by the writing skills of the participants, and the researcher is unable to probe or extend the responses (Patton, 2002). However, by using similar questions in my interviews I was able to probe a bit further if required, and this provides further evidence to be used with the answers from the questionnaires.

3.5.2 Development of the questions used in the interview

The questions used in the interviews were designed to complement the findings from the two TNA questionnaires used with growers and agronomists. The TNA questionnaire administered to growers and agronomists determined the number training events they attended, and what they liked about these events and how they could be improved. Participants were asked in the interviews why they had come along to the event, what sessions did they find useful and engaging, and how would they use this knowledge. By asking open-ended questions that allow participants to provide their opinions, perceptions and insights provide rich data to be triangulated with other data collected during the research (Creswell, 2009; Patton, 2002).

The interview questions were pilot tested using DAFWA employees attending an equal employment training course, and participants attending a nursery industry course, both of which were held in May 2014. This enabled me to practice: a) my interview techniques, b) approaching people to ask if they would mind me interviewing them and c) explaining what my project was about and why I was interviewing participants.
3.5.3 Data collection

At the training events, I randomly approached participants to ask if they were happy for me to ask them some questions. I aimed to interview a sample of 25% of the participants at the training events. There are no statistical numbers in qualitative data collection. In qualitative data collection the concept of data saturation is used; no new additional data provides new information or themes (Guest, Bunce, & Johnson, 2006; M. Mason, 2010). However, M. Mason (2010) found that numbers ranged from 5 to 30 or 50 depending on the type of study being done. The type of research being conducted, the theories that are being examined, ease of access to the participants all influence the saturation number (Guest et al., 2006; M. Mason, 2010).

This was achievable at the workshops because each workshop generally had a maximum of 25-30 people. This sample size would provide a cross-section of the people attending the course and provide the numbers for data saturation (Guest et al., 2006; M. Mason, 2010). This sampling strategy I used is known as typical sampling and purposeful sampling for each of the events I attended, because I would study the event first before conducting the interviews so that I understood the range of participants that were attending (Creswell, 2012).

It was quite easy to approach people during workshops and ask if I could spend five to ten minutes asking them questions either during their lunch or at the end of the course. Most people were quite receptive to this approach, because it was informal. Piloting the interviews had enabled me to learn the questions, so that I did not have the list in front of me when I spoke to people. This gave the appearance that the interviews were quite casual and informal.

At field days, interviewing proved to be more difficult than anticipated. The field days generally had more than 100 people attending and the questions had to be asked either at lunch or towards the end of the day, after the participants had been there for a while. The time allocated for lunch was generally 30 to 40 minutes, and I found by the time I explained what I was doing and why, I would only get two interviews completed. On the USA tours, we were on stadium seating hooked up to a tractor that moved from section to section, and this made it difficult to talk to people other than those sitting directly next to me. When arriving at a section, I felt that it was rude to not listen and pay attention to what the speaker was saying. I had not anticipated these problems. The field days in Western Australia have a large amount of walking involved or sitting on a bus, which enabled me to approach people and ask them the interview questions.
3.5.4 Data analysis

The transcripts were checked to ensure that they had been written verbatim for reliability of the qualitative data collected. To ensure that there was no drift in the meaning of the codes during coding, a coding manual was made, and the coding was crosschecked with colleague for inter-coding reliability (Creswell, 2009; Patton, 2002).

The transcribed interviews were grouped into categories based on the training event that participants had attended, then analysed using NVivo Ver 11 for Mac (NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 11, 2016). I then carried out inductive thematic coding using a combination of templates codes (based on the questions asked in the interview) and an inductive approach (Fereday & Muir-Cochrane, 2006).

Thematic coding involves looking for patterns in the transcripts from the participants, and for patterns in the open-ended short answer questions. These patterns can be based on recurring words or themes (Patton, 2002). Inductive analysis is about discovering these themes and categories in the data while deductive analysis uses an existing framework determined before the data was collected (Patton, 2002). Generally, thematic coding starts inductively while determining the categories and coding to be used and moves to deductive analysis in the final stages as the results are checked and confirmed (Patton, 2002).

This approach allowed the data collected to be grouped by the training event attended. Each interview had a set of standard questions that the participants were asked which formed the template for the coding. By developing the template based on the questions asked, the coding then occurs through an iterative process, which allows the data to be sorted, compared, reviewed and refined (Wang & Roulston, 2007).

The transcripts from each event were iteratively analysed, until the number of themes could not be collapsed any further. Once the themes had been decided on the data from each event were compared to see if there were any outliers and to determine if the themes were specific to the events, or there was a generalisation of themes across the training events.

A colleague completed a cross-coding check on six interviews using the coding template; a match of 82% was achieved for the inter-coding reliability.

Frequency data was then used to present the themes from the short-answer questions in the questionnaires used at the training events.
3.6 Usage data on information communication tools

In the third phase of my research, quantitative data were collected on the usage of the YouTube videos and podcasts that had been developed (Chapter 8). The analytics tool provided by ©Google, provides a good measurement of the usage and the success of web pages, and other information resources found on the Internet (Pakkala, Presser, & Christensen, 2012). The data were used to show the popularity of some videos compared to others on the same channel (Zeni, Miorandi, & De Pellegrini, 2013), and are used regularly by businesses, government departments, as well as by the public to monitor the success of their work (Kent, Carr, Husted, & Pop, 2011; Zeni et al., 2013).

The data collected includes the number of views, the average time that videos were watched. YouTube data were provided by Google analytics on the YouTube Channel “Training growers” (https://www.youtube.com/channel/UCGQqkODZkfqCAwXgnAh-Og)

and from DAFWA YouTube Channel (https://www.youtube.com/playlist?list=PLIRsVG3L9GNla2aohVxB8MfZjpCXfkb7y)

The data collected on the podcasts were provided by DAFWA and included the number of people who had viewed the page, the length of time they spent on the page and how many had accessed the page from another link.

The MPG Reports on presence or absence of RWA, diseases in grains 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, dplyr packages for data analysis, and the ggplot2, ggmap and RColorBrewer packages for geocoding data, and generating plots and maps of the results (Kahle & Wickham, 2013; Neuwirth, 2015; R Development Core Team, 2008; Wickham, 2009, 2012; Wickham & Francois, 2015).

3.7 Summary

In summary, a mixed method approach was used to collect and analyse data in this thesis, as this fits the pragmatist’s worldview paradigm. A sequential explanatory design was used, where questionnaires were used to collect quantitative data that was analysed in the first phase of the research. In the second phase, both quantitative and qualitative data were collected using a questionnaire with both closed and open-ended questions and interviewing participants attending training events. A third phase of the
research involved analysing usage statistics from the provision of webinars, YouTube videos and podcasts to participants in the Australian grains industry.

The quantitative data collected were analysed using a range of non-parametric tests that provided strong and rigorous analysis of the data. The qualitative data were analysed using thematic coding and frequency counts, which provides strong supporting evidence for the quantitative data. The quantitative and qualitative data were then compared and contrasted to examine their complementary results.
Chapter 4. Training needs analysis

There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don’t know we don’t know. (Donald Rumsfeld 2002)

Published paper:

Can grain growers and agronomists identify common leaf diseases and biosecurity threats in grain crops? An Australian example

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A B S T R A C T
The Australian grains industry relies upon growers and agronomists to be aware of pests and diseases in their crops and to notify their local State Department of Agriculture when they suspect an incursion of a high priority pest (HPP). This raises the question "Are growers and agronomists, within the Australian grains industry, able to meet this expectation?" A training needs analysis was undertaken to determine the capacity of growers and agronomists to identify three endemic diseases (powdery mildew in barley, stripe rust in wheat and blackleg in canola) in their crops. Their knowledge of the top four-biosecurity threats to the Australian grains industry (Karnal bunt, Khapra beetle, barley stripe rust and Russian wheat aphid) was also determined. Benchmarks for successfully identifying these diseases were set beforehand at 70% of growers and 80% of agronomists; participants’ ability to identify these endemic diseases in crops met these benchmarks. However, their ability to recognise blackleg in canola was significantly lower than for the two cereal foliar diseases. There was a significant correlation of region with these capabilities, with a greater proportion of participants in Western Australia (WA) recognising powdery mildew in barley than in Eastern Australia (EA). In contrast, a greater proportion of participants in EA were able to identify stripe rust of wheat than in WA. The education levels of participants corresponded with their ability to identify blackleg in canola. Participants’ knowledge and awareness of symptoms and signs associated with the top four biosecurity threats were well below expectations; fewer than half of the participants answered questions on these four HPPs. Gender, age and educational level did not correlate with the participants’ knowledge and awareness of the four HPPs with the exception of Karnal bunt. Participants with a higher level of education had significantly more knowledge of symptoms associated with Karnal bunt than did participants with lower levels of education. The use of diagnostic services by the grains industry participants is a vital component of general surveillance. This survey showed that use of these services by growers was significantly lower than by agronomists. Awareness of the National Exotic Plant Pest Hotline and GrainGuard was significantly lower than other diagnostic services for both growers and agronomists. Diagnostic services need to be promoted further to increase awareness and use by growers and agronomists. Correct diagnosis of disease and pest symptoms is vital for the biosecurity of the grains industry.

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1. Introduction

Accurate and rapid diagnosis is required for the effective management of endemic diseases and pests and to prevent the incursion and establishment of biosecurity threats to the Australian grains industry. Early detection requires growers and agronomists to be aware of and to be able to identify symptoms and signs associated with these pathogens and pests.

In Australia, the Emergency Plant Pest Response deed (EPPRD) covers the management and funding of responses to emergency plant pest (EPP) incidents. Plant Health Australia (PHA) is the custodian of this document (Plant Health Australia, 2015). PHA is a not-for-profit company that is the national co-ordinator of the government-industry partnership for plant biosecurity in Australia.
Chapter 4. Training needs analysis

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(Plant Health Australia, 2015). The EPPRD has increased the capacity of Australia to respond to incursions by allowing rapid, efficient and effective responses (Plant Health Australia, 2015). An EPP is either: a) a known exotic plant pest; b) a variant form of an endemic plant pest; c) a previously unknown pest or d) an officially controlled pest. These are pests that have a significant impact (environmental or economic) nationally (Plant Health Australia, 2015). Eradication is facilitated by early detection (Plant Health Australia, 2015). The deed lists the following three EPPs for the grains industry: a) Tilletia indica Mitra 1931 (Karnal bunt); b) Trogoderma granarium Everts 1809 (Khapra beetle); and c) Diuraphis noxia Kurdjumov 1913 (Russian wheat aphid) (Plant Health Australia, 2015). The pathogen that causes barley stripe rust (Puccinia striiformis f. sp. hordei Eriksson 1894) is not on the list of EPPs, but is listed as a high priority pest (HPP) for the grains industry within Australia. These four pests and pathogens are referred to as high priority pests (HPPs) in this investigation.

Australia has a very diverse agricultural sector that includes crop production (broadacre and horticultural) and animal production (sheep, cattle – beef and dairy, pigs and poultry). The Australian Bureau of Statistics (ABS) reported that in 2011/2012, 405 million hectares of land were used for agriculture in Australia, with 32 million hectares being planted for crops. The value of Australia’s exported grain exceeded $10 billion (AUD) in 2013/2014 and included these three major crops; wheat ($6 billion), canola ($2 billion) and barley ($2 billion) (Australian Export Grains Innovation Centre, 2015). Nationally 29.8 million tonnes of wheat were produced, with a total area planted to wheat of 13.9 million hectares (Australian Bureau of Statistics (2012)).

Pests and diseases cause considerable loss of value to Australian crops. The estimated annual loss is $76.64 (AUSD) per hectare in the Australian wheat industry (Murray and Brennan, 2009b). These losses represent 19.5% of the average annual value of wheat crop production over the past decade. Similar losses are reported in barley and canola crops (Murray and Brennan, 2009a, 2012).

Improving the knowledge and skills of growers and agronomists to facilitate effective management of pests and diseases, should reduce these losses.

The Grains Research and Development Corporation (GRDC) surveyed growers and agronomists about information products and services needs that they will require over a two-year period (Watson and Watson, 2014). Only 17% of growers thought that they would require information on pests and diseases in crops while approximately 30% of agronomists thought that this information would be required (Watson and Watson, 2014). This indicates that growers and agronomists within the grains industry believe that their existing skills are adequate for pest and disease management.

Community-based surveys and reporting by growers and agronomists can be used to address International Standards for Phytosanitary Measures (ISPM) 04 requirements for Area Freedom (2001; FAO, 2011; Hammond et al., 2016a; Mangano et al., 2011). The ability of community groups to detect exotic or HPPs (both disease and insects) was tested by Mangano et al. (2011) in a simulated exercise where three fictitious pests (two insects and one disease) were used. Success in detection of these pests was correlated with both participants’ age and professional experience. The term ‘general surveillance’ is used to encompass information that is collected through diagnostic services, reports from experts, growers and agronomists and reports to government departments. These activities are an important contributor to the early detection of a possible HPP (FAO, 2011; Hammond et al., 2016b).

The probability of a grower detecting a disease in their crop directly influences the sensitivity of general surveillance for that disease (Hammond, 2010), i.e. the higher the probability of detection by the grower, the greater the sensitivity of the surveillance.

When knowledge and awareness are lower than a benchmark level this is likely to impact on the ability of growers and agronomist to report suspected HPPs. The animal and plant industries have considered this using scenario tree analysis, based on probabilistic modelling (Hadorn and Stark, 2008; Hammond, 2010; Martin et al., 2007). The sensitivity of general surveillance for the detection of foot and mouth disease in animal production areas of Australia varied according to a number of factors including the attitudes, behaviours, the knowledge and understanding of this disease by farmers and livestock inspectors. This was demonstrated using a stochastic scenario tree model (Martin et al., 2015). In this model, disease awareness was broken down into three main components: a) the probability of clinical signs being observed in the animals, b) the probability that the farmer recognises these clinical signs as being a problem and c) the probability that a veterinary officer is notified of the problem (Martin et al., 2015). Therefore, the earlier that growers and agronomists recognise symptoms associated with HPPs in grain crops, the greater the probability that a HPP will be reported early, allowing for a more effective response to occur.

In a previous survey by Hammond et al. (2016a), knowledge of the symptoms and identification abilities of growers and HPPs in the grain industry was determined among growers and agronomists within Western Australia (WA). Participants had greater knowledge of the symptoms and signs associated with the pathogens causing Karnal bunt and barley stripe rust than of the two insect pests Khapra beetle and Russian wheat aphid.

There is little published literature concerning increasing the capacity of growers and agronomists to identify plant pests and diseases, although Levy (2005), Bagamba et al. (2006) and Yang et al. (2008) indicate that the awareness of growers and industry was increased when information was provided during a biosecurity campaign. However, there is more literature published within the animal industry examining the skills of farmers, veterinarians and other professionals in their identification and awareness of exotic diseases to determine what capacity building is required (Kunda et al., 2008; Martin et al., 2015; Mira et al., 2010).

No benchmark has been set previously in the grains industry for assessing the ability of growers and agronomists to identify endemic diseases in crops, nor is there an equivalent in the animal industry. The aim of this study was to use a training needs analysis (TNA) of Australian grain growers and agronomists to determine their ability to identify endemic leaf diseases in crops and the top four HPPs in grain crops. A TNA is often used before designing a course to determine what training the learners require. The TNA determines the level of discrepancy between the perceived knowledge or skill level of a learner and the actual knowledge or skill level of the learner (Prior, 1994). The TNA can be done using a questionnaire, as in our study reported here. The relationship of age, gender, level of education and location with the ability of growers and agronomists to identify the pests and diseases was also examined. This is an initial step in determining if there is a gap in the skills of growers and agronomists within the grains industry and if so, what capacity building is required. For our study, the following disease identification benchmarks of 70% of growers and 80% of agronomists were established. The results from the questionnaire given to growers and agronomists will determine if 70% of growers are able to identify diseases in their crops and if 80% of agronomists can identify diseases in crops.

2. Methods

2.1. Surveys

Two questionnaires were developed to examine the training needs of participants in the grains industry of Australia. One
diagnostic services – a fee for service enterprise used which test soil and plant material for a range of pathogens and other factors such as nutrition; g) state diagnostic services – these operate as a fee for service and are delivered through most state Agricultural departments.

4. The final section collected demographic information from the participants (Questions 39–44 in Appendix A). Other information collected included: a) how often crops were inspected (Q25); b) if growers employed an agronomist (Q28); c) how many years they had worked (Q40) and d) what crops were grown (Q45) (Appendix A).

Ten agronomists and researchers within the Department of Agriculture and Food, Western Australia (DAFWA) pretested the agronomists survey to ensure that questions were clear. Unclear questions were modified and then a pilot survey was undertaken at the GRDC Agribusiness Crop Updates held in Ballarat, Victoria in February 2014. A similar process was used for the grain growers survey, a test for clarity was conducted with three farmers in Goonawarra, WA and then the pilot survey was held at the GRDC Grains Research Update for Growers at Lake Bolac, Victoria in February 2014. Approval for this work was gained from the Human Research Ethics Committee of The University of Western Australia (RA/4/1/6607).

The questionnaires for growers and agronomists were distributed in March 2014 as an online questionnaire (Qualtrics, Provo, UT) and as a paper-based questionnaire. The online questionnaire was advertised through local grower group newsletters in WA, Queensland and Victoria. The paper-based questionnaires (400) were distributed with a reply-paid envelope at six regional crop updates held by the following Western Australian grower groups; Liebe, Mingenew – Irwin (MIC), West Midlands Group, Southern DIRT, Fitzgerald Biosphere Group, Stirlings to Coast and Ravensthorpe Districts, (Fig. 1). The questionnaires were also posted to growers and agronomists (200 growers and 100 agronomists) who were members of the Birchip Cropping Group in Victoria (Fig. 1). The survey was closed on 30th June 2014.

Crop updates and research updates are forums that are held at the beginning of each year around Australia, to inform growers and agronomists and others of the latest research in the Australian grains industry.

2.2. Data analysis

The data from the survey were compiled using Qualtrics software, 2013. Statistical Package for the Social Sciences (SPSS) (IBM ver. 22) was used to analyse the data using cross tabulation and Pearson’s Chi-Square test ($x^2$) to determine the influence of occupation (grower or agronomist), age, gender, education level and location on the ability to identify the three leaf diseases in grain crops and assess participants’ awareness of the symptoms associated with the four HPPs. If Pearson’s Chi-Square test failed the assumption that more than 20% of the cells had a frequency count of less than 5, then the Likelihood ratio was used in its place.

The demographic data contained 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 or Eastern Australia) and Gender (male, female) (Table 1).

Questionnaires with incomplete demographic data (n = 47) such as no postcode were not included in the analysis. Due to low number of questionnaires returned from Queensland, NSW, Victoria and South Australia separately, the data collected from these states were combined together to form “Eastern Australia” (EA) which was used in the corresponding cross tabulation and
Pearson’s Chi-Square analysis.

Questions 31–34 on endemic leaf diseases were analysed using cross tabulations and Pearson’s Chi-Square test. Frequency data was determined for the number of correct and incorrect responses for each endemic leaf disease. McNemar’s test was then used to determine if there were significant differences between participants’ ability to identify the three different leaf diseases.

Responses to the questions related to high priority pests (35–38) were analysed using the method of Hammond et al. (2016a). Each HPP had eight symptoms from which the

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**Table 1** Pearson’s Chi-Square analysis of demographic data collected from growers and agronomists who completed the training needs analysis survey on the identification of endemic diseases and high priority pests (HPPs) in grain crops.

<table>
<thead>
<tr>
<th>Group</th>
<th>Subgroup</th>
<th>Number of growers (n)</th>
<th>Growers (%)</th>
<th>Number of agronomists (n)</th>
<th>Agronomists (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>Western Australia</td>
<td>89</td>
<td>67</td>
<td>47</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eastern Australia</td>
<td>44</td>
<td>33</td>
<td>61</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>(133)</td>
<td>(100)</td>
<td>(108)</td>
<td>(100)</td>
<td></td>
</tr>
<tr>
<td>Pearson’s Chi-Square</td>
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<td>13.27</td>
<td>13.27</td>
<td>13.27</td>
<td>≤0.001</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>School</td>
<td>57</td>
<td>42.2</td>
<td>5</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocational Education Training</td>
<td>46</td>
<td>34.1</td>
<td>17</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>University</td>
<td>32</td>
<td>23.7</td>
<td>91</td>
<td>80.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>(135)</td>
<td>(100)</td>
<td>(113)</td>
<td>(100)</td>
<td></td>
</tr>
<tr>
<td>Pearson’s Chi-Square</td>
<td></td>
<td>83.97</td>
<td>83.97</td>
<td>83.97</td>
<td>≤0.001</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>≤30 years</td>
<td>15</td>
<td>11.1</td>
<td>28</td>
<td>24.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31-50 years</td>
<td>63</td>
<td>46.7</td>
<td>59</td>
<td>52.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥51 years</td>
<td>57</td>
<td>42.2</td>
<td>26</td>
<td>23</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
<td>(135)</td>
<td>(100)</td>
<td>(113)</td>
<td>(100)</td>
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</tr>
<tr>
<td>Pearson’s Chi-Square</td>
<td></td>
<td>13.80</td>
<td>13.80</td>
<td>13.80</td>
<td>≤0.001</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>116</td>
<td>87.2</td>
<td>88</td>
<td>78.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>17</td>
<td>12.8</td>
<td>24</td>
<td>21.4</td>
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<tr>
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<td>(100)</td>
<td>(112)</td>
<td>(100)</td>
<td></td>
</tr>
<tr>
<td>Pearson’s Chi-Square</td>
<td></td>
<td>3.26</td>
<td>3.26</td>
<td>3.26</td>
<td>0.071</td>
<td></td>
</tr>
</tbody>
</table>

*p values indicate if there is a significant difference between growers and agronomists.
participants were to select the three or four symptoms correctly associated with that HPP (Appendix A). Each correct symptom chosen scored 0.125. Each incorrect symptom not chosen scored 0.125, giving participants a total score of 1 when all answers were correct. In this section, participants who had not answered the question, or selected “don’t know” were treated as missing data and removed from the analysis, thus reducing the sample size. The responses were analysed using crosstabs and Pearson’s Chi-Square test. The Mann-Whitney U test was then used to compare the data collected in 2008 by Hammond (2010) with the data collected in our survey (Table 2).

3. Results

3.1. Response rate

A total of 156 questionnaires were returned by mail, with 54 of these coming from the Birchip Cropping Group and 132 questionnaires were completed online (65 grain growers and 67 agronomists). A total of 248 useable questionnaires were returned. The response rate was 22% for the paper-based questionnaires and Qualtrics recorded that 50% of participants that started the online questionnaire completed it. However, as the request to complete the online survey was made through newsletters it was not possible to accurately determine the number of people who received the request. The overall response rate was estimated to be 26% (248 useable questionnaires returned from 700 distributed and 264 started online).

In our survey, a number of the demographic variables (location, education level and age) were correlated with occupation (Table 1). However, there was no correlation between gender and occupation (Table 1).

As expected, the education level of growers and agronomists was significantly different (Table 1). For a high proportion of growers (42%) school was the highest education level achieved, and 34% of them had achieved vocational education training (VET). The majority of agronomists (80.5%) had completed a university degree. A significantly higher proportion of females (76%) had a university education compared to males (45%) in the population of growers and agronomists combined (Table 1). Diversity in age was observed among the participants and there were differences in the age groups between the two occupations (Table 1). There were a higher proportion of agronomists (25%) who were either 30 years of age or younger, compared to growers (11%). A higher proportion of growers than agronomists were older than 51 years of age.

The distribution of gender among the participants was as expected with the majority of respondents being male (87.2% of growers and 78.6% of agronomists) (Table 1).

3.2. Identification of leaf diseases

Powdery mildew was correctly identified by 79% of growers, and stripe rust was correctly identified by 71% of growers. Only 50% of growers correctly identified blackleg on canola while 83% of agronomists correctly identified this disease ($x^2 (1, n = 247), = 28.78, p \leq 0.001$) (Fig. 2). The proportion of growers that identified blackleg of canola correctly was less than the benchmark set at 70%.

The ability of growers to identify endemic leaf diseases in their crops was not related to whether they employed an agronomist ($p > 0.05$). The frequency of crop inspection had no impact on whether the correct identification was made ($p > 0.05$). There was no correlation between crops grown and the ability to identify the leaf diseases ($p > 0.05$). Age and length of time working did not correspond with the ability to correctly identify the three leaf diseases ($p > 0.05$).

Table 2 Comparison of data collected in 2008 (Hammond et al., 2016a) and 2014 on the knowledge of symptoms and signs associated with Karnal bunt, Khapra beetle, barley stripe rust and Russian wheat aphid by growers and agronomists.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Year data collected 2008</th>
<th>Year data collected 2014</th>
<th>Mann Whitney U</th>
<th>Z</th>
<th>Significance ($p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (Md)</td>
<td>Sample size (n)</td>
<td>Median (Md)</td>
<td>Sample size (n)</td>
<td></td>
</tr>
<tr>
<td>Karnal bunt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>0.75</td>
<td>36</td>
<td>0.75</td>
<td>66</td>
<td>843</td>
</tr>
<tr>
<td>Agronomist</td>
<td>0.75</td>
<td>10</td>
<td>0.75</td>
<td>77</td>
<td>218</td>
</tr>
<tr>
<td>Total (n)</td>
<td>46</td>
<td></td>
<td>143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khapra beetle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>0.625</td>
<td>24</td>
<td>0.625</td>
<td>20</td>
<td>216.5</td>
</tr>
<tr>
<td>Agronomist</td>
<td>0.625</td>
<td>9</td>
<td>0.625</td>
<td>41</td>
<td>154</td>
</tr>
<tr>
<td>Total (n)</td>
<td>33</td>
<td></td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley stripe rust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>0.875</td>
<td>48</td>
<td>0.75</td>
<td>96</td>
<td>1778.5</td>
</tr>
<tr>
<td>Agronomist</td>
<td>1.00</td>
<td>13</td>
<td>0.75</td>
<td>96</td>
<td>366.5</td>
</tr>
<tr>
<td>Total (n)</td>
<td>61</td>
<td></td>
<td>192</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian wheat aphid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower</td>
<td>0.625</td>
<td>21</td>
<td>0.625</td>
<td>23</td>
<td>184.5</td>
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<tr>
<td>Agronomist</td>
<td>0.625</td>
<td>9</td>
<td>0.625</td>
<td>48</td>
<td>162.50</td>
</tr>
<tr>
<td>Total (n)</td>
<td>30</td>
<td></td>
<td>71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* $p$ indicating the level of significant difference between the data in 2008 and 2014.
Education level influenced the ability of participants to identify blackleg in canola correctly. 56% of participants with a university education identified blackleg of canola correctly while 20% of participants with secondary schooling and 24% of participants with VET could correctly identify blackleg \((x^2 (2, n = 247), p = 0.05)\). There was a correlation between gender and disease identification; 61% of males correctly identified blackleg of canola while 83% of females correctly identified this disease \((x^2 (1, n = 244), p = 0.05)\).

A significantly higher proportion of participants from WA (88%) were able to identify powdery mildew in barley compared to participants from EA (76%) \((x^2 (1, n = 240), p = 0.05)\). The reverse occurred in the identification of stripe rust on wheat; 72% of participants from WA correctly recognised this disease compared to 88% of participants from EA \((x^2 (1, n = 240), p = 0.05)\). There was no difference between WA and EA participants in their ability to identify blackleg of canola. However, less than 65% of participants correctly identified blackleg of canola overall (Fig. 3), despite it being a very common endemic disease in canola crops across Australia.

Participants were able to identify powdery mildew and stripe rust more reliably than they were able to identify blackleg of canola. McNemar’s test showed a significant lower \((p < 0.05)\) the ability of participants to identify blackleg of canola compared to stripe rust in wheat. The ability of participants to identify powdery mildew in barley was significantly higher \((p < 0.05)\) than their ability to identify blackleg in canola. The ability of participants to identify powdery mildew of barley and stripe rust of wheat were not significantly different \((p > 0.05)\).

3.3. Identification of the four main HPPs for the Australian grains industry

Many growers and agronomist participating in this survey did not answer the four questions on HPPs; they either left the answer blank or ticked “I don’t know”. The response rate (Table 2) varied from 77% (n = 192, barley stripe rust) to 24%, (n = 61, Khapra beetle), indicating the lack of knowledge of these HPPs.

Growers and agronomists did not differ in their knowledge of symptoms and signs associated with the HPPs \((p > 0.05)\) considered except for Karnal bunt \((x^2 (4, n = 143), p = 0.05)\). The percentage of agronomists able to select all of the correct symptoms from the list associated with Karnal bunt was 11.7%, while only 1.5% of the growers were able to correctly identify all of the symptoms associated with Karnal bunt (Fig. 4).

Knowledge of symptoms and signs for the four HPPs were the same for growers and agronomists in WA and EA \((p > 0.05)\). The scores for the participants ranged from 0.375 to 1.0 for WA and EA respectively on the entomological HPPs. The participants’ scores for the two fungal HPPs were 0.625 and 1 for WA and EA respectively, indicating a greater level of knowledge by the participants of the symptoms and signs associated with the two fungal HPPs.

Neither gender, age nor education level of the growers and agronomists influenced the knowledge of symptoms and signs associated with three of the four HPPs \((p > 0.05)\). However, the education level did influence knowledge of Karnal bunt \((x^2 (4, n = 143), p < 0.05)\). Eighty percent of participants who had a university education identified all symptoms correctly compared to only 20% of those who had completed VET.

Many of the growers and agronomists selected symptoms and signs that were not associated with the four HPPs. For example, for barley stripe rust, 25% of agronomists selected insect feeding damage, and 42% selected pale green aphids. Other incorrect responses included bunted grain (20%), and grain damage (18%), and 20% of agronomists responded that they “don’t know”. In this example, 55% of growers selected the correct response of rust pustules in stripes on leaves while only 35% of agronomists selected this response.

3.3.1. Comparison of data from 2008 to 2014

The knowledge levels of both growers and agronomists differed between the surveys conducted in 2008 and 2014 \((p < 0.05)\) on the symptoms associated with Karnal bunt and barley stripe rust (Table 2). There was no difference between the median scores of growers and agronomists for Karnal bunt between the two surveys conducted in 2008 and 2014 (Fig. 5). However, there was a difference between the range of scores between 2008 and 2014 (Fig. 5). The knowledge of the symptoms associated with barley stripe rust by growers and agronomists decreased between the surveys conducted in 2008 and 2014 (Fig. 5 and Table 2).

The median scores (0.625) for growers and agronomists were the same for the entomological HPPs and did not change between 2008 and 2014 (Fig. 5). However, the range of scores varied between 2008 and 2014.

3.4. Awareness and usage of diagnostic services

Awareness and usage of the relevant diagnostic services within Australia differed between growers and agronomists (Fig. 6). For example, 40% of agronomists used state diagnostic services 1 to 3 times within the last 12 months while only 20% of the growers used the service in the same time period \((x^2 (3, n = 235), p = 0.001)\). The majority of growers (84%) and agronomists (95%) were aware of the services. For each of the six different diagnostic services, the majority of growers (40–60%) did not submit any crop samples for analysis. Pestfax/PestFacts were the most widely used diagnostic services by agronomists and growers (Fig. 6) with 30% of growers and agronomists submitting at least one report and 48% of agronomists submitting more than four reports in the last 12 months \((x^2 (6, n = 241), p < 0.05)\). A similar observation was made for the influence of education on the use of the PestFax/PestFacts diagnostic services; 27% of participants submitted at least one report and 40% of those who had completed university studies submitted more than four reports in the last 12 months \((x^2 (6, n = 241), p < 0.05)\).

There were no significant differences \((p > 0.05)\) between the proportion of growers (36%) and agronomists (32%) who were...
unaware of the National Exotic Plant Pest Hotline. Education level influenced use of the National Exotic Plant Pest Hotline; 10% of participants who had completed VET used the service to a greater extent than did participants who had a secondary school or university education ($\chi^2(4, n = 232), \chi^2 = 15.68, p < 0.05$), which was less than 1%. Regardless of education level, 60% of the participants did not submit any samples, while more than 64% of the participants were aware of the service.

Gender and age did not influence the usage or awareness of the six diagnostic services within Australia ($p > 0.05$).

4. Discussion

4.1. Demographics

The demographics collected in our survey indicated that the data collected from participants represented the grains community in Australia very well. The grains industry is a male dominated field and this has not changed over time. In our study, males were the majority of growers and agronomists (87% and 78% respectively). These data are similar to those collected by the ABS; 72% of the farming population were male (Australian Bureau of Statistics (2012)). GRDC conducted a survey of growers in 2013 and found 93% of growers were male and 78.6% of agronomists were male (Watson and Watson, 2014).

The majority of growers had no educational qualifications as the operations of a farm business become more complex (Australian Bureau of Statistics (2012)). Growers tend to be part of an ageing workforce; the median age of Australian farmers is 53 years (Australian Bureau of Statistics (2012)); 55% respondents from the GRDC survey were in the 40–59 years of age category (Watson and Watson, 2014) and in our study 42% were older than 51 years of age. Agronomists tend to be younger than growers; for the GRDC survey 55% were aged between 18 and 39 years of age (Watson and Watson, 2014) and in our study 25% were less than 30 years of age.

4.2. Identification of leaf diseases

This is the first training needs analysis of growers and agronomists within the grains industry of Australia. The benchmark for our survey, that 70% of growers and 80% of agronomists should be able to identify common leaf diseases in their crops were met except growers did not met this benchmark for blackleg in canola. It is important that growers and agronomists have a good knowledge of endemic diseases in their crops, so they can recognise and report symptoms that are different from those caused by endemic pests. This is a vital role in ensuring Australia’s grain industry detects and eradicates or contains emergency plant pests and pathogens (Plant Health Australia, 2015).

The different skill levels of participants in the survey from Western and Eastern Australia in their ability to identify leaf disease was not unexpected because the incidence and severity of these leaf diseases varies across Australia. For example, Murray and...
Brennan (2009a) demonstrated that the proportion of crop area affected by powdery mildew of barley was 40% for EA and 100% for WA respectively. Stripe rust of wheat has the potential to affect 80% of the area planted in EA and 60% in WA (Murray and Brennan, 2009b).

Our study showed that the ability of growers and agronomists to recognise blackleg on the leaves of canola was significantly lower than for the other two leaf diseases. The disease blackleg is prevalent throughout Australia. There is very little difference between the proportions of crop area (93% and 99%) in EA and WA respectively, affected by blackleg of canola (Murray and Brennan, 2012). The lack of recognition of blackleg is of concern, and may be due to the focus of published material on stem cankers and not leaf symptoms in the crop. This lack of recognition also highlights that further training in the recognition of blackleg is required to reduce the possibility of the disease being mistaken for white leaf spot (Mycosphaerella capsellae) as the symptoms are similar and can be confused.

The influence of education in correctly identifying diseases was evident for blackleg of canola. There was a significant difference between growers and agronomists in their ability to correctly identify blackleg of canola. In our survey, there is a correlation between education level and occupation of the participants; agronomists had completed university studies while most farmers had not completed university studies. This may explain why the agronomists met the benchmark for identification of blackleg as they had received more training. Mangano et al. (2011) demonstrated professional experience influenced the ability of participants in recognition and detection of the fictitious high priority pests created for use in their study.

Kunda et al. (2008) reported when knowledge (transmission, clinical features, and diagnosis) of a zoonotic disease in humans is low (<50% correct) reporting of that disease is low and it can remain undiagnosed or be misdiagnosed. This would impact severely on the control of a disease. Although this research on awareness of zoonoses within local communities and medical practitioners was done in Africa, the concepts are similar to those necessary for dealing with plant pests and pathogens. It is essential that participants within the grains industry are able to recognise symptoms of common endemic diseases within their crops. Hammond (2010) and Martin et al. (2015) have both shown that “disease awareness” influences the probability of a HPP being detected both in the plant and animal industry. The recognition of HPPs in our study was low; consequently it is anticipated that reporting of these HPPs will then be low.

4.3. Identification of the four main HPPs for the Australian grains industry

Knowledge among growers and agronomists of the symptoms and signs of the top four HPPs in the grains industry was well below the level perceived by members of Plant Health Australia and the GrainGuard Committee in Western Australia. This lack of knowledge was demonstrated by the large number of participants who selected “don’t know” as the answer to the questions, which lead to a decrease in the number of participants (n ranged from 71 to 192).
who were willing to answer these questions compared to the number of participants (n > 240) who answered the questions on endemic leaf diseases. Hammond et al. (2016a) demonstrated there was a significant decrease in the number of participants who were willing to answer the four HPP questions compared to the number who answered the rest of survey.

The results from our survey showed that demographics gender, education and age of growers and agronomists did not influence knowledge of symptoms and signs associated with the HPPs considered. However, occupation and education did influence the knowledge of symptoms associated with Karnal bunt. This result is not surprising as there is a correlation between the education level and occupation of the participants as shown in the data collected in our survey.

This survey demonstrated that the median agronomists’ knowledge level of barley stripe rust symptoms decreased from 1.00 in 2008 to 0.75 in 2014. This knowledge level should not have decreased as the symptoms of barley stripe rust on barley are very similar to the symptoms of wheat stripe rust on wheat; yellow pustules in stripes along the length of the leaves. The awareness and knowledge level decrease may be due to agronomists having not seen stripe rust of wheat for six years in Western Australia, which had occurred on a regular basis from 2000 to 2009 in WA. The disease did not occur at a yield limiting level in crops again until 2015 (https://www.agric.wa.gov.au/diseases/pesttax-map). For this disease to reoccur after six years indicates that the pathogen was present in crops at a low level or had been misdiagnosed as leaf rust. Another concern is that only 20% of the agronomists correctly identified the symptoms associated with the disease, although 40% correctly recognised the most conspicuous symptom “rust pustules in stripes on leaves”. In the identification of leaf diseases section of our survey, 90% of agronomists correctly identified stripe rust of wheat (Fig. 2), which suggests that a similar number should be able to identify barley stripe rust should it occur. However, this was not the case. Our results from this survey support the work done by other authors that showed that poor knowledge and awareness of symptoms of pathogens can lead to a misdiagnosis of diseases (Bagamba et al., 2006; Hammond, 2010).

Our results from this study indicate that the current methods used to provide information and training to the grains industry participants is not effective. Knowledge and awareness of diseases and pests in crops is dependent upon the extension and training programs used with growers (Bagamba et al., 2006; Levy, 2005; Yang et al., 2008). Information on HPPs in the Australian grains industry is available to all participants through fact sheets and other reading material available from their local grain biosecurity officers (Plant Health Australia, 2015). These officers promote on farm biosecurity and run information booths at local field days. The results from this study’s questions on HPPs indicates that the information is not being taken up by the growers and agronomists, and therefore the method of knowledge transfer needs to be redesigned. In the survey conducted by Hammond et al. (2016a) only 10% of respondents had attended a course focused on the recognition of HPPs. The group in the (Hammond et al., 2016a) study consisted mainly of growers (80%) and the rest were state departmental staff. No agronomists had attended training in this area. Thus the redesign of material on the recognition of HPPs may need to include hands on training, the use of videos and podcasts through social media and web-based training. The sources from which growers and agronomists seek information are a related and
ongoing investigation. The effectiveness of social media as a method to increase awareness and knowledge levels will be assessed in the future.

4.4. Use and awareness of the diagnostic services

The usage and awareness of diagnostic services were investigated, as these services are vital for providing information and data for general surveillance (FAO, 2011). In our study, although the majority of agronomists and growers (95% and 84% respectively) were aware of the services, only a few used the services. Hammond et al. (2016b) and Martin et al. (2015) demonstrated reporting systems and samples submitted to diagnostic services rely upon participants within the industry being able to differentiate between endemic pests and ‘unusual’ pests. Our study showed that growers used diagnostic services less frequently than agronomists and in most cases, except for GrainGuard, were unaware of available diagnostic services.

In our survey, less than 5% of growers and agronomists used a diagnostic service, and the majority of growers and agronomists were unaware of available services. The earlier survey conducted in 2008 by Hammond et al. (2016b), similarly showed that the majority of growers and agronomists were unaware of diagnostic services.

In our survey, PestFax/PestFacts were the most frequently used diagnostic services by agronomists. Growers and agronomists were more aware of this service than the other services. The survey conducted in 2008 by Hammond et al. (2016b) had very similar results; that Western Australian respondents were most familiar with PestFax (42.6%), compared to other services available within Western Australia. A possible reason for these services being used more frequently is that they are an interactive service allowing agronomists and growers to send in reports and have them confirmed rapidly through a weekly newsletter sent out to subscribers.

Awareness of the National Exotic Plant Pest Hotline increased from 36% in 2008 (Hammond et al., 2016b) to 70% in 2014. The lack of awareness in 2008 and the lack of usage were most likely due to the service being newly introduced, and a lack of trust by growers (Hammond et al., 2016b).

The use of diagnostic services by growers and agronomists is variable and is very much related to the growing conditions and the presence of pests and diseases in crops in the current season. Climatic conditions in 2013 during the growing season (April–October) in Western Australia were not conducive to high levels of disease being present in crops (G. Thomas pers. Comm 2016) which would explain the small number (<20%) of growers who used a diagnostic service during 2013. These services are vital, as they provide a general surveillance service and are usually the first to detect a biosecurity pest or disease. The lack of awareness of some of these services, such as GrainGuard indicates that promotion of their existence would be beneficial.

5. Conclusion

The Australian grains industry relies upon growers and agronomists to be aware of pest and diseases in their crops and to notify their local State Departments of Agriculture if they see something unusual which may be an incursion of a high priority pest. This study’s training needs analysis showed that growers’ and agronomists’ abilities to identify endemic diseases in grain crops met the benchmarks set for this survey (70% growers, and 80% agronomists). However, their knowledge and awareness of symptoms associated with HPPs did not meet these benchmarks. This indicates that further training in the knowledge and recognition of HPPs is required. In general, age and gender were not related to knowledge level or identification skills of growers and agronomists. However, education levels and occupation of the participants did influence knowledge and identification skills within the industry. The diagnostic services within Australia are an important tool for general surveillance activities, and the availability of these services needs to be promoted so that there is an increase in the awareness and usage of these services amongst growers and agronomists.

Conflicts of interest

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

Acknowledgements

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.cropro.2016.07.005.

References


Department of Agriculture and Food, WA. 2015. GrainGuard. Department of Agriculture and Food (Western Australia).


Hammond et al. 2016a.


Chapter 4. Training needs analysis

Chapter 5. Information sources used by growers and agronomists

This fits into the extension philosophy “One in Seven, make it once and get seven things out of it” (J. Cathey pers.comm 2016).

Manuscript to be submitted to Journal of Rural Studies

Wright, D., MacLeod, B., Pauli, N., Longnecker N 2017. Grain growers and agronomists use different information sources to solve on-farm problems (An Australian example).
5.1 Abstract

To understand information preferences among growers and agronomists when solving general and specific problems on farm, targeted surveys were undertaken. These surveys examined the sources of information used by growers and agronomists within the Australian grains industry. The data were split into two groups: a) information sources used for a general problem; and b) information sources used for a specific problem. Principal Component Analysis (PCA) was used to categorise the sources of information, followed by a cluster analysis to group participants based on information preferences. Log-linear analysis was conducted using the demographics of the participants to characterise the cluster profiles. The information sources and types used by growers and agronomists were varied. Types of information used to solve general problems were community-, training- or technical-based. Growers’ use of information to solve specific problems varied, with a preference for information from a private agronomist compared with publicly available sources. Agronomists’ preference for information was related to the content of the information, and how specific it was to the area they were working within. The clusters identified were characterised by the demographics of the participants. Information access has long been thought critical to building capacity in extension. This research demonstrates the need to consider the continued accessibility of information, and the method of transfer for a range of different participants within the grains industry. The cluster profiles identified can be used to refine the type and content of information produced by agribusinesses involved in the grains industry to ensure that the information needs of the wider audience are met.

Keywords: Information sources, information types, agricultural extension, demographics, grain growers, agronomists, grains industry, capacity building

5.2 Introduction

Agricultural extension in Australia has followed the capacity building and community engagement paradigm since 2000 (Coutts & Roberts, 2011). The change in extension from a linear, top-down approach in the 1960s, to the current focus on participation, community engagement and public-private partnerships also reflects reduced funding and resources invested by government departments in extension services (Carberry et
al., 2002; Marsh & Pannell, 2000). Concurrent with the shift away from government involvement, the providers of agricultural extension services in Australia are now largely agribusinesses (for example, companies such as Elders and Landmark), as well as fertiliser companies and chemical companies. These companies are coupled with selling goods as well as providing dedicated staff for advice (Klerkx, Petter Stræte, Kvam, Ystad, & Butli Hårstad, 2017). These changes and the specialisation of farming enterprises means that growers now require more sophisticated, technical and targeted information than ever before (Cristovao et al., 2009; Hunt, Birch, Coutts, & Vanclay, 2012; Hunt & Coutts, 2009; Ingram, 2008; Jones & Garforth, 1998; Marsh & Pannell, 2000). To date, little research has been undertaken on how changes in extension providers have influenced the sources, types and content of information delivered. There is extensive literature published on the UK and Europe advisory system that examines relationships between advisers and growers and their different information networks ((Ingram, 2008; Klerkx et al., 2017; Klerkx, Schut, Leeuwis, & Kilelu, 2012). Here, we provide insight on the question of whether the providers of information need to change the content and types of information they deliver to suit modern, diverse audiences of growers and agronomists within the Australian grains industry.

Within the capacity building and community engagement paradigm of agricultural extension in Australia, Coutts and Roberts (2011) identified five delivery models for extension projects: (i) Group facilitation and empowerment; (ii) Training; (iii) Technological development; (iv) Information access; and (v) Individual consultant/mentor. These five models are complementary and should work together ensure that capacity building needs within the agricultural sector are met. The interactions among the five delivery models are illustrated in the three-legged capacity building ladder shown in Figure 5.1. Three delivery models (information access, group facilitation and empowerment, and technological development) can be visualised as the three ‘legs’ of the ladder, which enable participants to move up the ‘rungs’ of capacity building through ongoing training and education products, and interactions with consultants and mentors (Coutts & Roberts, 2011).
Figure 5.1. The five main agricultural extension delivery models used within Australia: A) Information access; B) Training; C) Facilitation and empowerment; D) Consultant and E) Technology development. These are linked together to form the capacity building model. Redrawn with permission from Coutts and Roberts (2011).

Following Coutts and Roberts' (2011) model, information access is a critical component of all agricultural extension, so that individuals and groups have the information that they need in a form that suits them, at a time that they need it, in order to move to a higher ‘rung’ on the capacity building ladder. As individual and group capacity increases, information needs will also most likely change and evolve. Further, the types and providers of information that are sought and used by individuals are very diverse (Klerkx et al., 2017; Oreszczyn et al., 2010; Solano et al., 2003). Clearly, the utility of ‘information’ in serving capacity building requires further elaboration. In the following sections, we break down the general category of ‘information’ for extension into its component parts, and review the major influences on the providers, types and content of information used by different groups within the agricultural sector.
Research in the USA, Europe and Australia has examined the sources of information, used or sought by growers, for their economic value, marketing and usefulness in decision making (Diekmann et al., 2009; Ford & Babb, 1989; Gloy et al., 2000; Patrick & Ullerich, 1996; Schnitkey et al., 1992). A simplified graphical representation of the individual decision-making process for growers and agronomists is shown in Figure 5.2. This simplified diagram illustrates that a person relies on both internally- (such as personal experience and knowledge) and externally sourced information before making a decision. External information can be further classified based on the source (i.e., who has provided the information) (Figure 5.3), type and content of the information (Figure 5.4).

![Decision Diagram](image)

Figure 5.2. Graphical representation of how an individual's decision is based on a combination of their experience, together with the source, type and content of the information received.
Figure 5.3. Graphical representation of categorising information into sources, and how that information can be further broken down into components
Figure 5.4. Graphical representation of categorising information into; a) Types and b) Locus, and how that information can be further broken down into components
Government agencies, private industries and the community can produce the external sources of information (Figure 5.3). The type of information refers to whether information delivery is community-, training- or technically-based (Figure 5.4a). Locus is the spatial scale of the delivery and includes whether the information is general or specific in nature, for example at a national, state, regional or local community or individual farm level (Figure 5.4b). Figures 5.3 and 5.4 presents a simplified structure of a reality that can be very complex and is further confused by the lack of consistency in the use of terminology in the literature. The types of information can be targeted to an individual or to a group of people (Fulton et al., 2003; Hunt & Coutts, 2009; Jones & Garforth, 1998). The content also includes the mode of delivery; whether it is a direct observation, a verbal communication or a written document (Errington, 1986; Solano et al., 2003).

Experience of growers and age of growers influences the sources of information used (Ford & Babb, 1989; Gloy et al., 2000; Tucker & Napier, 2002). More experienced growers relied upon public co-operative information produced by the universities (Figure 5.3) while the less experienced preferred commercially produced newsletters, and commodity brokers (public companies and private) (Figure 5.3) (Ford & Babb, 1989; Gloy et al., 2000; Tucker & Napier, 2002). In the livestock industry, Ford and Babb (1989) found that the use of USDA news services and private firms increased with experience, while the less experienced still relied upon family and friends for information (Figures 5.4 and 5.4b).

Ford and Babb (1989) demonstrated family and friends were the primary source of information across all commodities, regions and years of experience in their survey of growers in Indiana, Iowa, Illinois and the Southeast of the USA. The secondary sources of information used included other growers, private firms, the Cooperative Extension Service of the USA. Among farmers in Edinburgh, Scotland, growers consider other growers, agricultural advisors and consultants an important source of information (Sutherland et al., 1996). Hunt and Coutts (2009) found that growers valued participating in groups and that personal gains were from networking, and the sharing of knowledge. Agricultural advisors (non-family) were trusted because of their objectiveness and independence, and are highly valued by growers (Ingram, 2008; Sutherland et al., 1996). However, self-reporting of performance by other growers was not a trusted source of information (Sutherland et al., 1996).

Farm size and the enterprise type influence the types of information used (Ford & Babb, 1989; Gloy et al., 2000). In the USA, Ford and Babb (1989) found small growers often use farm magazines as a type of information, and that less experienced growers
They also found a difference between crop growers and livestock growers. Livestock growers use a broader range of information types most likely due to the volatility in both the input and output markets for production, compared to crop growers who tend to only use a small number of different types of information (Ford & Babb, 1989).

In terms of content, information can be divided into two types; general information and specific (or specialised) information (Diekmann et al. 2009). General information is useful for a variety of on-farm activities (for example, such as nutrient and soil management), while specific information is focused on a small section or limited portion on farm (for example, a controlling a leaf disease in a wheat crop). The provision of information in a single format is unlikely to be suitable for both general and specific problems. For content delivery, growers generally prefer personal or verbal information to written information (Ford & Babb, 1989; Hunt & Coutts, 2009; Solano et al., 2003). Growers perceive the written information to be inaccurate; in some cases it is too general and often arrives after the event (Sutherland et al., 1996).

While much research has focused on the information needs of growers, very little has been published on how agronomists access and use information in their work. Radhakrishna and Thomson (1996) examined extension agents’ (agronomists) use of information sources. They concluded that the demographic characteristics of the participants surveyed influenced the information sources used. However, the demographic profiles of the participants actually determined in which roles those extension officers were employed, and this role determined where they sought information. Marshall (2002) surveyed agronomists in the UK to determine the environmental information required to help growers under the Pesticide Voluntary Initiative in the UK. Echoing Coutts and Roberts’ (2011) delivery model of information access for growers, Marshall (2002) recommended that training schemes for agronomists also need to be supported by knowledge and information resources, and that there needs to be a range of methods available to access these information resources to satisfy all learning styles.

There is no published research that included both growers and agronomists to compare the sources, types and content of information they use when solving general and specific problems on-farm. This is a vital knowledge gap, given the importance of a well-functioning relationship between these two groups in agricultural development. Consultants and mentors (including agronomists) are one of the main pathways by which growers can move up the ‘capacity-building ladder’ (Coutts & Roberts, 2011).
Therefore, research is needed on whether growers and agronomists use the same types or sources of information when trying to solve problems, and whether information providers need to take into account age, education and geographic location when developing the types and content of information for both groups. Regardless of the method of dissemination, information needs to be synthesized and processed, and delivered to learners in a format that is based on their needs (Fulton et al., 2003; Jones & Garforth, 1998).

Access to information is acknowledged as critical for growers to make effective decisions to solve on-farm problems and improve capacity (Coutts & Roberts, 2011; Fulton et al., 2003; Hunt & Coutts, 2009; Solano et al., 2003). However, given the rapidly changing face of modern agricultural extension, the increasing involvement of consultant agronomists, and the diverse range of formats in which information can be provided, there is a growing need to better understand how information needs are best met. In this paper, we use a case study of the Australian grains industry to investigate how growers and agronomists access information for general problems, and for specific problems. Pest and disease issues were chosen to represent the ‘specific’ problems because of the parallel research conducted by Wright et al. (2016) examining the ability of growers and agronomists to identify common leaf diseases and biosecurity risks in their crops.

The overall goal of this research was to identify emerging patterns of information preferences and needs within the grower and agronomist communities, and relate these to ongoing, effective capacity building as part of the ‘information access’ delivery model put forward by Coutts and Roberts (2011). Specifically, we sought to answer the following: Are there differences in the sources, types and content of information used by growers and agronomists for solving (i) general problems and (ii) specific problems on farm?

5.3 Methods

5.3.1 Surveys

The research reported here is part of a larger research 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 to 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, Smyth, 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 and herbicide spray programmes and general crop husbandry advice.

For this research, the results from the following three sections of the questionnaire were analysed and reported:

1) Section A, Question 1 (Appendix A and B) asked growers and agronomists how important were various information sources when looking for general information to change or solve problems on farm.

2) Section C, Question 26 (Appendix A and B) asked growers and agronomists where they seek information about managing pest and diseases in crops.

3) The final section collected demographic information from the participants (Questions 41, 43, 44, and 47, in Appendix A and B).

The pretesting and piloting of the questionnaires has been reported in Wright et al. (2016). 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. (2016).
5.3.2 Data analysis

The data from the survey were compiled using Qualtrics software, 2013. Statistical Package for the Social Sciences (SPSS) (IBM ver. 23) was used to analyse the data. The data were split into two parts based on if the questions asked about information sources used for a general problem or if it was about solving a specific problem such as pest and disease in a crop. A Principal Component Analysis (PCA) was used to categorise the sources of information and then a cluster analysis was used to cluster the participants based on the components produced in the PCA. Log-linear analysis was then performed to examine the participants’ demographics in the cluster profiles determined during the cluster analysis.

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).

The overall response rate of useable questionnaires was estimated to be 26% (Table 1) because it was not possible to accurately determine the number of people who received the request to complete the surveys online (Wright et al., 2016). Questionnaires with incomplete demographic data (n=47) such as no postcode were not included in the analysis. Due to the low number of returns from Queensland, NSW, Victoria and South Australia the data collected from these states were combined together to form the “Eastern Australia” (EA) which was used in the corresponding cross tabulation and Pearson’s Chi-Square analysis.

Table 5.1. Response rate for the surveys used to examine how growers and agronomists use information to solve problems on farm.

<table>
<thead>
<tr>
<th>Distribution method</th>
<th>Number distributed</th>
<th>Number complete used</th>
<th>of returns</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveys handed out</td>
<td>400</td>
<td>102</td>
<td></td>
<td>25.5%</td>
</tr>
<tr>
<td>Surveys mailed to Birchip group</td>
<td>300</td>
<td>54</td>
<td></td>
<td>18%</td>
</tr>
<tr>
<td>Online*</td>
<td>264</td>
<td>132</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Total</td>
<td>964</td>
<td>248</td>
<td></td>
<td>26%</td>
</tr>
</tbody>
</table>

*The number of online surveys started could only be estimated as the request to complete the survey was made through newsletters.
5.3.3 Defining the information categories

The relationship between the sources of information used by participants was determined using a principal component analysis (PCA) on the responses from Question 1 and Question 30.

For solving general problems, the responses were treated as ordinal data (1-4), and the median for each question was determined. An oblique rotation (direct Oblimin) was used because it was assumed that there would be a correlation between some of the factors (Field, 2013). One source of information “learn from agribusiness reseller” did not load onto any of the components so was removed and the PCA was rerun with 16 sources of information. A parallel analysis (MonteCarlo PCA, 2000) on a matrix of the same size confirmed that the first three components should be kept. Cronbach’s alpha was determined for each of the components.

For solving specific problems on farm, the PCA was done on growers and agronomists separately due to the three sources of information not being included in the agronomists’ questionnaire. The data was treated as ordinal (1 for yes and 2 for no). The parallel analysis confirmed that the first two and three components should be kept for growers and agronomists respectively.

5.3.4 Defining the population clusters

The population clusters of growers and agronomists for solving general problems and specific on farm were determined by using a hierarchical agglomerative cluster analysis, the metric was Euclidian distance and the linkage criterion was Ward’s method based on the individual factor scores from the PCAs conducted above (Solano et al., 2003).

5.3.5 Characterising the population clusters using demographics

The demographic characteristics of the population clusters were determined by using a Log-linear analysis. Two-way interactions were further explored using cross tabulations and Pearson’s Chi-Square analysis. If Pearson’s Chi-Square test failed the assumption that more than 20% of the cells had a frequency count of less than five, then Fisher’s exact test was used in its place (Field, 2013; Pallant, 2013).
5.4 Results

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 & Julian, 2014a). The sample size based on the return rate was 1.8% for growers, and 47% for agronomists in Western Australia. For Eastern Australia the sample size was 0.7% for growers and 10.6% for agronomists.

5.4.1 Defining information categories used when solving general problems on farm

Three components emerged from the PCA indicating that the list of 16 sources of information could be grouped into three types of information used by growers and agronomists for solving general problems on farm; Community, Training and Technical (Table 5.2). The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis, KMO= 0.80, which is above the acceptable level of 0.5 (Field, 2013) and Bartlett’s test Sphericity reached statistical significance (p< 0.00), supporting the factorability of the correlation matrix. The PCA showed that three components had eigenvalues over Kaiser’s criterion of 1.0 and in combination explained 46.92% of the variance. These three components explained 27.5%, 10.95%, and 8.46% of the variance respectively. All of the alpha scores were above 0.5; the first two components scored greater than 0.7 while the 3rd component scored 0.6. This indicates that there is an acceptable level of internal reliability.

5.4.2 Defining the population clusters

Six different population clusters were detected using Ward’s method (Figure 5.5) based on the three types of information used by growers and agronomists in the PCA. The six clusters were; Cluster 1 “Training-aphobe” (because they did not attend training events), Cluster 2 “Technical-aphobe” (did not use technical information), Cluster 3 “Allists” (use all three types of information), Cluster 4 “Internalists”(did not use any of the types of information), Cluster 5 “Trainilist” (only attended training) and Cluster 6 “Community-aphobe” (would not use any information from the community). The six clusters consisted of a mix of growers and agronomists in different ratios. A higher percentage of growers were in Clusters 1 to 4 and a higher percentage of agronomists were in the Clusters Trainilist and Community-aphobe.
Table 5.2. PCA results on 16 sources of information used by growers and agronomists, when searching for information to solve general problems on farm. Three factors were extracted, and seven iterations were required. Rotation method used was direct Oblimin with Kaiser Normalisation. The corresponding eigenvalues are given along with Cronbach’s alpha score for the three factors.

<table>
<thead>
<tr>
<th>Sources of information</th>
<th>Rotated factor loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Community</td>
</tr>
<tr>
<td>Learning from family</td>
<td>0.80</td>
</tr>
<tr>
<td>Learning from local community</td>
<td>0.75</td>
</tr>
<tr>
<td>Learning from neighbours</td>
<td>0.72</td>
</tr>
<tr>
<td>Listening to radio</td>
<td>0.56</td>
</tr>
<tr>
<td>Learning from own experience</td>
<td>0.51</td>
</tr>
<tr>
<td>Reading rural papers</td>
<td>0.45</td>
</tr>
<tr>
<td>Learning from State Agriculture Department</td>
<td>0.31</td>
</tr>
<tr>
<td>Attending crop updates</td>
<td></td>
</tr>
<tr>
<td>Attending field days</td>
<td></td>
</tr>
<tr>
<td>Attending workshops (free)</td>
<td>0.72</td>
</tr>
<tr>
<td>Attending fee paying workshops</td>
<td>0.66</td>
</tr>
<tr>
<td>Attending grower groups</td>
<td></td>
</tr>
<tr>
<td>Using internet</td>
<td></td>
</tr>
<tr>
<td>Reading books</td>
<td></td>
</tr>
<tr>
<td>Using mobile apps</td>
<td></td>
</tr>
<tr>
<td>Learning from Private consultant</td>
<td></td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>4.67</td>
</tr>
<tr>
<td>% Variance</td>
<td>27.50</td>
</tr>
<tr>
<td>Cronbach’s α</td>
<td>0.76</td>
</tr>
</tbody>
</table>
Figure 5.5. Types of information preferences used by growers and agronomists from the Australian grains industry when solving general problems on farm. Clusters were determined by hierarchical agglomerative cluster analysis, the metric was Euclidian distance and linkage criterion was Ward's method based on the individual factor scores from the PCA analysis in table 5.2. Cluster size, means and standard error are shown.
The Clusters Allist and Internalist were quite distinct in their preferences. Participants in the Allists cluster would use all three types of information while those in the Internalist cluster would not use any of the external types of information. Most clusters would use at least two types of information apart from the Internalist and the Trainilist (which would only attend training events for information) (Figure 5.5).

5.4.3 The demographic characteristics in the population clusters

The population clusters consisted of different demographic characteristics determined during the cluster analysis. The four-way Log-linear analysis produced a final model that only retained two effects for the three clusters; Training-aphobe, Technical – aphobe and Allists. These models were a perfect fit as expected. The two-way interactions in the model included the variables occupation, age, education level and location of the participants. The interaction between occupation and age was characteristic for the Clusters Train-aphobe, Technical-aphobe and Allist (Table 5.3).

The Trainilist and Community-aphobe clusters were unique in that only individual demographics (age and education level) were characteristic; age and the education level of the participant on the Trainilist cluster, while only age characterised the Community-aphobe clusters. Twenty percent of participants who had a university education level made up the majority of participants (71%) that were in the Trainilist clusters while only 5% and 7% of participants with school and VET education levels respectively made up the rest of the clusters ($\chi^2$(10, n=203), = 27.25, $p \leq 0.05$). The Internalist cluster was not characterised by any specific demographic variables (Table 5.3).

5.4.4 Defining information components for specific problems

The PCA on the list of information sources used by growers and agronomists when searching for specific pest and disease information showed that the data fitted into two components for growers (Table 5.4) and into three components for agronomists (Table 5.5). The PCA for both growers and agronomists used an oblique rotation (direct Oblimin). The KMO for was 0.9 (for growers) and 0.75 (for agronomist) verifying that there was adequate sampling and Bartlett’s test Sphericity reached statistical significance ($p \leq 0$), supporting the factorability of the correlation matrix.
Table 5.3. Log-linear analysis of demographic factors: *age* (A), *education level* (E), *location* (L) and *occupation* (O) on the influence of the participant groups determined from the cluster analysis using Ward’s method, when searching for information to solve general problems on farm. Two-way interactions that are significant are shown with their partial chi-square value and corresponding *p* value. For groups that have a significant two-way interaction, the individual effects are not shown as they are assumed to be significant. NS- not significant.

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Profile of group</th>
<th>K-way Interaction</th>
<th>Likelihood ratio</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Partial Chi-Square</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train-aphobe</td>
<td>Preferred technical and then community information. Did not like to attend training</td>
<td>2</td>
<td>$x^2 \ (29, n=50), = 51.01, p \leq 0.05$</td>
<td>O x A</td>
<td>2</td>
<td>27.22</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O x L</td>
<td>1</td>
<td>8.18</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A x L</td>
<td>2</td>
<td>8.7</td>
<td>0.01</td>
</tr>
<tr>
<td>Technical-aphobe</td>
<td>Did not like using technical information. Preferred to use community information and attend training</td>
<td>2</td>
<td>$x^2 \ (29, n=51), = 49.44, p \leq 0.05$</td>
<td>O x A</td>
<td>2</td>
<td>9.14</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A x E</td>
<td>4</td>
<td>1.18</td>
<td>0.02</td>
</tr>
<tr>
<td>Allist</td>
<td>Would use all three types; community, attend training and technical information</td>
<td>2</td>
<td>$x^2 \ (29, n=35), = 42.83, p \leq 0.05$</td>
<td>O x A</td>
<td>2</td>
<td>8.78</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O x L</td>
<td>1</td>
<td>5.50</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O x E</td>
<td>2</td>
<td>6.75</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L x E</td>
<td>2</td>
<td>6.89</td>
<td>0.03</td>
</tr>
<tr>
<td>Internalist</td>
<td>Did not like to use any of these types of information</td>
<td>2</td>
<td>$x^2 \ (29, n=11), = 15.93, p \leq 0.05$</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>$x^2 \ (35, n=11), = 34.40, p \leq 0.05$</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.3. **Continued**

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Profile of group</th>
<th>K-way Interaction</th>
<th>Likelihood ratio</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Partial Chi-Square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainilist</td>
<td>Preferred to attend training rather than using the community and technical information</td>
<td>2</td>
<td>$x^2$ (29, n=24), = 36.56, p &gt; 0.05</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>$x^2$ (35, n=30), = 61.65, p ≤ 0.05</td>
<td>A</td>
<td>2</td>
<td>14.20</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community-aphobe</td>
<td>Preferred to use technical information and then attend training and not use community information</td>
<td>2</td>
<td>$x^2$ (29, n=30), = 36.15, p &gt; 0.05</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>$x^2$ (29, n=30), = 56.17, p ≤ 0.05</td>
<td>A</td>
<td>2</td>
<td>13.60</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Chapter 5. Information sources

The two information components from the PCA for growers were based on if the information source was Public or Private information. Public information is information freely available to everyone. A private agronomist provides private information that is specific for that farm and owned by the grower. Growers who used private agronomists as their only information source would definitely not use neighbours, local community or their local Agriculture reseller as a source of information (Table 5.4).

Information sources used by agronomists fitted into three components based on the content of the information (Table 5.5); General information, Regional information and Local information. Regional information refers to a region within the wheatbelt determined by rainfall zones, and local information would be specific for the area within that region (Table 5.5).

Table 5.4. PCA results on 11 sources of information used by growers when researching specific pest and disease issues. Two factors were extracted, and 15 iterations were required. Rotation method used was Oblimin with Kaiser Normalisation. The corresponding eigenvalues are given along with Cronbach’s alpha score for the two factors.

<table>
<thead>
<tr>
<th>Sources of information</th>
<th>Rotated factor loadings</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Public</td>
<td>Private</td>
</tr>
<tr>
<td>Attending seminars</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional Crop updates</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agmemo</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending workshops</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmnotes / Bulletins</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PestFax / PestFacts</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending field days</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous knowledge</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighbours</td>
<td>0.56</td>
<td>-0.41</td>
<td></td>
</tr>
<tr>
<td>Local farm community</td>
<td></td>
<td>-0.63</td>
<td></td>
</tr>
<tr>
<td>Private agronomist</td>
<td>0.46</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Local Ag reseller</td>
<td>0.37</td>
<td>-0.57</td>
<td></td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>6.04</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>% Variance</td>
<td>46.50</td>
<td>9.94</td>
<td></td>
</tr>
<tr>
<td>Cronbach’s α</td>
<td>0.90</td>
<td>0.59</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.5. PCA results on 11 information sources used by agronomists when researching specific pest and disease problems in crops. Three factors were extracted, and seven iterations were required. Rotation method used was Oblimin with Kaiser Normalisation. The corresponding eigenvalues are given along with Cronbach’s alpha score for the three factors.

<table>
<thead>
<tr>
<th>Sources of information</th>
<th>Rotated factor loadings</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General</td>
<td>Regional</td>
<td>Local</td>
</tr>
<tr>
<td>Attending seminars</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending workshops</td>
<td>0.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous knowledge</td>
<td>0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agmemo</td>
<td></td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>PestFax / PestFacts</td>
<td></td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Farmnotes / Bulletins</td>
<td></td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Local Ag reseller</td>
<td></td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td>Regional Crop Updates</td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td>Attending field days</td>
<td></td>
<td></td>
<td>0.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Eigenvalues</th>
<th>% Variance</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.34</td>
<td>12.1</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>1.21</td>
<td>11.23</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>1.12</td>
<td></td>
<td>0.57</td>
</tr>
</tbody>
</table>

5.4.5 Defining the clusters profiles for specific problems

Five grower clusters (Figure 5.6) were identified using the Ward’s method in the cluster analysis, based on the two information sources from the PCA. These clusters were based on whether they used a private agronomist or public information, and were called the following: i) Privat-aphobe; ii) Internalist; iii) Semi-Allist; iv) Publiclist and v) Public-aphobe. Growers in Cluster 2 (Internalist) and Clusters 5 (Public-aphobe) would not use public information. The Internalist clusters would not use any of the external sources of information provided in the questionnaire.

Six clusters for Agronomists (Figure 5.7) were determined from the three sources of information determined in the PCA, and showed a mix of using general, regional and local information categories used to solve specific problems on farm.
Figure 5.6. Information source preferences used by growers in the Australian grains industry when searching for information on specific pest and disease problems in crops. A hierarchical agglomerative cluster analysis was used. Mean and standard error are given for each of the cluster profiles.
Figure 5.7. Locus of information preferences used by agronomists in the Australian grains industry when searching for information on specific pest and disease problems in crops. A hierarchical agglomerative cluster analysis was used. Mean and standard error are given for each of the cluster profiles.
These clusters were called the following: i) Regionalist; ii) Localist; iii) Internalist; iv) Generalist; v) Allist and vi) General-aphobe. Clusters 3 (Internalist) and Cluster 5 (Allist) were in complete contrast as participants in these clusters did not use any of these external sources of information (Internalist) or used all of the information available to them (Allist).

5.4.6 Characterising the clusters using demographic information

The Log-linear analysis using the demographic variables on the growers and their clusters determined that only individual variables would describe the characteristics of the clusters (Table 5.6), i.e. there were no two-way interactions between the demographic variables. The Semi-Allist cluster had a higher proportion (49%) of growers that were older than 51 years of age and only 11% of the growers were younger than 30 years of age. However, there was no significant difference ($p > 0.05$) between the age groups using Pearson’s Chi-Square analysis on this cluster only. The majority of growers (59%) in the Internalist cluster were older than 51 years of age.

The education level of growers characterised the Clusters Publiclist, Privat-aphobe and Public-aphobe (Table 5.6). There was a clear trend showing that more than 41% of growers in these clusters had school as their highest education level and a smaller proportion (<22%) had completed university. However, closer examination of the chi-square analysis revealed no significant differences ($p > 0.05$) between education levels and the use of information sources to solve specific pest and disease issues on farm.

Similarly, there were no two-way interactions between the demographic variables in the cluster profiles of the agronomists (Table 5.7). The variable location influenced Clusters Regionalist, Internalist, Generalist, and Allist (Table 5.7). In these clusters the majority of agronomists (> 70%) were based in EA apart from the Internalist cluster where the majority (93%) were from WA ($x^2 (5, n=108), = 29.29, p \leq 0$).

Some (30%) of the agronomist in Cluster Localist had a university education while there were no agronomists with school only level in the Generalist cluster. However, using Chi-square analysis showed no significant differences ($p > 0.05$) between the education levels in these clusters.

Observations in the data showed that 27% of agronomists who were older than 51 years of age were in the Clusters Regionalist or Allist. A much smaller proportion was present in the other clusters.
Table 5.6. Log-linear analysis on the influence of demographic factors (age (A), education levels (E), location (L) and occupation (O)) on the grower groups determined from the cluster analysis using Ward’s method in Table 6. The demographic characteristics that have a significant effect on the model are shown with their partial Chi-Square value.

<table>
<thead>
<tr>
<th>Grower Group Name</th>
<th>Profile of grower group</th>
<th>K-way Interaction</th>
<th>Likelihood ratio</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Partial Chi-Square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publicist</td>
<td>Would use public information and less likely to use information from a private agronomists</td>
<td>1</td>
<td>$x^2$ (35, n=28), $= 56.71$, $p \leq 0.001$</td>
<td>O</td>
<td>1</td>
<td>38.82</td>
<td>0.00</td>
</tr>
<tr>
<td>Internalist</td>
<td>Would not use public or private information.</td>
<td>1</td>
<td>$x^2$ (35, n=17), $= 44.92$, $p \leq 0.05$</td>
<td>O</td>
<td>1</td>
<td>23.57</td>
<td>0.00</td>
</tr>
<tr>
<td>Semi-Allist</td>
<td>Would use information from private agronomists firstly and then use public information</td>
<td>1</td>
<td>$x^2$ (35, n=36), $= 87.08$, $p \leq 0.001$</td>
<td>E</td>
<td>2</td>
<td>9.75</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>6.27</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>49.9</td>
<td>0.00</td>
</tr>
<tr>
<td>Private-aphobe</td>
<td>Would use public information and definitely not use private information.</td>
<td>1</td>
<td>$x^2$ (35, n=24), $= 68.01$, $p \leq 0.001$</td>
<td>E</td>
<td>2</td>
<td>16.15</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>33.27</td>
<td>0.00</td>
</tr>
<tr>
<td>Public-aphobe</td>
<td>Would not use public information and would use private information</td>
<td>1</td>
<td>$x^2$ (35, n=27), $= 66.99$, $p \leq 0.001$</td>
<td>E</td>
<td>2</td>
<td>7.87</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>1</td>
<td>8.83</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>37.43</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Table 5.7. Log-linear analysis on the influence of demographic factors (age (A), education (E), location (L) and occupation (O)) on the agronomist groups determined from the cluster analysis using Ward’s method in Table 7. The demographic characteristics that have a significant effect on the model are shown with their partial Chi-square value. NS- Not significant.

<table>
<thead>
<tr>
<th>Agronomist Group Name</th>
<th>Profile of agronomist group</th>
<th>K-way Interaction</th>
<th>Likelihood ratio</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>PartialChi-Square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regionlist</td>
<td>Would not use general information. Unlikely to use local information. Would use regional information.</td>
<td>1</td>
<td>$\chi^2$ (35, n=20), $= 58.87$, $p \leq 0.05$</td>
<td>L</td>
<td>1</td>
<td>5.23</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>11.87</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>27.73</td>
<td>0.00</td>
</tr>
<tr>
<td>Localist</td>
<td>Would use local information in preference to general information. Would not use regional information</td>
<td>1</td>
<td>$\chi^2$ (35, n=29), $= 104.23$, $p \leq 0.001$</td>
<td>E</td>
<td>2</td>
<td>7.78</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>40.61</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>40.20</td>
<td>0.00</td>
</tr>
<tr>
<td>Internalist</td>
<td>Would not use any of these sources of information</td>
<td>1</td>
<td>$\chi^2$ (35, n=14), $= 60.22$, $p \leq 0.05$</td>
<td>L</td>
<td>1</td>
<td>12.2</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>23.56</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>19.41</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Continued next page
<table>
<thead>
<tr>
<th>Agronomist Group Name</th>
<th>Profile of agronomist group</th>
<th>K-way Interaction</th>
<th>Likelihood ratio</th>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Partial Chi-Square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generalist</td>
<td>Would not use local information. Would use general information in preference to regional information</td>
<td>1</td>
<td>$x^2 (35, n=17), = 77.19, p \leq 0.001$</td>
<td>E</td>
<td>2</td>
<td>10.03</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>1</td>
<td>11.25</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>21.51</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>23.57</td>
<td>0.00</td>
</tr>
<tr>
<td>Allist</td>
<td>Would use all three information sources, preference is for general and regional over local</td>
<td>1</td>
<td>$x^2 (35, n=20), = 62.83, p \leq 0.05$</td>
<td>L</td>
<td>1</td>
<td>3.29</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>2</td>
<td>16.45</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>1</td>
<td>27.72</td>
<td>0.00</td>
</tr>
<tr>
<td>General-aphobe</td>
<td>Would use regional and local information, would not use general.</td>
<td>1</td>
<td>$x^2 (35, n=8), = 26.84, p &gt; 0.05$</td>
<td>NS</td>
<td></td>
<td></td>
<td>NS</td>
</tr>
</tbody>
</table>
5.5 Discussion

Our research is the first in the peer-reviewed literature to examine the information needs of both growers and agronomists to make decisions on farm in relation to general problems and specific pest and disease issues in crops. Information sources used by growers and agronomists for general problems on farm are explored first, followed by an examination of information sources used for specific pest and disease issues, and the key contributing demographic characteristics that determine information preferences among growers and agronomists. Finally, we discuss the implications of our research for models of capacity building in agricultural extension, and provide guidelines for the provision of information by agribusinesses and other key providers of knowledge for the rapidly changing face of modern agriculture.

5.5.1 Information sources used for a general problem on farm

Our results demonstrate that growers and agronomists use different types of information to solve general problems on farm. Growers preferred to use information that they trust and that is in close proximity, such as the local community, neighbour and family, and the rural paper, echoing the findings of Ford and Babb (1989), Hunt and Coutts (2009), Llewellyn (2007), Solano et al. (2003) and Vergot III., Israel, and Mayo (2005). Distance from the source of information played an important role in the value placed on it by growers; similarly, Llewellyn (2007) found that information sourced more than 150 km away from the farm is perceived as less valuable. The agronomists preferred to use information from attending training courses and would not use any information from the community. These results were further validated by the work of Wright (2017) that demonstrated knowledge levels of agronomists increased after attending training events such as workshops. These results show that there is a disparity between the growers and agronomists when using sources and types of information for solving general problems. Llewellyn (2007) clearly showed that highly localised agronomic information is very important to growers, and therefore agronomists need to understand that highly targeted information is very important for their growers.

The clusters of growers and agronomists showed distinct differences in the volume and diversity of information sources used for solving general problems. At either end of the scale, ‘Allists’ used community-, training- and technically-based information while ‘Internalists’ appeared to eschew external information and rely primarily on their own experience, with other groups using one or two types of information available. These
results mirror those of Jansen, Steuten, Renes, Aarts, and Lam (2010)) who found that growers will either actively seek advice or will not. Kilpatrick and Rosenblatt (1998) found that growers preferred to use three or more sources of information before making a decision. However, Gloy et al. (2000) found that the diversity of information and perceived usefulness by growers in the USA was related to the range of commodities that was produced on that farm. Our research is the first that has examined growers and agronomists together and their preferences for types of information when solving general problems. Understanding the crossover between the clusters in their usage of types of information and the mix of growers and agronomists is very important when developing and providing information to the grains industry.

### 5.5.2 Information sources used to solve specific pest and disease problems in crops

In contrast with the three categories of information types used for general problems, our results indicate that growers tended to use two sources of information for solving specific problems: either information that was available publicly, or information provided by a private agronomist. This is most likely because specific problems such as pest and diseases have specific solutions (the application of insecticides or fungicides) and the solutions do not vary widely between locations. Our results showed that growers using private consultants did not use neighbours, local farm community or their local agriculture reseller as a source of information. This could be due to a lack of trust, alternatively, the public information in their area is not sufficiently specific to deal with the pest and disease issues in crops. The risk for growers in this cluster is that they are not accessing all of the information available to them, and they are totally relying upon their agronomist to have the most up-to-date and relevant information. If the agronomist profile does not fit into the Allist cluster, they are not accessing all of the relevant sources of information to provide their grower with the most up-to-date information.

Information sources used by agronomists for pest and disease problems in crops fitted very well into the paradigm described by Llewellyn (2007) based on (i) the distance from the content of the information (whether it is regional or local), and (ii) the source of the information (i.e. the organisation that performed the trials or provided the information, rather than the information publisher). The six profile clusters for the agronomists showed a combination of using general, regional and local information. Interestingly, Generalists will not use local information and will use general information in preference to regional information; this implies that distance from the source is less
important for agronomists in this group than it is for growers when attributing value to information. Agronomists indicated that they would prefer information from a technical workshop, field days, the Internet and their own experience. Our research makes an important contribution to the extremely sparse literature on the sources, types and content of information used by agronomists. As the grower-agronomist relationship becomes increasingly important in the Australian grains industry, it is vital that information is developed and produced to encourage everyone to access to this information. This will reduce the impact of misinformation when solving specific problems on farm.

5.5.3 The demographic characteristics in the cluster profiles

Information preference clusters were clearly defined by demographic characteristics of age, education and location for both growers and agronomists, echoing findings by previous research showing that younger growers are interested in building information networks and that more educated growers used a broader range of information sources (Tucker & Napier, 2002) and that less experienced growers relied upon family and friends for information (Ford & Babb, 1989). This interaction between age and education was also present in our research, characterising the cluster profiles Technical-aphobe and Community-aphobe. Community-aphobes tended to be younger and more educated which concurs with the profile of agronomists within this group. The proportion of participants over 51 years of age with a university degree was significantly smaller than the proportion of university-educated growers under 51 years old. This is most likely due to an increasing proportion of students finishing school and continuing onto university studies during the past 40 years due to changes in Australian government policy which now requires all students to finish secondary schooling or continue with an apprenticeship or vocational education (Education, 2016).

Location and age characterised the Internalist cluster profile for specific pest and disease issues. The effect of age was expected, as the older the participant the more life experience that person is assumed to have, and hence are able to make decisions with less external input. The effect of location would suggest that those who are more isolated by distance would have to rely upon their own experiences more than those who are not isolated by distance, however, it would be assumed that with the advent of the Internet, that isolation by distance would be reduced. The Sensis Social Media report (2015) reported that WA has the lowest daily internet usage compared to the
rest of Australia, and that few people access the internet daily in regional and rural locations (Sensis, 2015). The use of social media and the Internet to provide information to growers and agronomists was explored in another part of our research (Wright, Hammond, Thomas, MacLeod, & Abbott, 2018).

It was not possible to explore all demographic dimensions of the cluster profiles. This was most likely due to the small number of respondents who participated in the surveys and would be improved if a larger sample could be surveyed. There were also interactions among age, education and occupation of participants in the survey, meaning that not all demographic categories were sampled equally (for example, 40% of growers were 51 or older, while one quarter of agronomists were in this age group, and 24% of growers had a university education compared with 80% of agronomists (Wright et al., 2016). Despite the survey limitations, the profiles developed for agronomists addressing specific pest and disease issues could be extrapolated to the rest of the agronomist population as the sample size adequately represented agronomists within the Australian grains industry. More growers (10-20% of the total grower population, between 3000 and 6000 participants) would need to be surveyed to determine whether the profiles developed are valid across the entire Australian grain-growing industry.

5.5.4 Implications for models of capacity building and information provision

Information access is a crucial component of the capacity building program within Australian agriculture. This research shows clearly that simply providing information is not a guarantee that all user groups will choose to access that information; information needs are not equal within or among growers and agronomists. This is similar to the findings of Klerkx et al. (2017), Jansen et al. (2010), Ingram (2008) and others.

Examining Coutts and Roberts (2011) capacity building model the information access leg of the ladder sits to the left hand side of the model (Figure 5.1). Only groups in the ‘facilitation and empowerment’ leg of the model will access this information, and have the ability to move up the rungs of the capacity building ladder, with the addition of training. So it is important that those that have a consultant (agronomist) as mentoring support still have access to the information leg of the ladder. This will only happen if those in the role of consultant / mentor (agronomists) perceive the benefit of belonging to a group that enables facilitation and empowerment and then they will have access to the training and information access leg of the ladder. However, for agronomists to move up the rungs of the ladder, the “consultant” component needs to be accessible to
all. This component needs to be changed to include all those participants within the immediate community and other communities.

Our research demonstrates that when supplying information for both general and specific issues in crops, the information sources need to be diverse, including the type and the content of the information. These results reflect those of Hunt and Coutts (2009), Coutts and Roberts (2011), and Solano et al. (2003) that catering for different subsets of users of information ensures that new knowledge is available to everyone.

Providers and developers of the information type and content, need to take note of the cluster profiles developed in our research, so that relevant, timely and useful information is produced that can be used by all within the grains industry. There needs to be a two-way interaction between those that develop the information and those that use the information to ensure that needs are met. Our research is an initial start for the providers and developers of the information to understand what is needed, and how to improve on the current information provided to those within the industry. This will ensure that participants within the industry can continue to move up the capacity building ladder.

The profiles reported here shows the information strategy required for each of the clusters identified and highlights where more effort is needed to ensure adoption by those clusters (eg Internalist) who are not using any of the sources of information listed in this study. Jansen et al. (2010)) discussed that there were four different types of hard to reach growers, and one of these types includes those that access the information but do not use it, as well as those who do not access the information How to get Internalists (or hard to reach) to engage and want to access information requires further research. This should include using information communication tools such as YouTube videos, and podcasts. The production of information that is valued by both growers and agronomists would be a good ‘hook’. In general terms, information developed and produced needs to be made publicly available through a variety of sources and types and needs to fit the requirements that agronomists have. This is very important to ensure that all relevant information is passed onto those growers who rely on agronomists for advice.

5.6 Conclusions

Understanding how and where growers and agronomists access information can help ensure that the information is targeted, relevant and supports the capacity building
program for that industry. Information sources used by growers and agronomists were varied and depended on whether they were looking for information to help make a decision on a general problem or specific pest and disease problem in crops. The growers and agronomists can be clustered according to which sources of information, the type of information and content of the information that they will use or not use. These clusters are characterised by the demographics of the participants and can be used to target information developed and produced by those involved in the industry.

**Conflicts of interest**

No potential conflict of interest was reported by the authors.

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Chapter 6. Training activity preferences by growers and agronomists from the Australian grains industry

Training as part of the capacity building ladder in Australian Agriculture Wright, D., Grand, A., MacLeod, B and Abbott, L. K. (2016)

Abstract accepted and presented at 23rd European Seminar on Extension and Education 4-7th July 2017, Greece (Appendix G)

Invited paper for special issue in The International Journal of Agricultural Extension. Submitted October 2017 (Appendix H)
6.1 Introduction

The delivery of extension to Australian farmers has changed over the years due to the political, social and economic climate (Carberry et al., 2002; Cristovao et al., 2009; Jones & Garforth, 1998; Marsh & Pannell, 2000) Extension moved from a solely government provided service to a service predominantly delivered by commercial entities (Keogh & Julian, 2014b; Marsh & Pannell, 2000). These changes corresponded with changes in farming systems within Australia, which have become more mechanised and more specialised (Keogh & Julian, 2014b). Furthermore in Western Australia, farms have grown three fold in size (from 1000 ha to 3,500 ha under crop) while in other states farms have increased to a lesser degree (average size is 1000 ha) (Keogh & Julian, 2014b). The use of agronomists (private consultants) has also increased over time and growers require more specialised technical and targeted information (Cristovao et al., 2009; Jones & Garforth, 1998; Marsh & Pannell, 2000).

Extension is the transfer of information in order to promote learning, to build capacity in skills and knowledge and to promote change within a community (Coutts & Roberts, 2011; Fulton et al., 2003; Jones & Garforth, 1998; Primary Industries Standing Committee, 2011). The tools and delivery mechanisms that are used need to be diverse, and depend upon the final outcome being sought (Primary Industries Standing Committee, 2011). Extension methods in agriculture include broadcast electronic and print media, field days, specific individual advice, focus farms, demonstrations, subject specific videos, and both general and specific publications. Regardless of the method used, information needs to be synthesized and delivered to learners in a format that is based on their requirements (Fulton et al., 2003; Jones & Garforth, 1998). Methods used have to be relevant to the farmer’s context and take account of the geographic location, regional setting, level of education, and amount of experience (Franz, Piercy, Donaldson, Westbrook, & Richard, 2010). Information has to be tailored so that it is understandable by all regardless of their education and experience levels. Presenting the information in different forms according to the demographics of the audience could provide this tailoring.

Since the early 2000’s, extension in Australia has focused on capacity building. There is a larger range of stakeholders and providers of extension (Coutts & Roberts, 2011; Keogh & Julian, 2014b). Agribusinesses, such as fertiliser companies and chemical companies now also provide extension services to growers. These companies employ agronomists who are responsible for trial work, plus the provision of advice to growers (Keogh & Julian, 2014b; Marsh & Pannell, 2000). In Western Australia (WA),
agronomists have used the Department of Agriculture and Food, Western Australia (DAFWA) for training in specific issues such as disease identification. Many private agronomist companies in WA now send their agronomists to DAFWA for training in disease identification (Geoff Thomas pers. comm. 2015).

The use of capacity building in extension has also led to changes in delivery method. Instead of one-to-one exchanges, there has been a major requirement for grower groups to be used (Marsh & Pannell, 2000). The one-to-one method involved an extension officer discussing and solving a problem with a grower. In the past extension officers from government departments spent their days visiting people to help them. This has changed through the use of grower groups, in which extension is provided from on a one-to-many process. One-to-one extension is viewed as a private good (helping a single grower) whereas providing extension to a group is seen as a public good. As the Research and Development Corporations (RDCs) have taken on a larger role in the provision of information and ensuring that extension is a major component of projects, they are also pushing for the information to reach a wider audience and asking that the researchers are responsible for this (Coutts & Roberts, 2011). To enable this to happen, the requirement for grower groups to be used in extension delivery continues (Keogh & Julian, 2014b), however, this runs the risk that larger groups will be targeted. The larger the group, the lower the interaction level will be and therefore the less knowledge will be constructed (Hare, 1952; Jaques, 2000; Print, 1993). There is also the risk of 'social loafing' occurring, which is when individuals reduce their input into a group (North et al., 2000).

In an extensive report into Agriculture Extension, Learning and Change for the Rural Industries Research Development Corporation (RIRDC), Fulton et al. (2003) considered the different processes used in Australia to facilitate learning and change on the farm. Woods et al. (1993) recommended that on-going groups had a great potential to support learning and change if a participatory approach or action learning were used. With the increase in the use of groups and action learning evaluation, Fulton et al. (2003) demonstrated significant learning occurring among the participants. However, Fulton et al. (2003) found that major questions in relation to group work still remained, including what were the best techniques used when evaluating the effectiveness of groups and an analysis of who participated in the groups and which group processes were appropriate for which circumstances. Marsh and Pannell (2000) also commented on the lack of studies that examined the effectiveness of the variety of extension methodologies currently in use in Australia. There are considerable amounts of qualitative data supporting the use of groups demonstrating that there is better
participation and better learning, however, there is a lack of quantitative data demonstrating that practice-change is implemented as a consequence of group work (Fulton et al., 2003; Marsh & Pannell, 2000; Petheram & Clark, 1998). It is well recognised that growers are social learners and most of their learning is done ‘on the job’ and through informal training (Kilpatrick & Fulton, 2003; Kilpatrick & Johns, 2003; Vanclay, 2004; Wenger, 2000). The community, workplace and home are major contributors to learning and contribute sources of information (Kilpatrick & Fulton, 2003; Kilpatrick & Johns, 2003; Wenger, 2000, 2009). Kilpatrick (2000) demonstrated that greater farm profitability was correlated with increased education and training. Growers who had been able to make successful changes to their farming practices had participated in more training both formal and informal (Kilpatrick, 1997).

In the capacity building and community engagement paradigm of agricultural extension in Australia, Coutts and Roberts (2011) identified five delivery models for extension projects: (i) Group facilitation and empowerment; (ii) Training; (iii) Technological development; (iv) Information access; and (v) Individual consultant/mentor. These five models are complementary and should work together to ensure that capacity building needs in the agricultural sector are met.

The training model is about training programs specifically designed at increasing skills and understanding for participants in the agricultural industry. In general these programs have set curricula and learning objectives and meet the standards required under the National Qualifications Framework in Australia, and are part of the Vocational Education and Training (VET) system. This allows participants to gain accreditation for their learning (Coutts & Roberts, 2011). It is essential therefore that there is extensive consultation done with the industry and community before resources are used to develop a training program. This can happen through the group facilitation and empowerment model where groups may seek out suitable and relevant learning opportunities (Coutts & Roberts, 2011).

Most literature focuses on capacity building from the perspective of the grower; there is little work on the capacity building of agronomists. Agronomists tend to have formal qualifications with further training through attendance at formal and informal training activities (Keogh & Julian, 2014a). Long (2013) ran a project funded by GRDC that focused on developing agronomists’ understanding of growers’ decision-making process and their skills for speaking to growers about science in a practical way. Through this process agronomists developed skills in working with growers as peer mentors. Agronomists were able to implement actions such as the use of social media, tailoring messages to different personality types, learning styles and the use of a
planning and evaluation process and they reported an increased rate of technology adoption by their clients (Long, 2013).

Unlike Australia, in the USA, crop advisers, consultants and agronomists are generally certified (Certified Crop Adviser, CCA and Certified Professional Agronomist CPAg). The American Society of Agronomy (ASA) runs the certification programs. These certifications were established in 1992 to provide a benchmark in the USA and Canada (CCA, 2016) and to protect both the public and the profession. Farmers and employers prefer to work with CCA or CPAg-certified professionals, because they have demonstrated a commitment to education, expertise and experience in their roles (CCA, 2016).

There are many studies that discuss or evaluate training attended by growers, but there is very little about what training events agronomists like to attend and why. Some studies have examined the training events as educational delivery methods (Franz et al., 2010; Kilpatrick, 1997) and the impact on farm businesses for growers (Kilpatrick, 1997, 2000; Kilpatrick et al., 1999).

Franz et al. (2010) surveyed growers and extension specialists and documented that the top six preferred learning methods from growers were (i) hands on, (ii) demonstration, (iii) farm visit, (iv) field day, (v) discussion and (vi) one-on-one. They showed that growers definitely did not like, (i) games, (ii) comics, (iii) role-playing and (iv) radio. Extension specialists thought that growers liked to learn through (i) farm visits, (ii) one-on-one, (iii) demonstration, (iv) field days and (v) on-farm tests. They thought farmers did not like comics, role-playing and games as a method for learning.

Grower groups in Australia are very popular within the farm community and they have been increasing in number since 1990 when the Australian Government encouraged rural communities to work together, to initially to protect water, vegetation and soil (Gianatti & Carmody, 2007). These groups continue to be proactive in conducting research trials and in the provision of extension using local publications and field days (Anil, Tonts, & Sidique, 2015; Gianatti & Carmody, 2007). In Western Australia, there are approximately 40 major grower groups; which are formally convened with more than 50 members (Grower Group Alliance, 2016). In Victoria there are seven major grower groups (Victorian Grower Group Alliance, 2016). The Birchip Cropping Group is one of the largest in Victoria with over 400 members.

Extension activities such as field days, workshops, seminars, and grower group meetings, are educational activities or training activities for growers and agronomists (Coutts & Roberts, 2011; Keogh & Julian, 2014b; Miller & Cox, 2006). However, it is
not clear which of these activities growers and agronomists prefer to attend. It is also unclear whether demographic characteristics such as education levels, age and location influence the activities in which they choose to participate.

The aim of our research was to compare the training activity preferences of growers and agronomists within the Australian grains industry, and determine if their demographic characteristics influenced these choices. The outcome from this research will then enable grower groups and other organisations providing training for capacity building to tailor their training to meet the requirements and preferences of growers and agronomists.

6.2 Materials and methods

6.2.1 Surveys

The research reported here is part of a larger research 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 targeted questionnaires were developed to examine the types of training attended by participants in the Australian grains industry. One questionnaire targeted growers and the other questionnaire was targeted to agronomists. Both 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 surveys were administered using Qualtrics (Qualtrics, Provo, UT) and developed following the principles of Fowler (2009) and Dillman, Smyth, et al. (2009); using questions which were simple and easy to understand and provide reliable and valid measures. The pretesting of the questionnaires was reported in (Wright et al., 2016). Approval for this work was gained from the Human Research Ethics Committee of The University of Western Australia (RA/4/1/6607).

For this study, a grower was defined as a person who lives and farms land to produce grain crops. An agronomist was defined as a person employed by grain growers to provide technical information and advice for grain crop production (Wright et al., 2016).

For the extent of the work reported here (Section B, Appendix A and B), the two questionnaires were identical thus allowing comparisons to be made between growers and agronomists. The questions were designed to determine what type of training they had attended (questions 7, 11, and 20), what barriers prevented them from attending
the training events (questions 8, and 14), what they liked about the training they had attended (questions 9, 12, and 22) and how could it be improved (questions 10, 13, and 23). Participants were asked if they belonged to a local grower group (question 15), how often they attended the meetings (question 17), what they liked about the grower groups (question 18) and what were the worst aspects of the meetings (question 19). Participants were asked to list 3 topics that they would like training in (question 24). The final section collected demographic information from the participants (Questions 41, 43, 44, and 47) in Appendix A and B.

The questionnaires were distributed as; (i) an on-line questionnaire, (ii) a paper-based questionnaires handed out at regional meetings during March 2014, and (iii) a paper-based questionnaire posted to growers and agronomists from the Birchip Cropping Group. Further details on the distribution of the questionnaires were reported in Wright et al. (2016).

6.2.2 Data analysis

The data from the survey were compiled using Qualtrics software, 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 ($\chi^2$) to determine the influence of occupation (grower or agronomist), age, gender, education level and location on the types of training attended by participants, the barriers to attending the training. If Pearson’s Chi-Square failed the assumption that more than 20% of the cells had a frequency count of less than 5, then the Likelihood ratio statistic test was used in its place. This test is preferred when samples are small and still uses a chi-square distribution (Field, 2013, p. 724)

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).

The overall response rate of useable questionnaires was estimated to be 26% because it was not possible to accurately determine the exact number of requests for people to complete the survey online. Questionnaires with incomplete demographic data (n=47) such as no postcode were not included in the analysis (Wright et al., 2016). Due to the low number of returns from Queensland, NSW, Victoria and South Australia the data collected from these states were combined to form the “Eastern Australia” (EA) which
was used in the corresponding cross tabulation and Pearson’s Chi-Square analysis (Wright et al., 2016).

The short answer questions were coded into themes using an inductive approach informed by previous research and developed incrementally (Fereday & Muir-Cochrane, 2006). Frequency counts were then used on these themes to determine what participants liked about the training they attended, how the training could be improved and for what topics they would like training.

6.3 Results

6.3.1 Field day attendance

Many participants found field days were informative (22%), interactive (19%), visual (13%) and provided an opportunity for networking (13%).

“Lets you keep up to speed with anything that’s happening in the area” WAP3.

“50-50 get it in the paper, read it and here you pick up a lot of visual” WAP1.

The demographics of the participants influenced the attendance at field days. The age of participants did not influence their attendance of field days ($p > 0.05$). Males participated in four or more field days in 2013 compared to females ($X^2 (n= 245), 2, = 9.36$, $p ≤ 0.05$) (Figure 6.1A). A greater proportion of participants from Western Australia (WA) attended more than four field days, whilst a greater proportion of Eastern Australia (EA) participants attended between one and three field days (Likelihood ratio $X^2 (n= 241), 2, = 9.29$, $p ≤ 0.05$) (Figure 6.1B). Participants with a higher education level were more likely to attend field days than those who did not (Likelihood ratio $X^2 (n= 248), 2, = 10.75$, $p ≤ 0.05$) (Figure 6.1C). Only 12% of agronomists surveyed did not attend any field days while 56% of them attended 4 or more field days during the season (Likelihood ratio $X^2 (n= 248), 2, = 14.39$, $p ≤ 0.001$) (Figure 6.1D).

The major barrier to attending field days was that participants did not have time to attend. Some participants do not find field days useful and the topics discussed at some field days were not relevant. The influence of demographics on the barriers to attending field days was examined and is shown in Table 6.1.
Figure 6.1. The demographic variables (gender, location, education level and occupation) influence on the attendance of participants at field days in 2013. A) Gender of participants and the number of field days they attended. B) Location of participants in either Eastern Australia or Western Australia. C) The education level of participants and the number of field days that they attended and D) the occupation of participants and the number of field days they attended.
Table 6.1. The influence of location and occupation on the barriers experienced by participants attending field days with their corresponding Pearson’s Chi-Square value.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Place of residence</th>
<th>Occupation</th>
<th>Pearson’s Chi-Square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eastern Australia</td>
<td>Western Australia</td>
<td>Growers</td>
<td>Agronomists</td>
</tr>
<tr>
<td>I do not find field days useful</td>
<td>6</td>
<td>0.7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>No field days were held in my district</td>
<td>6</td>
<td>0.7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>No time available to attend</td>
<td>10</td>
<td>4</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Topics not relevant to me</td>
<td>7</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Unaware of field days being held</td>
<td>5</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Unaware of field days being held</td>
<td>N/A</td>
<td>N/A</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

N/A: Not applicable. There was no significant difference between place of residence or occupations of participants.
Place of residence significantly influenced the barriers listed in the table, with participants in EA experiencing more barriers than those residing in WA.

Participants felt that field days could be improved by: (i) improving the quality (15%) of the information provided, (ii) reducing the number of filed days, (iii) greater range of crop varieties shown (15%), and (iv) the timing of the day; when the field day starts and finishes (10%).

### 6.3.2 Formal workshop attendance

The top three items participants liked about workshops were: (i) they were informative (40%); (ii) interactive (12%); and (iii) local (12%). Attendance of growers and agronomists at formal workshops varied significantly (Figure 6.2). A higher proportion of agronomists (54%) attended 3 or more workshops on agronomy compared to 27% of growers attending this many workshops ($\chi^2$ (n= 216), $\text{d}f = 19.15$, $p \leq 0.001$). Only 4% of agronomists did not attend any workshops on agronomy and only 16% of growers did not attend. Whilst for every other topic at least 37% or more did not attend any workshops indicating that agronomy workshops were most highly valued.

Agronomists did not value workshops on animal husbandry, however, growers attended these workshops at a significantly higher frequency than the agronomists ($\chi^2$ (n= 219), $\text{d}f = 10.96$, $p \leq 0.05$) (Figure 6.2).

There were significant differences between the proportion of growers and agronomists who attended herbicide application workshops ($\chi^2$ (n= 203), $\text{d}f = 7.39$, $p \leq 0.05$) and pest identification workshops ($\chi^2$ (n= 200), $\text{d}f = 7.28$, $p \leq 0.05$) (Figure 6.2). Most of the participants were agronomists for these workshops.

There was no significance difference between genders in attending formal workshops ($p > 0.05$). Furthermore, there was no significant influence ($p > 0.05$) of education levels on the workshops attended by agronomists and growers.

The age of the participants had a significant influence on the number and type of workshops attended (Figure 6.3). Growers and agronomists who were less than 30 years of age attended workshops more frequently than the other participants. More than 60% of the participants who were younger than 30 years of age attended, agronomy ($\chi^2$ (n= 216), $\text{d}f = 14.85$, $p \leq 0.05$), disease identification ($\chi^2$ (n= 188), $\text{d}f = 28.29$, $p \leq 0.001$), pest identification ($\chi^2$ (n= 200), $\text{d}f = 17.69$, $p \leq 0.05$), and herbicide application ($\chi^2$ (n= 203), $\text{d}f = 11.44$, $p \leq 0.05$) workshops. These participants did not attend any animal husbandry workshops.
Figure 6.2. The percentage of growers and agronomists and the number of formal workshops that they have attended between January 2013 and June 2014. Significant differences were seen between growers and agronomists at ^p ≤ 0.001 or * p ≤ 0.05
Figure 6.3. The influence of age on the participation of growers and agronomists in workshops attended between January 2013 and June 2014. There was a significant difference between age groups at $^p \leq 0.001$ or $^* p \leq 0.05$. 
There was a significant influence of the number of years a participant had been working on attendance at the disease identification workshop (Likelihood ratio $\chi^2$ ($n=188$ (6), $\chi^2 = 16.308$, $p \leq 0.05$), farm management (Likelihood ratio $\chi^2$ ($n=196$ (6), $\chi^2 = 15.967$, $p \leq 0.05$) and pest identification course (Likelihood ratio: $\chi^2$ ($n=200$ (6), $\chi^2 = 18.875$, $p \leq 0.05$).

The most frequent reasons given for not attending workshops were: (i) no time to attend (60%); (ii) none were held in my district (35%); and (iii) the topics were not relevant (31%).

Overall, many participants did not comment on how workshops could be improved, but some participants felt that the overall quality (6%), and the information provided (4%) could be improved.

### 6.3.3 Attending grower group meetings

Participants liked attending grower groups because they are local (26%), interactive (17%) and informative (17%). 15% of participants found that they enjoyed networking in these groups. There was a significant difference between growers and agronomists in their membership of growers groups. The majority of growers (82%) who responded to the survey belonged to a grower group while only 52% of agronomists did ($\chi^2$ ($n=242$ (1) = 24.93 $p \leq 0.001$).

The age of the participants influenced membership to a grower groups. A smaller proportion of participants (51%) who were less than 31 years of age belonged to a grower group, compared to a larger proportion (73%) of those that were older than 31 years of age belonged to a grower group ($\chi^2$ ($n=242$ (2) = 7.786 $p \leq 0.05$).

Location of the participant influenced their membership of a grower group. A smaller proportion (23%) of WA participants belonged to a group compared to 41% of participants from EA ($\chi^2$ ($n=235$ (1) = 9.35 $p \leq 0.05$) belonging to a grower group. This also influenced the frequency of attending the grower group meetings; 42% of participants located in EA attended at least 25% of the meetings, while only 22% of those located in WA attended 25% or more of the meetings. 34% of participants from WA attended at least 75% of the meetings while only 19% of participants from EA attended 75% of the meetings ($\chi^2$ ($n=162$ (4) = 12.73 $p \leq 0.05$).

Some participants (29%) found that time constraints prevented them from attending grower group meetings; and the distance to travel (12%) really impacted their attendance. In some cases, meetings were over 100 km away from where they lived.
Some participants (12%) would like to see more structure provided in the meetings, while 5% felt that the invited speakers need to improve their presentation skills and others felt that the meetings tended to be repetitive.

### 6.3.4 Attendance of other training events

The other types of training events attended by participants included; (i) meetings (9%), (ii) updates (regional, and agribusiness) (32%), (iii) seminars (23%), (iv) workshops (23%) and (v) webinars (14%). Most of these events were attended largely by agronomists (71%) compared to only 44% of growers ($\chi^2 (n=242 (1) = 18.07 p \leq 0.001$).

The majority of participants found these types of training to be informative (55%), local (21%), and they enjoyed the interaction and networking (7%). In the case of webinars, these are local; participants do not having to drive somewhere, similarly, some of the workshops and seminars were held locally and required very little travel.

The level of education only influenced attendance at “other learning events” with only 39% of those who had secondary school as their highest level of education attended other events compared to 64% of University educated participants ($\chi^2 (n=242 (2) = 10.90 p \leq 0.05$).

Participants were asked to list three topics that they would like training in, (Table 6.2). These topics are listed in order of priority from the participants. There was a significant difference between occupations and what training topics participants would like attend (Figure 6.4). For example, agronomists (18%) would like further training in crop nutrition and fertiliser management where as growers did not see this as important (Likelihood ratio $\chi^2 (n=149 (13) = 37.26 p \leq 0.001$); a higher proportion of growers (16%) would like further training in the use of IT equipment and other technology whereas agronomists did not see this as important (Likelihood ratio $\chi^2 (n=149 (13) = 37.26 p \leq 0.001$). There were no significant differences between the educational levels and age groups of participants and the topics they chose for training.
Table 6.2. Participants surveyed would like to see the following topics more readily available in training events. The participants listed the topics in order of priority. *Other refers to topics that did not fit into the main themes used in this list.

<table>
<thead>
<tr>
<th>Topic</th>
<th>1st Topic</th>
<th>2nd Topic</th>
<th>3rd Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>21 (14)</td>
<td>7 (8)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Other*</td>
<td>21 (14)</td>
<td>17 (18)</td>
<td>8 (16)</td>
</tr>
<tr>
<td>Business Management</td>
<td>20 (13)</td>
<td>21 (22)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Nutrition</td>
<td>15 (10)</td>
<td>6 (6)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Precision Ag</td>
<td>15 (10)</td>
<td>4 (4)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>IT and Technology</td>
<td>13 (9)</td>
<td>5 (5)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Pest and Disease</td>
<td>9 (6)</td>
<td>7 (8)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Soil Health</td>
<td>9 (6)</td>
<td>5 (5)</td>
<td>7 (14)</td>
</tr>
<tr>
<td>Soil physics</td>
<td>6 (4)</td>
<td>4 (4)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Marketing</td>
<td>6 (4)</td>
<td>2 (2)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Variable rate technology</td>
<td>4 (3)</td>
<td>2 (2)</td>
<td>0</td>
</tr>
<tr>
<td>HR</td>
<td>5 (3)</td>
<td>6 (6)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Grazing / Livestock</td>
<td>3 (2)</td>
<td>0</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Weeds</td>
<td>2 (1)</td>
<td>5 (5)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Pastures</td>
<td>0</td>
<td>1 (1)</td>
<td>3 (6)</td>
</tr>
<tr>
<td><strong>Total number of</strong></td>
<td><strong>149 (100)</strong></td>
<td><strong>92 (100)</strong></td>
<td><strong>49 (100)</strong></td>
</tr>
</tbody>
</table>
Figure 6.4: Topics that growers and agronomists would like training to be available on. *Significant difference between growers and agronomists (p ≤ 0.001).

<table>
<thead>
<tr>
<th>Topic for training</th>
<th>Percentage of participants</th>
<th>Agronomist %</th>
<th>Grower %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pastures</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pest and Disease</td>
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<tr>
<td>Chemicals</td>
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<td>Grazing / Livestock</td>
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<td>Soil Health</td>
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<td>Business Management</td>
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<td>Marketing</td>
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<td>Precision Ag</td>
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<tr>
<td>Soil physics</td>
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<td>Other</td>
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<td>IT and Technology*</td>
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<tr>
<td>Nutrition*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable rate technology*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Variable: rate technology, technology.
Figure 6.4. Topics that growers and agronomists would like training to be available. *Significant difference between growers and agronomists ($p \leq 0.001$)
general agronomists are employed in relation to the cropping phase of the farm system.

In my research presented here, there was no influence of education level on participation in the formal workshops. However, there was a distinct difference between occupation (grower and agronomist) and in previous work by Wright et al. (2016) there was a correlation between education level and occupation. Kilpatrick (1997) found the difference between growers who attending training or planned to attend training and those who did not, was related to the education level of participants. Those with a lower level of education generally do not perceive the need to attend formal training and this may be due to the lack of confidence and reduced literacy levels in this group (Kilpatrick, 2000).

6.4.3 Grower groups

Membership of grower groups is very popular with growers as it provides a network of like-minded people, generally from the same region, with the same or similar problems on their farm. Generally, grower groups are considered a community of practice (Anil et al., 2015; Gianatti & Carmody, 2007; Wenger, 2000, 2009), which provides an effective learning opportunity for growers (Kilpatrick & Johns, 2003). Gianatti and Carmody (2007) found that many growers in WA belong to more than one group; they may belong to a small local group, plus a larger regionally focused group and also a state-wide group (Anil et al., 2015; Gianatti & Carmody, 2007).

There is very little in the literature about the influence of participants’ age, education levels, occupation and location on belonging to a grower group. Anil et al. (2015) examined the participation rates of growers in the three main grower groups of Western Australia. They found the proportion of growers who actively participated in the groups varied between the groups and this was related to the location of the grower and whether the grower group was a large state-wide group that had a very widely dispersed membership or an active local group (Anil et al., 2015). In my research, a proportion of the growers found that time constraints and distance to travel were barriers to attending more grower group activities. However, participants in my survey also reported that they liked attending grower groups because of the interaction with other members, that they were local and that they were informative.
6.4.4 Other training events

Generally, agronomists attended other training events more frequently than did growers. They enjoyed the events because they were interactive, informative and, in the case of webinars, allowed attendees to stay within their local area and not have to travel.

The impact of education levels on attendance at other types of training was shown in our surveys. Those that had a university education were more inclined to attend other training events such as webinars. Technology advances can be used to improve communication between people who are regionally dispersed, however, it can also hinder communication; does not allow for informal networking opportunities which growers prefer (Anil et al., 2015; Wenger, 2000).

Occupation influenced the training topics listed by participants that they would like to attend. The topics listed by agronomists were related to the roles that they have when employed by the grower, such as nutrition. Growers were more concerned with the practical application of variable rate technology and the use of IT and new technology for on their farms.

6.4.5 Barriers to attending training

The barriers listed as impediments to attending field days and formal workshops were as expected and included, “no time to attend”, and “none were held in my district”. Kilpatrick (1997) found in the survey conducted with farm businesses that; a) 32% that did not have time to attend, b) 19% were too far away, and c) 15% were being held at a busy time of the year. Thus, nearly 20 years later the barriers to attending training have not changed. In my study, only 5% of the participants were unaware of field days being held, which suggests that there is a good level of promotion of the field days within regions. However, most of the barriers mentioned are associated with participants from the Eastern States, indicating in some regions the amount of promotional activity needs to be increased, and also event organisers need to determine more appropriate times to hold field days.

Another barrier that was stated by many participants (31%) was that workshop topics were not relevant to them. This may be explained by the research conducted by Kilpatrick (1997) which showed that the education level influenced the ability of growers to recognise training opportunities; those with less than Year 10 qualifications were unlikely to attend training events. Since 1996, all children in Australia are required
to attend school until Year 12. Less than 5% of participants in our survey did not attend any field days and a greater portion of those participants with University qualifications attended more than four-field days in the year. In previous research reported by Wright et al. (2016) agronomists in general had a higher education level than growers. In my study reported here, there was no influence of education levels on whether participants attended formal workshops. However, the occupation of participants did influence the number of workshops attended.

6.5 Conclusion

The range of training activities attended by growers and agronomists and the associated topics preferred varied considerably. Growers preferred to attend events such as field days that allow informal interaction to happen, and that represent conditions that are similar to their farming situation. This informal interaction allows for values and beliefs to be compared, before a grower will use this information.

This is the first study to report on agronomists’ from the Australian grains industry preferences for training activities that includes field days and formal workshops. These activities are important for agronomists as they provide an opportunity to network with colleagues, researchers, specialists and growers.

By understanding the influence of the participants’ demographic characteristics on their choice of training activities and how often they attended these events, it will be easier to design training events both formal and informal to meet their needs.

The effectiveness of these training events for capacity building is the next phase of my research. The change in knowledge levels of growers and agronomists attending training activities is investigated and how they are going to use this new knowledge.
Chapter 7. Does attending training events build the knowledge capacity of participants in the grains industry?
Scene Setting

In the previous chapter (Chapter 6), I discussed surveys conducted with growers and agronomists in the Australian grains industry to determine which training events they liked to attend, what they liked about the training events and what could be improved.

In this chapter, I discuss my evaluation of two types of training events: workshops (preferred by agronomists) and (field days preferred growers). The aim of the evaluation was to determine if knowledge levels increased when participants attended these training events, and how they intended to use this new knowledge.

I attended workshops and field days in Australia and the USA. The purpose of attending events in the USA was to examine if the formats of these training events were different to those in Australia and to determine if there was a difference in change in knowledge levels due to the different formats. The typology suggested by Creswell (2009) that diverse, most similar and most different can be used for case studies is appropriate for this work. The two countries share a culture of farming, the participants are generally living and working in a rural community and the grains industries are made up of agronomists and growers. As these factors are almost the same I can then determine if the format of the field days and workshops influence the outcome on knowledge levels (Creswell & Miller, 2000; Patton, 2002). However, the decision was also based on access and availability to attend particular field days and workshops (Corbin & Strauss, 1990).

To do this, I used open-ended questions in the questionnaires and in the interviews to allow triangulation of the data. Triangulation increases validity because multiple forms of evidence are used rather than a single incident or data point in the research (Creswell & Miller, 2000). The use of rich thick descriptions is also another valid method (Creswell & Miller, 2000), as it enables the reader to be transported into the setting. Below I have provided descriptions of the events that I attended and some of my observations.

Workshops

I attended five workshops in the evaluation phase of this research.

Fertcare® Training in Australia

Fertcare® is a joint venture with the Australian Fertilizer Services Association (Fertilizer Australia, 2016). Fertcare® was developed to improve the skills and knowledge of those working in the fertiliser and soil ameliorant industry. The aim of the training is to ensure
that high quality advice is provided to growers that allows them to simultaneously optimise productivity and minimise environmental risks (Fertilizer Australia, 2016). Training participants are trained and are assessed against the standards set by the Australasian Soil and Plant Analysis Council (ASPAC). Once assessed as competent, the participants are assessed biannually to ensure that these standards are being routinely applied (Fertilizer Australia, 2016). The training has been assessed and meets the standards required under the National Qualifications Framework in Australia. It is administered through Bendigo TAFE (Technical and Further Education) and the courses are aimed at three different levels, from the practical information needed by a fertiliser depot manager to the complexity needed by agronomists.

As an observer, as both an onlooker and as a participant, I attended three workshops, covering all three levels, held by the Back Paddock Company in Ballarat, a country town in Victoria, Australia. The three courses were held one after another in a seminar room at an hotel. Level A and Level B workshops lasted one day, separated by the two-day workshop at Level C. The room was set up as a classroom, with desks in rows and the Facilitator at the front, giving PowerPoint™ presentations. The number of participants in each course varied from three to ten; Level A had ten participants, Level B had three participants and Level C had ten participants. The participants came from companies that supplied advice to growers or from companies that sold fertiliser or soil ameliorants. Each day was based on a workbook that participants received and completed before the course. There were lectures, practical exercises outside, role-playing and a lot of worksheets filled with calculations.

**Community Gardens workshop, Kansas University, Kansas**

This training event was a cross between a workshop and a mini-conference. The event lasted 1½ days, starting after lunch on the first day. A series of talks was given as concurrent sessions on the first afternoon, in lecture theatres or seminar rooms at Kansas University (KSU). A wide range of participants, with a broad range of experience attended, with the majority coming from different communities in the wider Kansas State area. These participants belonged to, or had just started, a community project designing, building or improving community gardens. The majority (75%) of participants were women. On the second day, the morning was spent visiting a very large community garden in Kansas City, and then travelling to another new garden, where participants could attend classes on setting up and choosing the correct irrigation system for their gardens, and the use and maintenance of rotary hoes and other mechanical equipment for the garden.
Growing Growers workshop, Kansas
This was a small workshop with approximately 25-30 participants from very diverse backgrounds. This scheme is similar to an apprenticeship; participants spend a year working on a horticultural farm learning to grow fruit and vegetables, with the view that they will one day own or manage their own farm. During the year, they attend workshops on different aspects of production. This particular day was about the control of diseases and pests in horticultural crops. The morning was spent in lectures and the afternoon was a field trip to an organic vegetable farm, whose owner had been through this program approximately 5-6 years earlier and had the opportunity to buy some land with the person he had learned farming from.

Field days
Western Australian field days
I attended three field days in different rainfall zones of the Western Australian wheatbelt. The Western Australian wheatbelt covers approximately 154,862 square kilometres in the southwest of Western Australia (Department of Regional Development, 2016).

A) Esperance is on the Southern Ocean coastline, approximately 720 km east-southeast of the state capital, Perth. It has a high rainfall of more than 600 mm annually. The day focuses on soil issues, varieties for the region, and disease control options in crops. More than 100 participants attend these days.

B) Buntine is a long-term trial site that is used by the Liebe Growers Group with other partners such as the Department of Agriculture and Food, Western Australia. It is located approximately 300 km north-northeast of Perth. This area of the wheatbelt tends to have a much lower rainfall (<350 mm annually) than other areas. More than 100 participants attend these days.

C) Dandaragan is located approximately 200 km north of Perth. This shire is diverse with coastal areas and then National parks further inland. The coastal area has an annual rainfall of 600 mm whilst further inland that rainfall is 350 mm annually. This makes the area ideal for mixed cropping including beef cattle and grains (<350 mm annually) than other areas. More than 100 participants attend these days.
Washington State field days
These field days appeared to be similar to those held in Western Australia. The agriculture is similar, in that it is dry land farming, with no irrigation used to grow the grain crops. The number of participants at these days ranged from 50 to more than 100 with growers, agronomists, retail personnel, and researchers attending.

At most of these field days, the different stations (displays) were set up over large areas. Using buses, trucks and tractors with grandstand seating on a trailer, people were moved around to the different stations. It was interesting to be an observer at these field days; there was a wide variety of people present and in some cases it seemed as though small communities had come as a group to attend.

Kansas State field days
This field day at Kansas State University was very different to all the other field days I attended. It was two days long, and participants attended both days, to be able to see all of the different stations. Numbers were restricted to 100 participants, mainly agronomists, sales representatives, researchers and students; I did not meet any farmers at this event. Three groups followed a particular pattern for seeing the different stations. Because the event is so popular, it is repeated within the week, meaning 200 people attended this event. The event is very popular with agronomists because it allows them collect continuing education credits.
7.1 Introduction

In Australia, extension is about capacity building and community engagement (Coutts & Roberts, 2011). This paradigm has been operating since the early 2000’s and relies on interaction between five models; a) facilitation and empowerment, b) technological development, c) information access, d) training and e) consultant. These models can work alone, but are not effective for capacity building to occur unless they are linked together (Coutts & Roberts, 2011).

Extension in the rural community provides training events that enable change in individuals, communities and industries (Feder, Birner, & Anderson, 2011; Vanclay & Leach, 2011). In Australia Vanclay and Leach (2011) feel that extension is only related to the primary industry sector, and yet in the USA, the University land-grant system extension covers so much more. It involves nutrition, education, youth programs and is not only used in rural communities but also in cities, for example nutrition programs and community gardens and master gardener programs. These programs have a training component, using workshops, webinars, seminars, and field trips to supplement the printed material that is developed by the Universities.

When designing an extension activity or program, one of the main criteria to consider is the level of change that is expected. There are four main levels of change; i) change of awareness, ii) generic change in knowledge, understanding and skills, iii) change in practice or behaviour and iv) improved environmental, economic and social conditions (Crisp, 2010). Other elements that need to be considered include the target audience, the scale and complexity of the change, the adoptability of the technologies and the potential of the project to affect change (Crisp, 2010; Primary Industries Standing Committee, 2011).

The evaluation of extension is complex and there are multiple different evaluation models. Not one evaluation model fits all extension activities. In Australia three main frameworks are used: i) Bennett's hierarchy, ii) Wisemann’s six steps and iii) the MERI (Monitoring, Evaluation, Reporting and Improving) framework (Crisp, 2010; Keogh & Julian, 2014b; Roberts & Coutts, 2011). Evaluation can measure various parameters: the extent to which a program meets its goals, the content design, changes in participants (Llewellyn et al., 2006; Roberts & Coutts, 2011) or learning outcomes (Alvarez et al., 2004).

Evaluation can be both summative and/or formative. Summative is completed at the end of the project / program and provides evidence of validity. Validity is about if program outcomes have been met and to what extent these outcomes have been met
Chapter 7. Evaluation of training events

(Print, 1993; Roberts & Coutts, 2011). Formative evaluation examines how the project / program could be improved and is done during the learning process, and can also be used to assess the learners' performance (Fulton et al., 2003; Print, 1993; Roberts & Coutts, 2011).

How should the extension activity be evaluated? Kirkpatrick’s principles for evaluation of training are widely used in workplace-based training but can be used elsewhere. However, because the model is very simple, it can lead to over-generalisation (Alliger & Janak, 1989).

Most evaluation models are modifications of Kirkpatrick’s with some alterations (Alvarez et al., 2004; Holton, 1996). Kirkpatrick’s (1970) model has four levels:

a) Level 1 – Reaction. Did the participants like the program?

b) Level 2 – Learning. What principles, facts and techniques did the participants learn?

c) Level 3 Behaviour. What changes in job behaviour resulted from the program?

d) Level 4 – Results. What were the tangible outcomes of the program (Alliger & Janak, 1989; Kirkpatrick, 1970, 1979)?

Alvarez et al. (2004) suggest 'effectiveness' as another method for evaluating training programmes. Measuring effectiveness includes examining the variables that influence the outcomes at different stages of the program, such as before, during and after. These variables will increase or decrease the success of the training (Alvarez et al., 2004). Salas and Cannon-Bowers (2001) discuss that Haccoun and Hamtiaux (1994) suggest that a simple procedure for measuring training effectiveness is to assess the knowledge levels of participants before and after (the ‘internal reference’ strategy). This is based on the assumption that training with relevant content should show more change than training with irrelevant content (Salas & Cannon-Bowers, 2001). In some cases behavioural change is also monitored as a measure of effectiveness (Keogh & Julian, 2014b; Llewellyn et al., 2006; P. Murray, 2000).

The internal reference strategy is commonly used (Maredia, 2009) in the extension industry to assess the effectiveness of extension strategies such as farmer field schools, the use of farmer teachers and other activities. A considerable body of literature discusses the successes or failures of such extension strategies (Amudavi et al., 2009; van de Berg & Jiggins, 2007; Yang et al., 2008) in developing countries but there is very little literature discussing the use of these approaches in the grains industry of developed countries. Glaze and Ahola (2010)) monitored the change in
knowledge levels of participants in a training program by asking them to self-evaluate their knowledge level before and after the training, using a Likert Scale (Likert, 1932).

Extension services in Australia and the USA are vastly different. In Australia extension is generally provided by private consultant firms and in the USA extension services are public organisations at a regional and national level, that are generally publicly-funded (Keogh & Julian, 2014b). The USA land grant system has been operating since 1914 (Franz & Townson, 2008; Keogh & Julian, 2014b; Roush, 2014). Extension in Australia has undergone many changes since the 1990s when it was privatised (Coutts & Roberts, 2011; Keogh & Julian, 2014b; Marsh & Pannell, 2000). Both countries have a large grains industry and links between the two countries are very strong in terms of plant disease research in both horticultural and agricultural practices (CRC, 2017). The typology suggested by (Creswell, 2009) that diverse, most similar and most different can be used for case studies is appropriate for this work. The two countries share a culture of farming, the participants are generally living and working in a rural community and the grains industries are made up of agronomists and growers. However, in the USA agronomists are certified and earn continuing education units (CEUs) from attending these training events (CCA, 2016) where in Australia agronomists are not certified.

What was not clear from the literature was if the field days in both countries use a similar format or are vastly different. This purpose of this chapter was to determine if participants’ knowledge level changed when attending field days and workshops and if the format of the workshops and field days influenced that change.

### 7.2 Materials and methods

In May 2014, I attended 3 workshops held by the Back Paddock Company in Ballarat, a country town in Victoria, Australia. In these courses I was a participant observer (Creswell, 2009, 2012; Patton, 2002); I was partly engaged in the course (I followed the lectures and participated in the written exercises) whilst observing the class and the interactions that occurred during the day.

In June and July 2014, I visited Washington State University (WSU) and Kansas State University (KSU) to examine how the land grant universities in the United States of America held field days and other extension activities that engaged rural communities. At each of these field days and workshops I was a participant observer. At WSU, I attended six field days that engaged between 50 and more than 150 people. One of
these field days was held in Idaho, which is 7 miles from Pullman in Washington State, USA. At KSU I attended two workshops that engaged 30 to 50 people, and one field day. This field day was very large and had a program that covered two days. The program was then repeated. Approximately 100 people attended each day. See Table 7.1

In September 2014, I attended three local field days in Western Australia. These were the Esperance Downs Research Station (EDRS), the Liebe Group Field Day and West Midlands field day. These field days are very popular with growers and agronomists in those regions and more than a hundred people attended each event. See Table 7.2.
Table 7.1. Description of field days attended in the USA in June and July 2014.

<table>
<thead>
<tr>
<th>Location</th>
<th>Event name</th>
<th>Type of event</th>
<th>Where</th>
<th>Length of event</th>
<th>General information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington State, USA</td>
<td>Lind Dryland Research Station</td>
<td>Field day</td>
<td>Lind, Washington State</td>
<td>1 day</td>
<td>This research station is part of WSU. Its research priorities are: wheat breeding, wheat emergence, alternative crops, weed and disease control, soil fertility, erosion control and residue management. It lies in the 8 – 12 inches (low) annual rainfall zone of eastern Washington. It has been in operation for a hundred years and is funded by public donations. The field day is used to show the results from the above research priorities. Over 100 people attend this event annually. <a href="http://lindstation.wsu.edu">http://lindstation.wsu.edu</a></td>
</tr>
<tr>
<td>Washington State, USA</td>
<td>Spillman Agronomy Farm</td>
<td>Field day</td>
<td>Pullman, Washington State</td>
<td>1 day</td>
<td>This farm has a strong tradition in wheat, barley and legume breeding programs. Currently breeders are developing cropping systems that include organic, perennial and biotechnology components in their breeding programs. The field day here had a diagnostic focus for growers and agronomists, including pest, diseases and weeds in crops. Approximately 50-80 people attended the event. <a href="http://css.wsu.edu/facilities/spillman/history">http://css.wsu.edu/facilities/spillman/history</a></td>
</tr>
<tr>
<td>Location</td>
<td>Event name</td>
<td>Type of event</td>
<td>Where</td>
<td>Length of event</td>
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<tr>
<td>Washington State, USA</td>
<td>Cooke Farm</td>
<td>Field day</td>
<td>Washington State</td>
<td>Half a day</td>
<td>Research priorities are based on the development of direct seed cropping systems and precision agriculture for a typical eastern Palouse landscape. This includes reducing risks, increasing profits, and conserving soil and other natural resources in a high rainfall area. The farm maintains a database of historic crop yields and quality attributes, pest pressure and soil characteristics in relation to precision agriculture. The field day focuses on showing the results from the research conducted. 50 people attended the day. <a href="http://css.wsu.edu/facilities/cook/">http://css.wsu.edu/facilities/cook/</a></td>
</tr>
<tr>
<td>Washington State USA</td>
<td>Wilke Research and Extension farm</td>
<td>Field day</td>
<td>Davenport, Washington State</td>
<td>1 day</td>
<td>This farm is in the 12–17 inches rainfall zone (intermediate) of eastern Washington. Its main research priorities are centered on the need to develop cropping systems that are economically and environmentally sustainable. The focus was on systems that reduced soil erosion by wind and water, improved the efficiency and net return of farming operations, enhanced soil quality, reduced stubble burning, and reduced agrochemical and fossil fuel use. The farm is split into two by a highway. The north side has had continuous winter or spring cereal production for more than 13 years in a no-till system. The south side has seven sections that focus on either three- or four-year rotations, which include a chemical fallow and a spring crop such as canola, peas, safflower, sunflower, yellow mustard and proso millet. Approximately 80 people attended this day. <a href="http://wilkefarm.wsu.edu/aboutus.html">http://wilkefarm.wsu.edu/aboutus.html</a></td>
</tr>
</tbody>
</table>

Continued next page
<table>
<thead>
<tr>
<th>Location</th>
<th>Event name</th>
<th>Type of event</th>
<th>Where</th>
<th>Length of event</th>
<th>General information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington State, USA</td>
<td>McGregor's Field Day</td>
<td>Field Day</td>
<td>Washington State</td>
<td>1 day</td>
<td>This is a private company, and part of the McGregor’s Research and Technology Division. This company is an independent fertilizer, agri-chemical and equipment dealer in the Pacific Northwest. They provide consultants to help with agronomy issues such as crop scouting. The research and technology division works closely with WSU, University of Idaho and Oregan State University researchers on weed and pest control, variety trials etc. 60 people attended this event. <a href="http://www.mcgregor.com/home/research-and-technology/">http://www.mcgregor.com/home/research-and-technology/</a></td>
</tr>
<tr>
<td>Kansas State, USA</td>
<td>KARA and KSU</td>
<td>Field day</td>
<td>North Agronomy farm at KSU</td>
<td>2-days and is repeated within the same week</td>
<td>Approximately 100 people attend each day, and the group is split into 3 groups that rotate through the program. Mainly agronomists as they register for the CCA credits <a href="http://www.kansasagland.com/calendar/kara-s-ksu-field-day-will-be-held-july/event_528b0866-445f-11e6-979a-f7b4107dcf80.html">http://www.kansasagland.com/calendar/kara-s-ksu-field-day-will-be-held-july/event_528b0866-445f-11e6-979a-f7b4107dcf80.html</a></td>
</tr>
<tr>
<td>Idaho, USA</td>
<td>Idaho Weeds Tour</td>
<td>Field day</td>
<td>Moscow, Idaho</td>
<td>1 day</td>
<td>This field day is run by the College of Agricultural and life sciences Department of the University of Idaho. They have a research division (Idaho Agricultural Experiment Station (IAES) that operates nine agricultural research and extension centers across the state. The tour consisted of various stops before visiting Parker Farm, two miles east of Moscow, Idaho to see herbicide trials. 50 people attended this day. <a href="http://www.uidaho.edu/cals/idaho-agricultural-experiment-station">http://www.uidaho.edu/cals/idaho-agricultural-experiment-station</a></td>
</tr>
<tr>
<td>Location</td>
<td>Event name</td>
<td>Type of event</td>
<td>Where</td>
<td>Length of event</td>
<td>General information</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------</td>
<td>---------------</td>
<td>--------------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Kansas State, USA</td>
<td>Growing Growers</td>
<td>Workshop</td>
<td>County Office within Kansas State</td>
<td>1 day event</td>
<td>Offers learning opportunities in sustainable farming. It is an apprenticeship program that also includes annual workshops. The series comprises five core workshops on the basics of farming and nine advanced workshops on more specific topics. It is a collaborative effort of K-State Research and Extension, University of Missouri Extension, Lincoln University Cooperative extension, Kansas City Food Circle, Cultivate KC and Kansas Rural Center <a href="http://www.growinggrowers.org/workshops.html">http://www.growinggrowers.org/workshops.html</a></td>
</tr>
<tr>
<td>Kansas State, USA</td>
<td>Community Gardens</td>
<td>Workshop</td>
<td>Kansas State University</td>
<td>2 day event</td>
<td>Provides several 'workshop'-like activities, involving a small group of 50 people. This group is committed to supporting community and home gardens. It was set up under a grant program that has now finished but maintains an active website. <a href="http://www.kansascommunitygardens.org">http://www.kansascommunitygardens.org</a></td>
</tr>
</tbody>
</table>
### Table 7.2. Description of field days attended in Western Australia in September 2014.

<table>
<thead>
<tr>
<th>Location</th>
<th>Event name</th>
<th>Type of event</th>
<th>Where</th>
<th>Length of event</th>
<th>General information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Australia</td>
<td>Esperance Downs Research Station</td>
<td>Field day</td>
<td>Esperance, Western Australia</td>
<td>1 day</td>
<td>EDRS is within the Esperance Port Zone and is the main field day for this region. It is held in conjunction with the South East Premium Growers Association (SEPWA) and the Department of Agriculture and Food, WA (DAFWA). The day focuses on soil issues, varieties for the region, and disease control options in crops. This research station is in the high rainfall zone of Western Australia.</td>
</tr>
<tr>
<td>Western Australia</td>
<td>Liebe Field Day</td>
<td>Field day</td>
<td>Buntine, Western Australia</td>
<td>1 day</td>
<td>The grower group Liebe runs the Liebe Group Field day. It has a membership of 120 farm businesses and the group is expanding throughout the north-eastern wheatbelt of Western Australia. This region does not have a high rainfall. Liebe has a long-term trial site and is very active in its community and employs a full-time research and development coordinator. The area covers the low to medium rainfall zone.</td>
</tr>
<tr>
<td>Western Australia</td>
<td>West Midlands Field Day</td>
<td>Field Day</td>
<td>Moora, Western Australia</td>
<td>1 day</td>
<td>The West Midlands grower group runs the West Midlands Field day. This group complements the Liebe grower group, covering in the north-western part of the wheatbelt, where there is higher rainfall and a more mixed cropping system.</td>
</tr>
</tbody>
</table>
7.2.1 Data collection

At training events I attended, I selected potential interview participants at random. If they agreed, I conducted a short semi-structured interview. With the agreement of the field day manager, I also handed out a one-page questionnaire to participants (See Chapter 3, Methodology). Table 7.3 shows how many people were interviewed at each event and how many completed the questionnaire.

The interviews were semi-structured, and designed to be very casual and chatty so that participants did not feel threatened and were happy to answer the questions. The questions were designed to complement the questionnaire. Participants were asked; i) what they hoped to learn, ii) what was the most useful, iii) what was the least useful and iv) what was the most engaging and how would they use the information learned. Interview participants were asked to sign a consent form (Appendix D) and were told that they would remain anonymous.

The one-page questionnaire was designed to examine the knowledge levels (Appendix F) of participants before and after the training events. Participants were asked to self-rate their knowledge a) before and b) after the event (using a Likert scale of 1-5), c) if they were satisfied with the learning (1-5) and d) how they planned to use their new knowledge (an open answer question). Demographic information such as occupation, length of time working and what crops they grew were also collected.

7.2.2 Data analysis

Interview data

After interviewing the participants, the interviews were transcribed verbatim. The interview transcriptions were then analysed using NVivo 11 for Mac (NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 11, 2016) and grouped into categories based on the training event that participants attended. I then carried out thematic coding, using a combination of templates codes (based on the questions asked in the interview) and an inductive approach (Fereday and Muir-Cochrane 2006). A colleague completed a cross-coding check on six interviews, using the coding template; a match of 82% was achieved.

In the following section data from the interviews are identified thus: the first two letters refer to the training event. The letter G represents a grower; the letter A represents an agronomist. The number at the end refers to the interview number for that event.
### Table 7.3. Training event and location held with the number of participants interviewed and the number of responses collected from the questionnaires at these events. KSU - Kansas State University, WSU - Washington State University, WA - Western Australia

<table>
<thead>
<tr>
<th>Topic</th>
<th>Type of training event</th>
<th>Location</th>
<th>Number attendees</th>
<th>Number interviewed</th>
<th>Number of questionnaires handed out</th>
<th>Number of questionnaire responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back Paddock</td>
<td>Workshops (2 x 1-day and 1 x 2-day)</td>
<td>Victoria (Australia)</td>
<td>22</td>
<td>8</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Idaho weeds tour</td>
<td>Field day</td>
<td>Idaho State, USA</td>
<td>50</td>
<td>3</td>
<td>50</td>
<td>39</td>
</tr>
<tr>
<td>Spillman Farm</td>
<td>Field day</td>
<td>WSU USA</td>
<td>80</td>
<td>0</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Wilke Farm</td>
<td>Field day</td>
<td>WSU USA</td>
<td>80</td>
<td>0</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>WSU weeds day</td>
<td>Field day</td>
<td>WSU, USA</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>Lind Field day</td>
<td>Field Day</td>
<td>WSU USA</td>
<td>100</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MacGregors Field Day</td>
<td>Field Day</td>
<td>WSU USA</td>
<td>60</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Community Gardens</td>
<td>Workshop</td>
<td>KSU USA</td>
<td>50</td>
<td>2</td>
<td>50</td>
<td>39</td>
</tr>
<tr>
<td>Growing Growers</td>
<td>Workshop</td>
<td>KSU USA</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Kara KSU</td>
<td>Field Day</td>
<td>KSU USA</td>
<td>200</td>
<td>2</td>
<td>200</td>
<td>112</td>
</tr>
<tr>
<td>EDRS</td>
<td>Field day</td>
<td>WA</td>
<td>100</td>
<td>4</td>
<td>100</td>
<td>74</td>
</tr>
</tbody>
</table>

Continued next page
<table>
<thead>
<tr>
<th>Topic</th>
<th>Type of training event</th>
<th>Location</th>
<th>Number attendees</th>
<th>Number interviewed</th>
<th>Number of questionnaires handed out</th>
<th>Number of questionnaire responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Midlands field day</td>
<td>Field day</td>
<td>WA</td>
<td>100</td>
<td>4</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Liebe field day</td>
<td>Field day</td>
<td>WA</td>
<td>100</td>
<td>4</td>
<td>50</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>922</strong></td>
<td><strong>30</strong></td>
<td><strong>582</strong></td>
<td><strong>361</strong></td>
</tr>
</tbody>
</table>
Questionnaire data

The data collected from the knowledge level questionnaire handed out at the field days were analysed using SPSS (IBM ver 23). The data were split into groups based on whether they came from workshops or field days and which state and country they were held in. A Wilcoxon Signed Rank test was used to compare participants’ knowledge levels before and after the training event. A Kruskal-Wallace test was used to examine the influence of occupations and length of working on knowledge levels before and after the training event and on the amount of learning participants felt they received from the training event. If the result from the Kruskal-Wallace test was significant, a means test was conducted to determine the median levels of each category. This was followed up with a Mann-Whitney U-test to determine if there were any significant differences between the categories. A Bonferonni adjustment was done on each Mann-Whitney U-test to reduce the type 1 errors.

7.3 Results

In this section, I present a combination of qualitative and quantitative data. The qualitative data were collected from the interviews, and the short answer questions from the questionnaire used at the field days. The data are presented as themes that emerged from the thematic coding.

7.3.1 Field days

In both field days in Australia and the USA I observed that:

1. There were some participants that formed groups and tended to stand to one side, only interacting amongst themselves or with speakers after the talks had been given. There was no interaction with other participants.

2. At some of the stations, the speakers did not have a microphone, or a loud voice, therefore only those who were standing directly in front of the speaker were able to hear what was being said. In these situations, towards the back of the main group there were many small groups of people speaking to each other rather than listening.

3. Other speakers were able to catch the attention of the participants by using props, having a loud voice, or being enthusiastic about what they were showing and talking about.
7.3.2 Reasons for attending field days

People came to training events for a variety of reasons, ranging from compulsory (work related or told to attend), wanting a better and deeper understanding on a range of subjects, to networking with other growers, colleagues and specialists, as well as gaining knowledge. For example:

*We’re new to the area yeah we wanted to know a bit more about agriculture in the least high rainfall areas.* WAG6

In some cases, people attended to see if there was any new knowledge available and to “brush up” their skills. This was a common theme from agronomists in the USA who are required to attend events for their continuing education credits.

*I represent the USA dry legume council so I represent pulse crops in the United States we have some trials that we sponsor so I wanted to see what was up and I’m a farmer so I needed to see what other products are available for wheat and peas.* IWDR1

*But it’s always interesting to hear what some of the folks have to say that aren’t always necessarily at all the other field days.* WSU6

*Absolutely, large knowledge of disease and identification to better serve customers* WSCA1

Others wanted confirmation, that the farming practices they were using were correct.

*Absolutely, we’re doing it all now but just wanted confirmation what we’re doing is the right thing.* WAG5

*Honestly in my job I’m not as familiar with the use of pesticides in wheat. That was pretty useful but of course, because I represent eastern farmers the tolerance trials were pretty important and we have to troubles with carry over so you know it’s good for me to see what else is going on so I can understand what the growers tell me when they tell me their problems.* IDW2

The reasons for attending field days were very similar for field days in both Western Australia and the USA despite the differences in the format of the training event.
7.3.2 Knowledge levels at field days

Definitely, I am a crop advisor for Wilburn-Ellis and will use everything I learned in that field. WSAA8

Western Australian field days

I conducted 12 interviews and collected 114 questionnaires at the three Western Australian field days. The majority of participants were farmers (62%), and agronomists (13%). The rest of the participants were: a) Other (11%); b) Government (8%); c) Sales representatives (4%); and d) University staff or students (2%). The length of working life of participants ranged from less than one year to more than 31 years.

Generally, participants showed a significant increase in knowledge levels after participating in the field days \( z = -7.64 \ p \leq 0 \), with a large effect size (0.40). The 25th percentile of participants’ knowledge level increased from ‘some knowledge’ \( Md = 2 \) to ‘moderate knowledge’ \( Md = 3 \) after the field days. The 50th and 75th percentiles stayed the same, at a moderate level and a considerable level respectively (Figure 7.1).

Participants’ occupation significantly influenced (determined using a Kruskal-Wallis test) knowledge levels before and after the field days (knowledge levels before \( X^2 (n=116), 5 = 15.80 \ p \leq 0.05 \), knowledge levels after \( X^2 (n=116), 5 = 14.21 \ p \leq 0.05 \)).

University participants (mainly students) ranked themselves lowest in knowledge levels before the field day; their median knowledge level was 1.5 (a little knowledge) compared to all other occupations, which had a median knowledge level of 2 (some knowledge). However, a Mann-Whitney U test conducted on these data showed that the difference between university participants and other occupations was not significant \( (p > 0.01 \text{ with the Bonferroni adjustment=0.01}) \).

Government participants ranked the lowest for knowledge levels after the field day; their median score was the same as those who identified as farmers \( Md = 2 \), moderate level). Agronomists and sales representatives had a median knowledge level of 3 (considerable). Agronomists had a significantly higher median score than government participants. However, using the Mann-Whitney U-test there were no significant differences between scores of government participants and other occupations \( (U = 27.5, z = -3.04, p = 0.007, \text{ Bonferroni adjustment = 0.01}) \).
Figure 7.1. The knowledge levels of participants before and after the training events (field days and workshops) held in different locations. Each box corresponds to the 25th and 75th percentile of scores (1-5) while the bar within the box represents the median (50th percentile score). Whiskers on each box indicate the range of scores (1.5* inter-quartile range). Outliers are denoted by circles.
The length of time working had a significant influence on knowledge levels before the field days, Kruskal-Wallis test ($X^2 (n=110), 4 = 11.06 \ p \leq 0.05$). Participants who had worked for 11 to 20 years had a higher mean rank than the other participants, however, the Mann Whitney U test conducted showed that there were no significant differences ($p > 0.012$, Bonferroni adjustment=0.01) between the group with 11-20 years of working and the other groups.

**Washington State, USA**

I attended four individual field days and collected 103 questionnaires. The majority of participants were growers (50%), and agronomists (44%). A smaller group of participants were from the University (5%) and in sales (1%). The number of years participants had worked ranged from one year to more than 31 years.

Participants identified a significant increase in knowledge levels after participating in the field days compared to before participating, $z = -6.38 \ p \leq 0$, with a large effect size (0.45). The 25th percentile of participants’ knowledge level increased from some knowledge level ($Md = 2$) to a moderate knowledge level ($Md = 3$) after the field days. The 50th and 75th percentiles stayed the same, at a moderate level ($Md = 3$) and a considerable level ($Md = 4$) respectively (Figure 7.1).

A Kruskal-Wallice test showed no significant difference between participants’ occupation and their knowledge levels before and after the field day and there was no difference on how much they felt they learned. There was no influence ($p > 0.05$) from the number of years worked and knowledge levels before and after the field days, or the amount that they learned.

**Kansas State, USA**

Kansas State University holds a field day “Kara field day” that runs for two days. Participants were placed in two groups that rotated throughout the two days. A total of 112 surveys were collected over these two days. There were two main occupations of the participants, “Other” category (34%), and agronomists (32%). The rest of the participants were from the University (14%), farmers (12%) and some in sales (8%). The number of years participants had worked ranged from less than 1 year to more than 31 years. Participants identified a significant increase in knowledge levels after participating in the field days compared to before participating, $z = -7.17 \ p \leq 0$, with a large effect size (0.48). The 75th percentile of participants’ knowledge level increased from moderate level knowledge ($Md = 3$) to considerable level ($Md = 4$) after the field days (Figure 7.1).
Occupation had no influence on the knowledge levels before or after the field days, and no influence on the amount learnt at the field days. However, the length of time working influenced the amount of learning at the field days $X^2 (n= 104), 4 = 11.44, p \leq 0.05)$. The group of participants who worked from 1-10 years had a lower median score of 2 (some learning) compared to all the other groups that had a median score of 3 (full level of learning). This group 2 (1-10 years) was significantly different in its score from group 3 (11-20 years) (Mann-Whitney U test, $U = 450, z = -2.84, p = 0.004, r = 0$, Bonferroni adjustment = 0.013).

Participants at the field days thought that they had increased their knowledge and could use this knowledge to improve how they grew their crops, and how to solve problems such as controlling weeds and pests in crops:

### 7.3.3 Workshops

I attended three workshops in Australia. The Fertcare® workshop was made up of three courses were held in Victoria, in May 2014. Participants in the course were either in sales (63%) or were agronomists (37%). I conducted eight interviews and collected 22 questionnaires.

I observed that most of the participants were engaged with the facilitator and the course material. The facilitator was very professional, and was very keen to see the participants understand and complete their workbooks.

The majority of participants came to this course because it was compulsory for them to attend. For example:

> Probably actually my branch manager that thought it was a good idea for me to come. And then obviously when he explained what it was I thought it was a good idea as well. Just basically to broaden my knowledge on the whole fertiliser soil aspect of the job which I am currently working in. BPC3

Participants hoped for a range of outcomes, from broadening knowledge to achieving accreditation, to learning new ideas and techniques:

> I hoped to learn about soil science but also to gain the accreditation of being Fert. Care accredited. BP7

> I wanted to come away with a lot more understanding of fertilisers, soil testing, and all that sort of thing which I think I have a good base knowledge now. I
need to go away and put a little bit more of that into practice, working with James the economist at work. BP9

Participants had a significant increase in knowledge levels after participating in the workshops compared to before participating, \( z = -2.22 \ p \leq 0.05 \), with a medium effect size (0.34). The 50th percentile of participants’ knowledge level increased from a moderate knowledge level \( (Md = 3) \) to considerable knowledge level \( (Md = 4) \) after the workshops (Figure 7.1)

A Kruskal- Wallice test showed that there was no significant difference \( (p > 0.05) \) between participants’ occupations and their knowledge levels before, and after the workshop.

Participants said the most engaging sessions were those that broadened their outlook or those that were ‘hands on’:

*It was probably the role playing, it was probably the most engaging although the going out and doing the soil samples was engaging, that was probably the most engaging, doing the soil sample out in the park. BPC1*

Participants’ valued activities that were practical or related directly to their work:

*The practical session was I think, yeah definitely. Doing the soil test, even doing the role play I quite enjoyed, I thought that was going to be hard but you actually got more out of it than I thought I was going to get. BPP2*

Participants also valued having a good speaker, with interaction between the presenters and the participants, whether through the use of props, the presenter asking participants questions, or an element of ‘hands on’ activity.

**Kansas State University workshops**

A total of 64 participants was surveyed at two workshops held with Kansas State University: the Community Gardens workshop and the Growing Growers workshops (Table 7.3). There was a wide range in the number of years participants had worked, from less than 1 year to more than 31 years. The majority (61%) of participants were classified as gardeners (from the community gardens workshop), 23% of participants were ‘other’ (which included apprentices), 11% were farmers, 1% sales and 3% from the university. Apprentices were required to attend the Growing Grower workshop as part of their apprenticeship agreement.
The Growing Grower workshop included lectures and then a visit to a farm. The farm showed some good examples; a) of how important it was to have good weed control; b) use rotations when growing vegetables crops; and c) what can happen if you expand too fast without good management guidelines in place. I observed, participants asking the grower lots of questions, which indicated their enthusiasm and interest. Others showed shock at the state of the equipment, and the large amount of weeds present in some areas of the farm.

At the Community Gardens workshop, participants were very enthusiastic about being there; many questions were asked during all sessions. During the practical time when visiting one of the community gardens, there was a man demonstrating the use of equipment. He was very good at engaging with the audience and answering questions. In the afternoon, a late lunch was combined with a feedback session and each community group talking about what they had achieved in the last 12 months and what they were hoping to achieve in the next 12 months.

Participants’ largely attended because they were committed to the cause:

*I recently got involved in our local community gardens. I like everything that they are doing. It’s a project that I would like to see grow and to continue to grow in the future.*

KSUCG1;

Some wanted to learn new ideas and techniques:

*Picking up new ideas, and different techniques. I think you can learn something everyday.*

KSUCG1.

Participants’ knowledge levels increased after participating in the workshops, $z = -6.44$, $p \leq 0$, with a large effect size (0.41). The 25th percentile level knowledge before the workshop increased from some knowledge ($Md = 2$) to moderate level ($Md = 3$) after the workshop. The 75th percentile increased from moderate level of knowledge ($Md = 3$) to considerable level of knowledge ($Md = 4$) (Figure 7.1).

The course that participants attended influenced their self-rated knowledge levels. The majority of the community garden participants felt that they had a high level of knowledge, while 53% of participants from the growing growers workshop felt that they had a moderate level of knowledge (Likelihood ratio: $X^2(n=64 (1) = 6.02 p < 0.05)$).

The amount of learning from the event was influenced by the workshop that participants attended; the majority (71%) from the community gardens workshop felt that they had fully learnt from the event and 67% from the growing growers felt that they had learnt a moderate amount (Likelihood ratio: $X^2(n=64 (1) = 7.9 p < 0.05)$).
Occupation and length of time working did not influence the participants’ knowledge level before, or after the event or on the amount that they felt that they had learnt during the event.

7.3.4 Using the information

Many of the participants said the information or new skill they learnt at these training events would be used every day at work, or applied on their farm. Some felt that they had become more aware of issues or had a greater understanding of issues faced by their clients:

- Definitely, most certainly. Hopefully it will make it a bit more useful for the farmer, hopefully he will get more useful information out of me rather than just hand ball it over to somebody else that deals with it. BPA2
- I mean, I take a look at whatever is applicable, take it right back to the farm, all the way from the different varieties and how they perform and the quality information that they come up to the different things that are going on. WSUG1
- I’m going to be a guinea pig and I’m going to go out and use some of this fall, use it in crop as well as in pasture because I run cattle as well. WSUG1

Participants at the Back Paddock Workshops said they would use their new knowledge to make better recommendations to their clients:

- Providing better recommendations, giving my clients more efficient ways of using fertilisers. BP2

Many consultants felt that the herbicide demonstrations at the field days in WS and KS allowed them to learn and use this information to make better recommendations to their customers:

- Yes! Good information /study on various grass herbicides, rates and timing, and control. Great comparisons. Will help me to make informed recommendations to growers! Thanks. WSC2
- The information I gathered today will be helpful in making informed decisions this fall. THANK YOU! KSG4

Both farmers and consultants learned from the disease identification parts of the field days and felt that it would be helpful in monitoring fields before harvest, allowing them to better serve their customers:
It is my job to take the information provided at field days like today and provide it to the general public. So the info gained today will go directly back to farmers of my county. KSBGR4

Yes, informative great for monitoring fields before harvest. Identify problems early to treat. No surprises later WSCG1

Participants indicated that they would take back the new knowledge and information and pass it on to their colleagues or to their community:

Going back and telling the other gardeners about what we learned at our meeting. KSWG14

In fact I thought to create a "Field Day" fact sheet to pass on to colleagues at work in Canberra. WAG1

Many of the responses implied that the knowledge would be passed on verbally, although WAG1 described creating a fact sheet.

Participants used the field days and workshops to consider new directions and make future plans based in the information that they learned:

Learning more about direct seeding and rotational cops as a possible new direction in my farming. WSBG1

Might try chickpeas again, more aware of wild dogs. WACG3

One participant mentioned in passing that the field days allowed him to think and question what he was doing currently and how that could be changed:

I mean, I take a look at whatever is applicable, take it right back to the farm, all the way from the different varieties and how they perform and the quality information that they come up to the different things that are going on. WSUG1

Field days were the only opportunity for this kind of reflection.

7.3.5 Getting information

Participants at the Western Australian field days mentioned that they liked to get information by attending field days, receiving crop updates, using their agronomist, from the Internet, reading and talking to leaders. These are analogous with the information groups (see Chapter 5) from which growers look for information to solve general and specific problems on their farm:
Talking to the main leaders in the industry, people doing the research - same as going to Crop Up days in Perth. We like to do that. That's the reason why you actually get to talk to the people who have done the work and ask them from your own point of view, you get the answer. WAG2

They're one of them. There are several different types around the countryside. [...] Well from a plan type aspect, I mean our own consultancy group we went to a field day there on Monday. We haven't been to the Liebe Group, those types of organisations always do good work. And of course from a machinery point of view you've got the Dowerin family field day, keep up to speed with anything that is happening in that area. WAG3

To see if there was any new information out there and to just brush up and make sure I was up to speed on where things are and how things work. KSUA3

Growers and agronomists seek information from different sources; sources of information are either community, technical or training based (see Chapter 5).

7.4 Discussion

The range of field days I attended were very varied in how they were run, where they were held, the local rainfall zones and the characteristics of the participants. Despite these differences, participants consider field days are an effective route for learning, providing opportunities for growers, agronomists and other people in rural communities to assess new technologies including varieties and equipment suitable for in their environments (Amudavi et al., 2009; Fulton et al., 2003; Schmitt, Durgan, & Iverson, 2000; Wortmann, Glewen, & Williams, 2011). Growers and agronomists value field days and workshops, for the opportunity for them interact with other growers, specialists and agronomists and for offering a space to to learn new information and therefore gain new knowledge that they can take back to the farm or workplace.

7.4.1 Knowledge levels

This is the first study to examine the knowledge levels of both growers and agronomists in Australia at both informal training events (field days) and formal events (workshops). In the capacity building model of Coutts and Roberts (2011) the training leg is very important for increasing skills and knowledge of participants within the
In my research, the closest fit to Coutts and Roberts’s (2011) training component description were the workshops. Although the workshops’ format and the participants’ characteristics of were very different in Australia and the USA, changes in knowledge levels were broadly similar, demonstrating that participants’ knowledge levels will increase if they attend a workshop regardless of the format used and why they attended. The Australian workshops were designed for agronomists and agribusiness personnel and had set curricula and set learning outcomes. The Growing Growers workshop in Kansas also had set curricula and learning outcomes however, the participants were apprentices, with no formal education qualifications. In both these workshops, it was compulsory for participants to attend. The Community Gardens workshop had no set learning objectives, although it could be argued that the format of the workshop, with a wide range of topics that participants could chose from, including both lectures and practical sessions, ensured that participants could set their own learning objectives.

In informal learning there is no set curricula or learning objectives (Malcolm et al., 2003; Marsick & Watkins, 2001; Merriam, 2001). Australian field days very much fit into the informal learning environment. However, the USA field days enable agronomists to claim continuing education units (CEUs) when attending which implies that there are learning objectives involved. The field days have to be registered with the ASA for CEUs to be registered (CCA, 2016). These field days would then fit into the definition of non-formal learning; has learning objectives and occurs outside the school system (Kyndt et al., 2009). However, there is no follow-up after the events to determine if the agronomists who attended the field days and obtained their CEUs have gained knowledge and how they intend to use this knowledge.

Despite the different formats between the field days in Australia and the USA, there was no difference between Australian and American participants’ changes in knowledge levels before and after the field days. The median level of knowledge remained the same at all the field days, while participants in the 25th percentile increased their knowledge.
Kilpatrick and Johns (2003) show that growers use a variety of informal learning to educate themselves and increase their capacity and skills. Informal learning includes interacting with other growers, participating in grower groups, observation and experience (Kilpatrick & Johns, 2003; Kilpatrick et al., 1999; Kilpatrick & Rosenblatt, 1998). Participants indicated that gaining knowledge from others (researchers, growers and colleagues) either by listening or from interactions was very important and one of the main reasons they came to field days. However, I must acknowledge that the questionnaire used to examine changes in knowledge levels did not ask directly by which route the respondent had learned new information, for example if the change in knowledge was due to listening to a speaker or from an interaction with another person.

Glaze and Ahola (2010) monitored the change in knowledge levels of participants in a training program by asking them to self-evaluate their knowledge levels before and after the training, using a Likert Scale. They then calculated the percentage of change in knowledge using straight maths equation. This unfortunately invalidates their results, as Likert scales are ordinal numbers; the intervals between the response categories are not equal, although there is a ranking between the response categories (Boone & Boone, 2012; Jamieson, 2004). Through the correct use of the non-parametric tests (Wilcoxon Signed Rank Test) (Field, 2013), I am able to demonstrate the change in knowledge levels of participants.

The occupations of participants in the field days held in Western Australia influenced their knowledge levels both before and after the training event. However, the occupation of participants attending the field days in the USA had no influence on their knowledge levels before and after the training event. These findings are quite different from those of Schmitt et al. (2000); Wortmann et al. (2011)) in their work with agronomists in the USA. The difference between Western Australia and the USA data is most likely due to the demographics of the participants that attended the training events. In Western Australia, a greater percentage of participants are growers and in the USA, the majority of participants are agronomists. Growers in Western Australia have a range of education levels ranging from secondary school only to tertiary education (see Chapters 4, 5 and 6) while in the USA, agronomists have to have a bachelor’s degree, five years’ experience and pass two exams (CCA, 2016) before they can be certified.

Participants’ education levels influenced their perception of their knowledge levels before a training event. Those with higher education levels (post secondary school) generally ranked themselves lower than those with secondary school education only,
although Western Australian university students ranked themselves at a lower level of knowledge than the other participants who were attending the field days. This research is analogous with the finding of Schmitt et al. (2000); participants’ education level influenced their perception of their knowledge before a training course; those with higher education levels generally self-ranked lower than those with lower education levels.

There are very few publications about the capacity building of agronomists in Australia, and no published evaluations of change of knowledge levels and how agronomists will use their new knowledge. This is the first study examining agronomists’ knowledge levels at formal workshops and field days in Australia. The research has shown that agronomists’ knowledge levels changed after attending training events such as field days and workshops. Agronomists indicate that they will use their new knowledge to help their clients and that they valued attending workshops. This also suggests although Australian agronomists are not certified and are not required to attend training events for CEUs that they are still very much interested in increasing their knowledge by attending training events.

7.4.2 Engagement and usefulness

Wortmann et al. (2011)) argued that the most effective learning methods were hands-on experience and talking to agricultural professionals, and the least effective were learning via the press and other media. I found an overlap between identification of events as ‘engaging’ and ‘useful’. I did not provide formal definitions of either, so this overlap is probably due to participants using personal definitions. Participants used ‘engaging’ and ‘useful’ to describe sessions that were practical, ‘hands on’, networking, interactive, broadening or awareness-increasing. The main difference was that most participants used usefulness to describe a topic they were interested in and engaging to describe the style of the presentation or activity. This correlates with the findings of Chapter 6, which showed that growers prefer field days because they are visual, hands-on and allow for informal interaction, and agronomists prefer field days and workshops because they can network with growers and specialists (Chapter 6). These descriptions could be taken into account in the design of future training events. Vanclay (2004)) commented that classroom-based training events for growers are not as effective in increasing knowledge as those that are field-based and offer hands-on experience. This was validated by the work of van de Berg and Jiggins (2007)) and
Yang et al. (2008)) which demonstrated that it is much harder to teach complex ideas such as integrated pest management in a classroom.

### 7.4.3 Using the information

All participants indicated that the knowledge learnt would benefit them in some way, whether on the farm or at work. Agronomists felt that they understood the problems that clients could be facing better and had more knowledge to offer solutions especially in relation to herbicide resistance issues. Many growers would use the new knowledge of varieties to improve their crop production, or the use of herbicides to control weeds.

Most of the existing literature, for example van de Berg and Jiggins (2007); Yang et al. (2008)) examine behaviour change in participants after they have attended a training event but there is an implicit assumption that behaviour change means knowledge has been learnt and then applied (Kilpatrick & Rosenblatt, 1998). However, behaviour change does not happen immediately. This research examined how participants intended to use the information learned but uncovering whether participants actually used their new knowledge would require longitudinal follow-up (Llewellyn et al., 2006; Roberts & Coutts, 2011).

### 7.4.4 Evaluation method

The evaluation of extension and training is complex and generally relies on whole-program evaluation (Crisp, 2010; Keogh & Julian, 2014b; Roberts & Coutts, 2011). The internal reference strategy of Haccoun and Hamiaux (1994)) which assesses knowledge levels before and after training, does not evaluate change in practice or behaviour after the training or assess improvements in environmental, economical and social conditions (Alliger & Janak, 1989; Bennett, 1975; Crisp, 2010; Fulton et al., 2003; Kirkpatrick, 1979). To uncover this would require follow-up interviews with participants some time after the workshops and field days to gather information on how they actually used their knowledge and the tangible results of doing so ((Kirkpatrick, 1970, 1979; Llewellyn et al., 2006; Roberts & Coutts, 2011). Although planned as part of the research programme, this follow-up proved impossible to organise due to lack of responses, participants having moved to new jobs and changes of email address.
7.4.5 Building capacity

Coutts and Roberts (2011) model (Figure 2.3) was designed with growers in mind. However, it is equally important for agronomists. Participants at the field days and workshops increased their knowledge levels and can therefore be assumed to have moved up the training rungs of the capacity-building ladder. Coutts and Roberts (2011) state that the ‘consultant/mentor’ model involves building relationships with individuals and communities and that the change to provision of extension by agribusinesses and private agronomists means this part of the ladder has become more important. However, my research shows that majority of participants at training events value the ability to interact both in their communities and outside these communities. For example, growers valued attending field days because they could interact with other growers, agronomists and research specialists, rather than engage with specialists in a mentoring or consultancy relationship. This suggests the consultant model of the capacity building ladder should perhaps be relabelled as “community interactions” to include all communities in the agricultural.

7.5 Limitations

There were some limitations in the research that I had not predicted:

1. Managers of two of the field days in the USA did not permit me to distribute the questionnaire.
2. It was difficult to interview participants at the field days. Participants used breaks to network with friends and colleagues and I did not feel that I could intrude on this.

7.6 Recommendations

The main recommendations from this research are:

1. It is important for training event organisers to realise that community interactions are an essential component.
2. The use of props or hands-on activities is greatly valued by participants.
3. The use of a microphone by speakers when in the field is very important, otherwise the majority of the participants will be unable to hear
7.7 Summary

This chapter discussed my evaluation of training events (field days and workshops) to assess their effectiveness in increasing the knowledge levels of growers, agronomists and other members of the agricultural industry. I have demonstrated that participants view field days and workshops as important training events that are engaging and useful. Participants greatly valued the interactions that they were able to have while attending training events. Knowledge levels increased after attending training events and most participants intend to use this knowledge on the farm or in the workplace. Regardless of the training event format, in general, participants’ knowledge levels increased after attending the event.
Chapter 8. The provision of pest and disease information using information communication tools (ICT); an Australian example

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

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ABSTRACT

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.

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, 2012a). 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 pest or disease threat (Hammond et al., 2016a; Hammond et al., 2016b). 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 communication and are used for providing information in relation to the surveillance and reporting of pests and diseases in crops (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; Hammond et al., 2014; James, 2009; Rhoades and Aue, 2010; Wright et al., 2010a). 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 found that they knew information. Instead of 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). This is even more so 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 (Salesenink et al., 2017; Wilis and Tranner, 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 (Salesenink 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 more likely to have access compared to those that live in regional Australia. Indeed, 85% 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 productivity and 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 consists of the use of apps to share information when they want to (Drill, 2012). The Department of Agriculture and Food, Western Australia (DAFWA) developed the MyPestGuide 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:

1) 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, 2008; Johanson and Schwarz, 2016; Vignart, 2013).

The goal of this study was to determine if ICT tools would be used by growers and agronomists within the Australian grains industry in relation to pest and diseases in their 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 profile of participants their 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 MPVs 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 Frohler (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 on pests and diseases in crops. 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.

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 diseases 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/UCGoqH070XugAxA4A-0g, due to the restrictions imposed on developing digital content in the workplace, the lead author of this paper created a independant 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 (www.youtube.com/pajaylot?list=PJiva5HgXSn62anbYxvBM2LgKgCXb7), providing two different channels for the videos to be watched.

In May 2016, six podcasts were trialled as an alternative
2.1. MyPestGuide app

The use of MPG reporter function as a surveillance tool was trialled from June 2016 until November 2016. This app was promoted 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 software, 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 ($\chi^2$) 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 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 interaction between occupations, phone ownership, location and Internet usage.

The overall response rate of useable questionnaires was estimated to be 26% because it was not possible to accurately determine if those who did not complete the survey online (Wright et al., 2016a) Questionnaires with incomplete 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 corresponding 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 information were provided by Google analytics.

The MPG Reports on presence or absence of RWA, diseases in grains 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, gmap and RColorBrewer packages for geocoding data, and generating plots and maps of the results (Kahle and Wickham, 2013; Neuwirth, 2015; R Development Core Team, 2008; Wickham, 2009, 2012; Wickham and Francois, 2015).

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 (Kemp 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/tablets, the use of the internet and the use of mobile apps.

A Pearson Chi Squared analysis showed that there was a significant 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 ($\chi^2$: (2, $n = 248$), $p = 0.001$ (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 agronomists in the usage of the Internet ($\chi^2$: (2, $n = 248$), $p = 0.001$). 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 ($\chi^2$: (2, $n = 248$), $p = 0.001$).

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 ($\chi^2$: (2, $n = 248$), $p = 0.05$). There was a significant difference between age groups and the use of the internet ($\chi^2$: (2, $n = 248$), $p = 0.05$). There was no significant difference between growers and agronomists for ownership of a smart phone/tablet and the frequency of use of the Internet ($\chi^2$: (2, $n = 248$), $p = 0.05$).

A hierarchical log linear analysis was conducted to determine if there was an interaction between Occupation (grower, agronomist), Internet usage (I), phone ownership (P) and Location (L, Eastern/Western Australia). The hierarchical analysis from the saturated model that a four-way interaction (O X P X L) was not significant. However, a model that included a three-way interaction between Occupation (O), gender (G), Location (L, Eastern/Western Australia), and phone ownership (P) showed a significant three-way interaction (O X P X L) ($\chi^2$: (2, $n = 248$), $p = 0.05$).

<table>
<thead>
<tr>
<th>Effect</th>
<th>df</th>
<th>Partial chi square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>O x L</td>
<td>2</td>
<td>0.19</td>
<td>0.99</td>
</tr>
<tr>
<td>O x P</td>
<td>2</td>
<td>1.32</td>
<td>0.47</td>
</tr>
<tr>
<td>L x P</td>
<td>2</td>
<td>0.50</td>
<td>0.03</td>
</tr>
<tr>
<td>O x P x L</td>
<td>2</td>
<td>1.7</td>
<td>0.15</td>
</tr>
<tr>
<td>O x L</td>
<td>2</td>
<td>2.88</td>
<td>0.00</td>
</tr>
<tr>
<td>P x L</td>
<td>2</td>
<td>1.1</td>
<td>0.44</td>
</tr>
<tr>
<td>O x L</td>
<td>1</td>
<td>1.4</td>
<td>0.00</td>
</tr>
<tr>
<td>O x L</td>
<td>2</td>
<td>2.1</td>
<td>0.05</td>
</tr>
<tr>
<td>O x L</td>
<td>1</td>
<td>2.1</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 1: Associated Chi Square values for significant three and two-way interactions between Occupation (O), gender (G), Location (L, Eastern/Western Australia), phone ownership (P) and Internet usage.
interaction \((D \times P \times L)\) 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 3. 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, smartphone ownership and city showed that there was a significant difference between percentage of participants in WA and EA that own smartphones compared to 76% in EA (\(X^2(9, n = 241) = 26.081, p \leq 0.05\)).

The 1-way effects of individual variables are not shown as these are assumed to contribute to the 2-way interactions.

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) Willows weather; 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 use of chat groups, GRDC news feed, podcasts and other forms of electronic media except PestFax (Fig. 1). 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 or more) 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 in the usage of PestFax/PestFacts by growers and agronomists; 10% of agronomists would use it frequently (once a week or more) whilst only 1.5% of growers would use it that frequently \((X^2(2, n = 247) = 26.081, p \leq 0.05)\).

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 \((X^2(2, n = 245) = 6.99, p \leq 0.05)\) and Twitter (14.4% agronomists compared to 6.7% growers) was used on a regular basis \((X^2(2, n = 246) = 12.014, p \leq 0.05)\).

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 \((X^2(2, n = 246) = 9.054, p \leq 0.05)\) 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 1). 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 recorded 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 by 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
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...
their use of the Internet. 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).

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). 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).

Table 3

<table>
<thead>
<tr>
<th>Webinar</th>
<th>Date</th>
<th>Time (24 h clock)</th>
<th>Number registered</th>
<th>Number attended</th>
<th>Interest rating (Average) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slugs in canola</td>
<td>13th July</td>
<td>0800</td>
<td>3</td>
<td>2</td>
<td>NA</td>
</tr>
<tr>
<td>Barley leaf rust update</td>
<td>18th July</td>
<td>1231</td>
<td>3</td>
<td>2</td>
<td>66</td>
</tr>
<tr>
<td>Aphids on your crop</td>
<td>17th July</td>
<td>0730</td>
<td>5</td>
<td>2</td>
<td>71</td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>22nd July</td>
<td>0739</td>
<td>2</td>
<td>3</td>
<td>94</td>
</tr>
<tr>
<td>Powdery Mildew in Wheat</td>
<td>10th July</td>
<td>0736</td>
<td>9</td>
<td>7</td>
<td>79</td>
</tr>
<tr>
<td>Wheat streak mosaic virus</td>
<td>23rd Aug</td>
<td>0750</td>
<td>3</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>Rusts in your wheat</td>
<td>20th Aug</td>
<td>0751</td>
<td>10</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>Russian wheat aphid</td>
<td>10th June</td>
<td>0800</td>
<td>10</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>Powdery Mildew in wheat</td>
<td>6th July</td>
<td>0804</td>
<td>6</td>
<td>4</td>
<td>78</td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>11th July</td>
<td>0817</td>
<td>11</td>
<td>9</td>
<td>90</td>
</tr>
</tbody>
</table>

Fig. 3. The frequency of electronic media usage by growers and agronomists to solve general problems on the farm. * Significant difference in usage between agronomists and growers at p < 0.001. ** Significant difference in usage between agronomists and growers at p < 0.05.

Table 3
Webinars held on pest and disease issues in broadacre crops during the growing season of 2015 and 2016 for the Western Australian wheatbelt. Number of participants registering and attending along with average interest rating in given.
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 there was no significant 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 were one of the groups that were digitally excluded, and those with a higher education qualifications such as a Bachelor Degree have a strong influence on Internet use (Thomas et al., 2016; Willis and Tranter, 2006).

Although our research has shown the influence of occupation, age and education levels on Internet usage from smart phones and tablets, there was no influence of demographics on the use of mobile apps. If the sample size had been larger the influence of demographics on app usage may have been evident.

### 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., 2013). 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 messages included the main management options, which is what growers want to know (Formiga et al., 2013).

The implications of Powdery Mildew in wheat for this season 2015

### Table 4

<table>
<thead>
<tr>
<th>YouTube video</th>
<th>Date</th>
<th>Number views 2015 Training Growers Channel</th>
<th>Number views 2016 Training Growers channel (DAFWA channel)</th>
<th>Average view duration (minutes) Training Growers channel</th>
<th>Length of YouTube video (mins)</th>
<th>Percentage of video watched (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLME resistance</td>
<td>2nd 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>6th July 2015</td>
<td>56</td>
<td>12</td>
<td>2.10</td>
<td>8.38</td>
<td>28</td>
</tr>
<tr>
<td>Barley leaf rust update</td>
<td>23rd 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 crops</td>
<td>1st August 2015</td>
<td>45</td>
<td>44</td>
<td>4.35</td>
<td>10.51</td>
<td>41</td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>21st 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>5th August 2015</td>
<td>199</td>
<td>92</td>
<td>8.02</td>
<td>20.05</td>
<td>40</td>
</tr>
<tr>
<td>Wheat Stalk Mosaic Virus</td>
<td>16th August 2015</td>
<td>38</td>
<td>43</td>
<td>2.27</td>
<td>10.10</td>
<td>22</td>
</tr>
<tr>
<td>Rusts in your wheat crop</td>
<td>26th August 2015</td>
<td>97</td>
<td>25</td>
<td>4.52</td>
<td>18.50</td>
<td>24</td>
</tr>
<tr>
<td>Brown spot in your paddocks</td>
<td>11th August 2015</td>
<td>101</td>
<td>101</td>
<td>1.10</td>
<td>8.14</td>
<td>16</td>
</tr>
<tr>
<td>Russian Wheat aphid</td>
<td>10th June 2016</td>
<td>103 (177)</td>
<td>3.45 (2.54)</td>
<td>12.04</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>The implications of Powdery Mildew in wheat for this season 2015</td>
<td>6th July 2016</td>
<td>29 (107)</td>
<td>3.46 (3.53)</td>
<td>16.28</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Sclerotinia in canola</td>
<td>11th 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>4th July 2016</td>
<td>5 (42)</td>
<td>3.25</td>
<td>9.57</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>755</td>
<td>1335</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 8. Use of ICT

“Sorry I missed the webinar, will when the YouTube video be ready”
Agronomist 1 and

“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 using the app 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 can be used as 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 provides to the survey. However, the initial results look promising and the development and release of the podcasts would need to continue. However, the initial results look promising and the development and release of the podcasts would need to continue.

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.

References


Holmes, T., Rumsey, A., 2016a. Using ICT to strengthen agricultural extension and advice services. 4th International Agricultural Information and Communication Technologies Conference, Orlando, FL.

Holmes, T., Rumsey, A., 2016b. Using ICT to strengthen agricultural extension and advice services. 4th International Agricultural Information and Communication Technologies Conference, Orlando, FL.


Rhodes, E., Ane, K., 2018. Social Agriculture: Adoption of Social Media by Agricultural Editors and Broadcasters. Southern Association of Agricultural Scientists Conference, Orlando, FL.


Wickham, H., 2012. reshape2: Flexibly Reshape Data: a Reboot of the reshape Package. CRAN.


Wright, D., 2017. Are We Going against the Grain in Training; Developing an Innovative Training Framework for Farmers and Agronomists in Australia. School of Agriculture, and Environment. The University of Western Australia.


Chapter 9  General Discussion
9.1 Introduction

In this chapter, I discuss the main findings associated with the objectives of my research and how industry can benefit from these findings. Towards the end of the chapter, I will make recommendations for further research and how training events such as field days and workshops can be improved.

The overall aim of this research was to develop a training and information framework to be used in the Australian grains industry that could, if appropriate, be used in other rural industries. As my case study, I examined the ability of growers and agronomists in the Australian grains industry to identify pest and diseases in crops, including the top four high priority pests (HPPs) that pose biosecurity threats in crops.

Agriculture is the second biggest industry in Australia, and it is very diverse. The grains industry is a major component of this diversity, with 32 million hectares, owned by 25,000 business (Keogh & Julian, 2014b), planted under crops. The major crops in the grains industry include wheat, barley, oat, lupins, canola and triticale. Minor crops include chickpeas, lentils, faba beans and field peas. G. M. Murray and Brennan (2012) estimated that 19.5% of the annual value of crop production is lost to pest and diseases each year. These losses could be reduced by rapid and accurate diagnosis of endemic pest and diseases, which requires growers and agronomists to be able to identify symptoms and signs associated with the endemic pests and the HPPs.

9.2 Knowledge levels on biosecurity threats

I conducted a training needs analysis (TNA) with growers and agronomists, examining their ability to recognise and identify symptoms and signs associated with endemic diseases in their crops, and with the top four HPPs in the Australian grains industry. This research is the first to provide a benchmark on the ability of growers and agronomists to recognise such endemic diseases. The results from the TNA showed that 70% of growers and 80% of agronomists could identify powdery mildew in barley and stripe rust in wheat. However, their ability to recognise blackleg in canola was significantly lower than for the two cereal foliar diseases.

Hammond (2010) conducted the first survey on the ability of participants in the Australian grains industry to recognise the symptoms and signs associated with HPPs. The data from Hammond’s survey and the survey I conducted showed that there was no change in the participants' ability to recognise HPPs. My research confirmed that their ability to recognise HPPs were well below expectations and did not meet the
benchmarks set at 70% of growers and 80% of agronomists who could recognise the symptoms and signs associated with HPPs. Only 71 to 192 participants were happy to answer the questions on the symptoms and signs of HPPs compared to 248 participants who answered the endemic disease questions (Chapter 4). When knowledge and awareness are lower than benchmark level this is likely to impact on the ability of growers and agronomists to report suspect HPPs (Wright et al., 2016). The Australian grains industry relies on participants to notify their local State Department of Agriculture when they suspect an incursion of a HPP. Because of this Plant Health Australia (PHA) provides biosecurity threat awareness training for industries and government organisations. They also provide a range of written publications that include images of the HPPs (Plant Health Australia, 2015).

9.2.1 Further research

The data from my research, and that of Hammond (2010), indicate that the current methods used for training and providing information on HPPs need to be re-examined and changed to meet the needs of participants in the grains industry. By using TNA on a regular basis it is possible to examine if skills and ability to recognise HPPs and endemic pests are increasing or decreasing. Incorporating ICT as part of the information and training framework could do this. To avoid survey fatigue the TNA could rotate through a different state each year or through the GRDC regional cropping zones for the Australian grains industry, so that each group would only be tested every 3 years.

9.3 Information and training availability

As part of developing the framework for providing information and training to the grains industry, it was important to examine where and how growers and agronomists obtain information, the types of training events they like to attend and whether these training events increase their knowledge levels.

One of the major gaps in the literature is a scarcity of information about agronomists, their demographics, where and how they obtain information and what training they attend. There is no literature comparing growers and agronomists, and how their demographic profiles influence the choices that they make. My study is the first to compare growers and agronomists in the Australian grains industry in relation to where and how they obtain information, what training events they like to attend and if knowledge levels increased from attending these events.
9.3.1 Information used by growers and agronomists

The capacity building model presented by Coutts and Roberts (2011) showed that the information access leg is very important to both groups and individuals; that is, being able to access a range of information at a time that suits them. Although the repository of information posited by the model is important, the model does not address the issue that information needs to be presented in different ways if it is to be used by all participants. In the second part of my study—a targeted survey with growers and agronomists—I demonstrated that there were distinct clusters within the grains industry about types, sources and content of the information participants’ use. I used a PCA to categorise the source of information, followed by a cluster analysis to group participants based on their information preferences, and a log-linear analysis to characterise the clusters using the demographics of the participants. The clusters were varied and depended on whether participants were looking for information to solve a general problem or a specific problem such as pest and disease in a crop.

For solving general on-farm problems, the clusters of participants could be grouped according to the type of information they used: community-, training- and technical-based information. There was a disparity between growers and agronomists on the sources and types of information used to solve general problems. Growers preferred to use information sources that they trust and are in close proximity, such as the local community, neighbours and family. These findings echo those in the literature (Ford & Babb, 1989; Hunt & Coutts, 2009; Llewellyn, 2007). Agronomists did not use community-based information and preferred to use training- and technical-based information.

Within the clusters for solving general problems, two groups were at opposite ends of the scale: those who used all sources and types of information and those who relied solely on their own knowledge and experience to solve problems.

The clusters identified when examining growers’ use of information to solve specific problems varied, showing a preference for information from a private agronomist compared to publicly available sources. The agronomists’ preference for information was related to the content of the information and how specific it was to the area in which they were working. Within these clusters for growers and agronomists were those who used all sources and those who relied solely on their own knowledge.

To summarise, the key concern about the provision of information is that there is not enough variety in the sources and types of information produced and provided to
participants. Therefore, when developing and producing information it is important to target the different clusters present in the industry and to understand how the demographics of the participants influence their choices.

9.3.2 The effect of training on knowledge levels

Another important component of the capacity building model is the training component (Coutts & Roberts, 2011). Training includes a range of activities that can be classified as formal, non-formal or informal (Clemans et al., 2012; Malcolm et al., 2003; Merriam, 2001). However, Coutts and Roberts (2011) discuss formal training only as the main method for participants within the industry to climb the capacity-building ladder.

I conducted a targeted survey to examine the types of training farmers and agronomists prefer to attend, and why they liked to attend such events. There is considerable literature mainly from developing countries (Bagamba et al., 2006; Khoury & Makkouk, 2010; Yang et al., 2008) on the training of growers, in relation to pests and diseases in crops, and a few sources that discuss training of growers in Australia and the benefits that it brings to farm businesses (Kilpatrick, 1997, 2000). However, there is very little known about the training of agronomists or comparing the training of growers and agronomists in the Australian grains industry.

My research demonstrated that growers and agronomists valued training events that provide the opportunity for interaction with other growers, specialists and agronomists, and a space to gain new knowledge that they can take back to the farm or workplace. Growers’ have been characterised as social learners, who prefer informal methods of learning that use a ‘hands on’ approach and interacting with other growers and researchers (Anil et al., 2015; Franz et al., 2010; Kilpatrick & Johns, 2003; Wenger, 2000). Such informal interaction allows them to compare views and values before making a change on their farm (Eckert & Bell, 2006; Kilpatrick & Johns, 2003). Field days are an effective route for learning, providing opportunities for growers, agronomists and other people in rural communities to assess new technologies, including varieties and equipment suitable for their environments (Amudavi et al., 2009; Wortmann et al., 2011). Agronomists are more likely than growers to attend formal workshops that offer them an opportunity to network with colleagues, researchers, specialists and growers.

Demographic characteristics such as sex, location, occupation and length of working life affect participation in training. Greater understanding of the influence of demographic characteristics and preferences for type of event should be used to
improve the design and relevance of training events (Chapters 6 and 7). For example; age did not influence attendance at field days, however, the sex and education level of the participants. Field days are still male dominated and those participants with higher education level than school are more likely to attend. Greater understanding of the influence of demographic characteristics and preferences for type of event should be used to improve the design and relevance of training events.

The training part of the capacity building ladder, does not consider grower groups. Grower groups can be considered a community of practice (Anil et al., 2015; Gianatti & Carmody, 2007; Wenger, 2000, 2009) and therefore an informal training mode that provides an effective learning opportunity (Kilpatrick & Johns, 2003). Membership of grower groups is very popular among growers, as they create a network of like-minded people, who might be facing the same or similar problems on their farms. The interactions at grower groups thus offer an opportunity for reassurance that a participant’s farming practices are correct. This research has uncovered new data on the influence of participants’ age, education levels, occupation and location on the likelihood of them belonging to a grower group. For example, growers and agronomists who are older than 31 years of age are more likely to belong to a grower group than someone who is less than 30 years of age.

Coutts and Roberts (2011) capacity-building model places high importance on using training to increase growers’ skills and knowledge but there is little research on capacity-building for agronomists, and no evaluation of knowledge gain or how agronomists intend to use new knowledge after training.

It is clear that Coutts and Roberts (2011) based their deductions on formal training events, with set curricula and specific learning objectives, whereas informal learning events are flexible in their content and objectives (Malcolm et al., 2003; Marsick & Watkins, 2001; Merriam, 2001). This research provides important information on what type of training events should be targeted at which participants. A formal workshop on pests and diseases is most likely to be filled with agronomists; very few growers would attend such an event (data in Chapter 6). Growers preferred informal interaction amongst themselves or with the speakers, rather than the formal knowledge transfer that would be used in a workshop. Kilpatrick and Johns (2003) argue that growers use a variety of informal learning to educate themselves and increase their capacity and skills. Australian field days very much fit into this informal learning pattern and both growers and agronomists who attended informal events showed an increase in knowledge. The knowledge gained during training benefits participants in some way, whether on the farm or at work, for example to improve crop production or control
weeds but there are also benefits in simply having time to think and ponder the issues they face. Further research is needed to determine if participants did subsequently use their new knowledge in the ways they planned. However, my research has shown that participants at field days increased their knowledge levels and so can be assumed to have moved up the training rungs of the capacity-building ladder. Therefore, it is clear that informal training events should form part of the capacity-building ladder.

Coutts and Roberts (2011) state that the ‘consultant/mentor’ model involves consultants (agronomists) building relationships with individuals and communities, and *vice versa*, and that the change to provision of extension by agribusinesses and private agronomists means this part of the ladder has become more important. However, my research shows that majority of participants at training events value the ability to interact both in their communities and outside them. For example, growers valued attending field days because they could interact with other growers, agronomists and research specialists, rather than engaging with specialists in a professional mentoring or consultancy relationship. This suggests the “consultant” leg of the capacity-building ladder should perhaps be relabelled “community interactions” to include all communities in the agricultural sector.

In summary, this is the first study to evaluate the impact of training events such as field days and workshops on the knowledge levels of growers and agronomists in the Australian grains industry (see Chapter 7). Growers and agronomists see training as engaging, useful and important for capacity building (see Chapter 6). Participants’ knowledge increased after attending training and most participants feel they will be able to use their new knowledge on their farm or in their consultancy. Overall, I have demonstrated that knowledge levels increased when attending these activities and most participants would use this knowledge on the farm or in the workplace. Some participants felt that they had become more aware of issues in crops, whilst agronomists had a greater understanding of issues faced by clients; an important factor in their work, because growers prefer highly localised information to help them solve problems.

**9.3.3 Further research**

A larger survey of growers and agronomists is required to fully understand the cluster profiles (see Chapter 5) showing how and where they obtain information. By further developing the demographic profiles of these groups, it will be easier to target information effectively. There remain participants within the grains industry who rely
solely on their own experience and knowledge and therefore are not receiving any new information except from their own ongoing observations. This is a concern for example, when a HPP has been detected within the industry and control measures need to be put into place.

Because the use of social media has changed rapidly since this work was started another survey conducted to examine the reliance of growers and agronomists are on the use of ICTs to provide information would be useful. ICTs would also include the use of social media such as Twitter and Instagram. This would provide longitudinal data for the industry and would help determine the necessary changes needed for the provision of information.

Further research to actually follow participants after a training event and determine how they used this new knowledge (longitudinal study). The research could also determine if the new knowledge helped the participant create change and what impact this change had.

9.4 The use of ICTs to provide information

In Chapter 6, I identified barriers that prevented growers and agronomists from attending training events. These barriers (such as lack of time and distance to the training course), led to the testing of ICTs as a method to provide information that was relevant, up-to-date, and could be accessed when growers and agronomists needed it. In 2015, the series of webinars I ran were held when pest and disease issues were actually occurring in the growing crops. The webinars were recorded, converted into videos and uploaded to the YouTube channel, “Training Growers”. This enabled participants within the grains industry to access the information when needed. In the following year, I tested the use of podcasts for those in areas with poor access to the Internet. The downloading of Podcasts use very little data and many regional areas within Australia have very poor access to the Internet (Thomas et al., 2016).

The success of these online methods was demonstrated when the HPP Russian wheat aphid was detected in South Australia in June 2016. Within a week, a webinar was held for agronomists and industry members, explaining how to identify and differentiate RWA from other aphids present in crops. This was the first time a webinar had been held with growers and agronomists in the grains industry for a biosecurity threat. The YouTube video was watched more than 300 times in a week, demonstrating it met the need for up-to-date and relevant information in the industry (see Chapter 8).
Hammond (2010) showed that growers and agronomists might report suspect HPPs, but that there needs to be an easier method to enable this to happen. The development of MyPestGuide (MPG) suite of apps was created to enable such reporting. The MPG reporter app allowed agronomists, growers and DAFWA staff to report the presence or absence of aphids in crops. These data were collated to use as supporting evidence of absence of RWA from Western Australia.

My work in using ICTs for reporting pest and disease issues in crops was a first for participants in the Western Australian grains industry, and the development of the YouTube videos on current pest and disease issues aimed at Australian growers were the first not developed by professional film-makers. The videos and podcasts were promoted through a new online community called Field Crop Diseases (www.extensionhub.com.au/web/field-crop-diseases).

### 9.4.1 Further research

Growers’ and agronomists’ knowledge, skills and abilities on the identification of symptoms and signs associated with HPPs need to be increased using a different approach to that currently in use. The TNA in Chapter 4 demonstrated that ability to recognise HPPs within the grains industry did not meet the set benchmarks. The use of webinars and YouTube videos, combined with a mobile app, should be tested as a method to increase knowledge, because the current training methods and publications used in industry have not been successful. To determine the success of these tools would require testing growers’ and agronomists’ knowledge levels before and after the release of the online resources.

The information and training needs of growers and agronomists are quite different and distinct. These needs depend on whether the user is solving a general or a specific problem on-farm. For specific problems, such as pest and diseases in crops, the majority of growers prefer to rely on private advice. This indicates that for pest and disease training, agronomists should be targeted, as they provide advice to the growers. However, the use of online methods could supplement this training, as they can provide information as needed to the industry.

Further research is needed to examine the use of ICTs based on educational design principles, and determine if these principles are appropriate for the target audience for example the grains industry in Australia. This would then be linked back to see if growers and agronomists had made changes on farm and the outcomes from these changes.
Figure 9.1. Theoretical framework for information and training of growers and agronomists in rural Australia. The red circle indicates how information communication tools can be used as both an information source and a training opportunity.
9.5 Theoretical framework for information and training

I have proposed a framework (Figure 9.1) that demonstrates the complexity of growers’ and agronomists’ information and training needs. The current literature (Coutts & Roberts, 2011; Fulton et al., 2003; Hunt & Coutts, 2009; Llewellyn, 2007; Llewellyn, D’Emden, & Kuehne, 2012) tends to look at each part separately and does not account for the interactions among, and differences between, growers and agronomists in their use of information or training preferences. I have shown that online tools provide a great opportunity to connect information and training in a way that can be used by growers, agronomists and other participants in the industry.

In the theoretical framework, the grower and the agronomist are separate entities that interact with each other in relation to solving specific or general problems. My research shows that the demographic profiles (shown by the blue circle in Figure 9.1) of each entity are very important; the demographic profiles of growers and agronomists clearly influence the sources and types of information they use, and the types of training events they prefer. For example, growers prefer to attend informal and non-formal training events, and agronomists prefer to attend formal training. The interaction between growers and agronomists implies that the agronomist understands the information needs of the grower and is able to present this information in a suitable manner.

On the right and left hand sides of the framework (Figure 9.1), are the information area and the training area; this is similar to the capacity building ladder developed by Coutts and Roberts (2011). However, I have shown that within each of these areas lie three main factors (or subgroups). In the information area, growers and agronomists use different sources and types of information. The locus of the information used by agronomists depends on whether the information is regional, state or local. In the training area, events can be formal, informal or non-formal. All training is able to increase participants’ knowledge levels if the training is appropriate. However, the training methods used and the information produced must be relevant to the growers’ and agronomists’ context and take account of their geographic location, regional setting, level of education and amount of experience (Franz et al., 2010). Information must be tailored so that it is understandable by all, regardless of their education and experience levels as demonstrated in Chapter 5. I have shown that presenting information in different forms according to the demographics of the target audience could provide this tailoring.
The red circle in Figure 9.1 indicates the intersection of information, training, growers and agronomists. This intersection is not discussed in the literature and requires further exploration of methods and tools that can be used, to ensure that appropriate information and training can occur for growers and agronomists. I propose that the use of online tools will fill this gap. The range of tools available, such as videos, webinars and podcasts provide a variety of formats that can contain the same information but accommodate differences in learning preferences. Providing information in different formats also reduces the exclusion of those with reduced Internet availability.

The framework in Figure 9.1 provides a map to enable those who are organising and providing information and training to a community to plan how they will do this. The map indicates areas that would need to be considered and understood before planning the training event. For example, if providing information and training to an agronomist on a specific issue, the agronomist will have a preference for information that is either regional, or local or state based. The agronomists would prefer to attend formal workshops. For example, maybe rural health services could use the framework to examine the interactions between patients and medical practitioners. Another example would be to use the framework in the horticultural industry to examine the interactions between growers and horticultural advisers.

9.5.1 Recommendations for further research

Podcasts about pests and diseases need to be used more frequently and made available more widely through a RSS feed. By providing information in this format to growers, they are more likely to use the resources. This will provide another source of information to growers who enjoy listening to programs and information in their tractors or car. More research is needed into how effective podcasts are for providing information and training.

Further research needs to be done on the knowledge levels of participants after using information communication tools, and the effect of the demographic characteristics of the participants on the knowledge levels using ICTs. As the average age of growers is increasing and a younger generation are starting to farm, the traditional methods used to provide information and training do need to change as the younger generation are more internet and social media savvy than their older counterparts.

The extent to which the framework could be transferred to other communities such as the health community would need to be examined and tested to determine if it does work.
9.6 Recommendations for training organisers

Training organisers are often told to “understand your audience”. My research indicates that this is still essential, but not always recognised in the agricultural industry. For example, the researchers who present at field days with lots of graphs and a PowerPoint presentation rather than having hands on or practical demonstrations.

9.6.1 Field days

My research in Chapters 6 and 7 shows that:

1. Sufficient time should be made available for informal interactions among participants.
2. Hands-on activities are offered to growers.
3. Presenters are engaging and interact with the audience\(^3\).
4. Demonstrations at the field day should reflect conditions on local farms.
5. Presenters must understand the area and pertinent local issues.\(^4\)
6. The event is adequately advertised.
7. Where many different activities occur at the same time, talks are kept short and to the point, and recorded for conversion to a video or podcast.

9.7.2 Workshops

1. Time is allowed for networking before, during and after the event. Such interactions can provide powerful learning opportunities.
2. Hands-on activities are offered, especially in workshops about pests and diseases in crops.
3. The information is either relevant to the local area or generic with local examples.
4. The format in which information is provided take participants’ demographic profiles into account.

\(^3\) I have observed researchers present graphs and statistics to a group of growers on pieces of cardboard during a field day. More than 50% of the audience was asleep.

\(^4\) For example, there is no point in a plant pathologist from Western Australia going to Queensland to talk about yellow spot in wheat. Farms in Queensland do not have yellow spot as a major disease.
9.8 Recommendations for using Webinars

My research in Chapter 8 shows that:

1. Webinars should be short and sharp, for example no more than ten PowerPoint slides.
2. Begin with a summary slide. This allows participants to digest the information and means they are more likely to ask questions.
3. Have a moderator as well as a presenter. The moderator can deal with participants’ questions.
4. Ensure presenters’ material is pertinent to the problem being addressed.
5. Do practice runs with the presenter so that they get used to talking to a screen and are not put off by not seeing their audience.
6. The moderator should prepare a few questions, to give participants time to think.
7. Provide routes for both verbal and written questions.
8. Webinar videos do not need to be made by professionals. Participants often prefer simple videos.

9.9 Recommendations for using Podcasts

My research in Chapter 8 shows that:

1. Growers and agronomists prefer a relaxed interview style.
2. Send the to the researcher before you interview them.
3. Record the podcast soon after the webinar. The information is fresh in the presenter’s mind and the interview comes across more naturally.
4. Ensure the creator has access to effective tools for creating online resources, and that the host organisation supports the use of these tools.

9.10 Conclusion

The information and training needs of growers and agronomists are different and distinct, depending on whether the user is solving a general or a specific problem on-farm. For specific problems, such as pests and diseases in crops, the majority of growers prefer to rely on private advice. This indicates that agronomists should be targeted for pest and disease training, as they provide advice to the growers. However,
the use of online methods should supplement this training by providing information as needed to the industry through the use of webinars, YouTube videos and Podcasts.

When using online methods, it is important to consider the ‘digital divide’ in Internet access. The re-organisation of the information when conducting Webinars and creating videos highlights the important elements but also provides the background and rationale. This gives participants the choice of either listening to the pertinent bits or to the whole item.

My research shows that the routes for provision of information and training to growers and agronomists in the Australian grains industry are diverse and no single solution can provide all information and training. Most previous research focuses on growers and ignores the very close relationship between growers and their agronomists. My research is the first to compare growers’ and agronomists’ information and training needs.

I have shown that participants’ demographics influence their information and training needs, and it is important to use and understand these differences when designing and providing information and training.

**Author’s note**

I hope you have enjoyed reading this thesis as much as I enjoyed doing the research. It has been challenging. It has been fun and it has been very rewarding to see some of the strategies suggested here embraced by the industry. If I had known I would end up doing a part PhD in social science statistics along the way, I might never embarked on this research. However, I have arrived at the end of this journey unscathed, and with far greater knowledge.
Appendices

Appendix A. Growers Survey

Questionnaire to identify training needs of grain growers

The goal of this survey is to identify the training requirements of growers within the grains industry. This survey is part of a research project funded by the Council of Grain Growers Organisation (COGGO).

Your responses to the questionnaire will contribute to the understanding of requirements of growers in the grains industry for up-skilling their skills and knowledge in all aspects of farming. In this research, the case study used will be based on diseases in your crops, so that you will receive better training, will have a greater understanding on the biology of the diseases, and thus grow better crops with better yields.

Participation in this survey is voluntary and anonymous and all data will be treated as confidential. It should only take 15 minutes to complete.

There are questions relating to a) how you like to get information, b) the types of training you like to attend, c) common diseases found in crops and e) biosecurity risks in grain crops.

This survey has been approved by the University of Western Australia Human Ethics Committee, (RA/4/1/6607).

If you have any questions or concerns in relation to this survey, contact Dominie Wright at dominie.wright@agric.wa.gov.au or on 0477 310 663. Or you may contact Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au

Completion Instructions

Please use a black or dark blue pen. Please tick "X" the appropriate boxes to answer the questions. If you make a mistake, you may cross it out and tick the correct response.

Please return your completed questionnaire to either the box placed out the front of the venue, or use the reply paid envelope provided.

Survey terms

All data collected from the survey will be confidential. If at any time you wish to withdraw from the survey, you can. All information you have entered to that point will be discarded.

By continuing with this survey, completing it and submitting the survey, I consent to participate within the research.

I understand that all information provided is treated with strict confidentiality and will not be released by the investigator.
Appendix A. Growers survey

### Section A: How you like to obtain information to make a change or solve problems on the farm

1. How important are these methods for you when looking for general information to help you make a change or solve a problem on the farm.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Not important</th>
<th>Slightly important</th>
<th>Very important</th>
<th>Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending Crop Updates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attending fee paying technical workshops</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Attending field days</td>
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<td></td>
</tr>
<tr>
<td>Attending grower group meetings</td>
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<td></td>
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<tr>
<td>Attending workshops (fee)</td>
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<tr>
<td>Learning from agribusiness reseller</td>
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<td></td>
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<tr>
<td>Learning from family members</td>
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<tr>
<td>Learning from local community</td>
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<tr>
<td>Learning from my own experience</td>
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<tr>
<td>Learning from neighbours</td>
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<tr>
<td>Learning from private consultant</td>
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<tr>
<td>Learning from State Ag Dept person</td>
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<tr>
<td>Listening to radio</td>
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<td></td>
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<tr>
<td>Reading books (text/journals/bulletins)</td>
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<tr>
<td>Reading rural papers</td>
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<td></td>
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<tr>
<td>Using mobile applications (apps for smartphones / tablets)</td>
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<tr>
<td>Using the Internet</td>
<td></td>
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</tr>
<tr>
<td>Other: (please state)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

2. How often would you use the following electronic media when looking for information about farming issues?

<table>
<thead>
<tr>
<th>Media</th>
<th>Daily</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Twice a year</th>
<th>Once a year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blogs</td>
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</tr>
<tr>
<td>Chat groups</td>
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<tr>
<td>DAFWA Pestfax / PestFacts</td>
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<td>Facebook</td>
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<td>GRDC News Feed</td>
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<td>Podcasts</td>
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<tr>
<td>Twitter</td>
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<tr>
<td>YouTube</td>
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<tr>
<td>Other: (Please state)</td>
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</tr>
</tbody>
</table>
3. How often would you use the Internet to look for information that you require in relation to crops and cropping?

Never  □
Less than once a month □
Once a month □
Two to three times a month □
Once a week □
Two to three times a week □
Daily □

4. Do you own a smart phone or tablet?

Yes  □ → Please go to Q 5.
No □ → Please go to Q 7.

5. How often do you use mobile applications to help with your day-to-day work?

Never □
Less than once a month □
Once a month □
Two to three times a month □
Once a week □
Two to three times a week □
Daily □

6. Please name the top three mobile applications that you use to help solve problems on the farm.

   

Section B: Types of training you have attended in the last 12 months

Field days / Field walks

7. In the last 12 months how many field days / field walks have you attended?

0 □ → Please go to Q 8
1 □
2 □
3 □
4 □
5 or more □ → Please go to Q 9

8. What prevented you from attending any field days? (Tick all that apply)

Distance to travel was too far □
I do not find field days useful □
Lack of childcare facilities / help □
No field days were held in my district □
No time available to attend □
Time of day was inconvenient □
Topics were not relevant to my situation or me. □
Unaware that they were being held □
Other [Please state]:

Please go to Q 7.

Please go to Q 9.
Appendix A. Growers survey

9. What did you like about the field days?
   a. _____________________________________________________
   b. _____________________________________________________
   c. _____________________________________________________

10. Do you have any suggestions on how the field day(s) could be improved?
   a. _____________________________________________________
   b. _____________________________________________________
   c. _____________________________________________________

11. In the last 12 months how many times have you attended face-to-face workshops on the following subjects?

<table>
<thead>
<tr>
<th>Subject</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agronomic issues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal husbandry</td>
<td></td>
<td></td>
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<tr>
<td>Disease identification</td>
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<tr>
<td>Farm management</td>
<td></td>
<td></td>
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<tr>
<td>Herbicide application</td>
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<tr>
<td>Pest identification</td>
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<tr>
<td>Precision agriculture</td>
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<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. What did you like about these workshops?
   a. _____________________________________________________
   b. _____________________________________________________
   c. _____________________________________________________

13. Do you have any suggestions on how the workshop(s) that you attended could be improved?
   a. _____________________________________________________
   b. _____________________________________________________
   c. _____________________________________________________

14. What prevents you from attending these workshops? (Tick all that apply).
   Cost of attending was too high    ☐
   I do not find workshops useful    ☐
   Lack of childcare facilities / help ☐
   No time available to attend      ☐
   None were held in my district     ☐
   Time of day was inconvenient      ☐
   Topics were not relevant to my situation or me ☐
   Unaware that they were being held ☐
   Other (Please state): ____________________________

15. Are you a member of a grower group?
   Yes ☐ Please go to Q 16
   No ☐ Please go to Q 16

16. Please name the grower group
   _______________________________________________________

17. How many of the grower group meetings held would you attend?
   None ☐
   Quarter of the meetings ☐
   Half of the meetings ☐
   Three quarters of the meetings ☐
   All of the meetings ☐

18. What are the best aspects of these meetings?
   a. _____________________________________________________
   b. _____________________________________________________
   c. _____________________________________________________
19. What are the worst aspects of these meetings?
   a.____________________________________________________
   b.____________________________________________________
   c.____________________________________________________

Seminars / Other types of learning events

20. Have you attended any other seminars / learning events / information events / webinars in the last 12 months?
   Yes □ Please go to Q 21
   No □ Please go to Q 24

21. Please name these events
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________

22. What did you like about these events?
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________

23. Do you have any suggestions on how the events that you attended could be improved?
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________

What would you like to learn about?

24. Can you list some topics that you would like training in?
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________

Please go to Q 21
Please go to Q 24
### Section C: Pest and diseases in your crops. This section will provide information for the case study

25. How often would you inspect your crops looking for pest and diseases?
- Never
- Once during the growing season
- Once a month
- Every second week
- Once a week

26. Where do you seek information from about managing pest and diseases in your crops? (Please tick all that apply).
- Agmemo
- Attending field day
- Attending seminars
- Attending workshops
- Farmnotes / bulletins
- Internet
- Local agricultural reseller
- Local farm community
- Neighbours
- PestFax
- Previous knowledge
- Private agronomist
- Regional Crop Updates
- Other:

27. How much do you think pest and diseases impact on crop yields on an annual basis?
- <5%
- 6-11%
- 12-19%
- >20%

28. Do you employ an agronomist to help you with issues on the farm?
- Yes
  - Please go to Q 29.
- No
  - Please go to Q 31.

29. Does the agronomist help you manage pest and diseases in your crops?
- Yes
- No

30. How often would the agronomist inspect your crops looking for pest and diseases?
- Never
- Once during the growing season
- Once a month
- Every second week
- Once a week

31. How often have you used the following services for pest and disease identification in the last 12 months?

<table>
<thead>
<tr>
<th>Service</th>
<th>0</th>
<th>1-3</th>
<th>&gt;4</th>
<th>Unaware of the service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grainguard</td>
<td></td>
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<tr>
<td>National Exotic Plant Pest Hotline - 1800 084 881</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>PestFax / PestFacts</td>
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<tr>
<td>PredictaB soil testing service</td>
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<tr>
<td>Private Diagnostic service</td>
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</tr>
<tr>
<td>State Diagnostic service</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
32. What is this leaf disease seen in barley crops?
- Yellow spot
- Net blotch
- Powdery mildew
- Don’t know

33. What is this leaf disease seen in wheat crops?
- Wheat leaf rust
- Yellow spot leaf disease
- Stripe rust
- Don’t know

34. What is this disease on canola?
- Black spot diseases
- Blackleg
- Speckled dot disease
- Don’t know
Appendix A. Growers survey

Section E: The following questions relate to diseases and pests that are not present in Australia and represent a biosecurity risk. (Please tick all that apply).

35. Which of the following signs would you associate with Karnal bunt?

- Insects in grain
- Fishy odour
- Leaf lesions (spots or stripes)
- Ergot in the grain
- Pink grain
- Partially bunted grain
- Shrivelled grain
- Insect feeding damage
- Don't know

36. Which of the following signs would you associate with Khapra beetle?

- Hairy larvae
- Black-brown beetles
- Bunted grain
- Presence of larvae skins
- Flying beetles
- Beetles larger than 1 cm
- Insect feeding damage
- Fishy odour
- Don't know

37. Which of the following signs would you associate with Barley Stripe rust?

- Rust pustules on stems
- Bunted grain
- Pink grain
- Rust pustules in stripes on leaves
- Pale green aphids
- Yellow-orange rust pustules
- Insect feeding damage to leaves
- Rust in stripes on barley plant
- Don't know

38. Which of the following signs would you associate with Russian Wheat Aphid?

- Bleached, curled heads and awns
- Insect feeding damage to grain
- Reddish-brown beetles
- Aphid with long antennae
- Rolled up flag leaf
- Pale green aphids
- Streaks on leaves
- Fishy odour
- Don't know

Section F: This is about you and your farm. The information that you provide is completely confidential.

39. Which of these categories best describe you?

- Owner
- Salaried farm hand
- Salaried Manager
- Share farmer / Lessee
- Other (Please state): ____________________________________________

40. How many years have you worked as a farmer?

- <1 year
- 1-5 years
- 6-10 years
- 11-15 years
- >16 years

41. What is the highest level of education that you have completed?

- Completed Year 10
- Completed Year 12
- Trade qualification
- Diploma
- Bachelor's degree
- Post-graduate qualifications

42. How large is your farm? (Please indicate if the size is in acres or hectares. This includes owned, leased, and shared farmland).

__________________________________________
43. Your Gender
- Male
- Female
- Other

44. Please indicate the age group that you fit into based on your last birthday.
- <21
- 22-30 years old
- 31-40 years old
- 41-50 years old
- 51-60 years old
- >60 years old

45. What type of crops do you grow? (Please tick all that apply).
- Cereals
- Legumes / pulses
- No crops are grown
- Oilseeds
- Other (Please state):

46. What type of animals do you produce on your farm? (Please tick all that apply)
- Beef cattle
- Dairy cattle
- No animals are farmed
- Poultry
- Sheep
- Other

47. What is the postcode of where your farm is located?

48. What is the rainfall zone that you farm in?
- Low
- Medium
- High

Do you have any comments or questions that you would like to ask? (I will respond by email if you leave your details).

Please provide your details if you are willing to participate in the following training events (select your preference).

- Further discussion in relation to training
- Training workshops
- Both

Name: ________________________________
Phone number: __________________________
Email: ________________________________

(This information will remain confidential and will not be passed onto any 3rd parties).

Thank you for participating in this survey. Your time spent doing this is greatly appreciated. The information collected will provide data to determine training requirements for grain growers.
Questionnaire to identify training needs of agronomists

The goal of this survey is to identify the training requirements of agronomists within the grains industry. This survey is part of a research project funded by the Council of Grain Growers Organisation (COGGO).

Your responses to the questionnaire will contribute to the understanding of requirements of agronomists in the grains industry for up-skilling their skills and knowledge in all aspects of farming. In this research, the case study used will be based on diseases in your crops, so that you will receive better training, will have a greater understanding on the biology of the diseases, and thus grow better crops with better yields.

Participation in this survey is voluntary and anonymous and all data will be treated as confidential. It should only take 15 minutes to complete.

There are questions relating to a) how you like to get information, b) the types of training you like to attend, c) common diseases found in crops and e) biosecurity risks in grain crops.

This survey has been approved by the University of Western Australia Human Ethics Committee, (RA/4/1/6607).

If you have any questions or concerns in relation to this survey, contact Dominie Wright at dominie.wright@agric.wa.gov.au or [redacted]. Or you may contact Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au

Survey terms

All data collected from the survey will remain confidential. However, if at any time you wish to withdraw from the survey, you can. All information you have entered to that point will be discarded.

By continuing with this survey, completing and submitting the survey, I consent to participate within the research.

I understand that all information provided is treated with strict confidentiality and will not be released by the investigator.
### Section A: How you like to obtain information to make a change or solve problems on the farm

#### 1. How important are these methods for you when looking for general information to help you make a change or solve a problem for a grower?

<table>
<thead>
<tr>
<th>Methods</th>
<th>Not important</th>
<th>Slightly important</th>
<th>Very important</th>
<th>Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending Crop Updates</td>
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<tr>
<td>Attending fee paying technical workshops</td>
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<tr>
<td>Attending field days</td>
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<tr>
<td>Attending grower group meetings</td>
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<tr>
<td>Attending workshops (free)</td>
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<tr>
<td>Learning from agribusiness reseller</td>
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<tr>
<td>Learning from family members</td>
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<tr>
<td>Learning from local community</td>
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<tr>
<td>Learning from my own experience</td>
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<tr>
<td>Learning from neighbours</td>
<td></td>
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<tr>
<td>Learning from private consultant</td>
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<tr>
<td>Learning from State Ag Dept person</td>
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<tr>
<td>Listening to radio</td>
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<tr>
<td>Reading books (text, journals, bulletins)</td>
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<tr>
<td>Reading rural papers</td>
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<tr>
<td>Using mobile applications (apps for smartphones / tablets)</td>
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<tr>
<td>Using the Internet</td>
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<tr>
<td>Other: (please state)</td>
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</tbody>
</table>

#### 2. How often would you use the following electronic media when looking for information about farming issues?

<table>
<thead>
<tr>
<th></th>
<th>Daily</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Twice a year</th>
<th>Once a year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blogs</td>
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<tr>
<td>Chat groups</td>
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<tr>
<td>DAFWA Pestfax / PestFacts</td>
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<td>Facebook</td>
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<td>GRDC News Feed</td>
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<td>Podcasts</td>
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<td>Twitter</td>
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<td>YouTube</td>
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<tr>
<td>Other: (Please state)</td>
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</tbody>
</table>
Appendix B. Agronomist survey

3. How often would you use the Internet to look for information that you require for your farming business?

Never ☐
Less than once a month ☐
Once a month ☐
Two to three times a month ☐
Once a week ☐
Two to three times a week ☐
Daily ☐

4. Do you own a smart phone or tablet?
Yes ☐ Please go to Q 5.
No ☐ Please go to Q 7.

5. How often do you use mobile applications to help with your day-to-day work?

Never ☐
Less than once a month ☐
Once a month ☐
Two to three times a month ☐
Once a week ☐
Two to three times a week ☐
Daily ☐

6. Please name the top three mobile applications that you use to solve problems for growers.

7. In the last 12 months how many field days have you attended?

0 ☐ Please go to Q 8.
1 ☐
2 ☐
3 ☐
4 ☐
5 or more ☐ Please go to Q 9

8. What prevented you from attending any field days?

I do not find field days useful ☐
No field days were held in my district ☐
No time available to attend ☐
Time of day was inconvenient ☐
Topics were not relevant to my situation or me. ☐
Unaware that they were being held ☐
Other (Please state):

Section B: Types of training you have attended in the last 12 months

Field days / Field Walks

7. In the last 12 months how many field days have you attended?

0 ☐ Please go to Q 8.
1 ☐
2 ☐
3 ☐
4 ☐
5 or more ☐ Please go to Q 9

8. What prevented you from attending any field days?

I do not find field days useful ☐
No field days were held in my district ☐
No time available to attend ☐
Time of day was inconvenient ☐
Topics were not relevant to my situation or me. ☐
Unaware that they were being held ☐
Other (Please state):

Page 3
9. Did you present or provide information at these field days you attended?
   Yes ☐
   No ☐

10. How important is it for you to present or provide information these field days?
   Not at all important ☐
   Slightly important ☐
   Very important ☐
   Extremely important ☐

11. What did you like about the field days?
   a._____________________________________________
   b._____________________________________________
   c._____________________________________________

12. Do you have any suggestions on how the field day(s) could be improved?
   a._____________________________________________
   b._____________________________________________
   c._____________________________________________

Workshops

13. In the last 12 months how many times have you attended workshops on the following subjects?

<table>
<thead>
<tr>
<th>Subject</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agronomic issues</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Animal husbandry</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Disease identification</td>
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<td>Farm management</td>
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<td>Herbicide application</td>
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<td>Pest identification</td>
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<tr>
<td>Precision agriculture</td>
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<tr>
<td>Other:</td>
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<td>☐</td>
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</tbody>
</table>

14. What prevents you from attending workshops? (Tick all that apply)
   Cost of attending was too high ☐
   Distance to travel was too far ☐
   I do not find workshops useful ☐
   No time available to attend ☐
   None were held in my district ☐
   Time of day was inconvenient ☐
   Topics were not relevant to my situation or me ☐
   Unaware that they were being held ☐
   Other (Please state):
   ________________________________________________________

15. What did you like about these workshops?
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________

16. Do you have any suggestions on how the workshop(s) that you attended could be improved?
   a._________________________________________________
   b._________________________________________________
   c._________________________________________________
## Grower Group

17. Are you a member of a grower group?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Yes</td>
<td></td>
<td>Please go to Q 18</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>Please go to Q 22</td>
</tr>
</tbody>
</table>

18. Please name the grower group

_________________________________________________

19. How many of these grower group meetings would you attend?

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>None</td>
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<tr>
<td>Quarter of the meetings</td>
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<tr>
<td>Half of the meetings</td>
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<td>Three quarters of the meetings</td>
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<tr>
<td>All of the meetings</td>
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</table>

20. What are the best aspects of these meetings?

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<td>a.</td>
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<td>b.</td>
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<td>c.</td>
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</table>

21. What are the worst aspects of these meetings?

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<tbody>
<tr>
<td>a.</td>
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<td>b.</td>
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<td>c.</td>
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</table>

22. Do you run a grower group?

<p>| | |</p>
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<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
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</tbody>
</table>

23. Please name the group that you run?

__________________________________________________

---

## Seminars / other types of learning events

24. Have you attended any other seminars / learning events / information events / webinars in the last 12 months?

<p>| | |</p>
<table>
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<th></th>
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<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
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</tbody>
</table>

25. Please name / describe these events.

<p>| | |</p>
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<tbody>
<tr>
<td>a.</td>
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<td>b.</td>
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26. What did you like about these events?

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<td>b.</td>
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27. Do you have any suggestions on how the events could be improved?

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Appendix B. Agronomists survey

What would you like to learn about?

28. Can you list some topics that you would like training in?
   a. ____________________________________________
   b. ____________________________________________
   c. ____________________________________________

29. Why do you attend training (Tick all that apply)
   - Like to learn    □
   - Mandatory training    □
   - Professional development    □
   - Networking    □

Section C: Pest and diseases in crops. This section will provide information for the case study

30. Where do you seek information from about managing pest and diseases in your crops? (Please tick all that apply).
   - Agmemo    □
   - Attending field days    □
   - Attending seminars    □
   - Attending workshops    □
   - Colleagues    □
   - Company specialist    □
   - Farmnotes / bulletins    □
   - Internet    □
   - Local agriculture department    □
   - PestFax    □
   - Previous knowledge    □
   - Regional Crop Updates    □
   - Other: ____________________________

31. How often would you inspect a client’s crop looking for pest and diseases?
   - Never □
   - Once during the growing season □
   - Once a month □
   - Every second week □
   - Once a week □

32. How much do you think pest and diseases impact on crop yields on an annual basis?
   - <5% □
   - 6-11% □
   - 12-19% □
   - >20% □

33. How often have you used the following services for pest and disease identification in the last 12 months?

<table>
<thead>
<tr>
<th>Service</th>
<th>0</th>
<th>1-3</th>
<th>&gt;4</th>
<th>Unaware of the service</th>
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<tr>
<td>Grainguard</td>
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<td>National Exotic Plant Pest Hotline - 1800 084 881</td>
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<td>PestFax / PestFacts</td>
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<td>PredictaS soil testing service</td>
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<td>Private Diagnostic Service</td>
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<tr>
<td>State Diagnostic Service</td>
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</table>
Section D: Common diseases seen in crops. Determines the level of knowledge present in the industry.

34. What is this leaf disease seen in barley crops?
- Yellow spot
- Net blotch
- Powdery mildew
- Don't know

35. What is this leaf disease seen in wheat crops?
- Wheat leaf rust
- Yellow spot leaf disease
- Stripe rust
- Don't know

36. What is this disease on canola?
- Black spot diseases
- Blackleg
- Speckled dot disease
- Don't know
**Section E: The following questions relate to diseases and pests that are not present in Australia and represent a biosecurity risk. (Please tick all that apply)**

37. Which of the following signs would you associate with Karnal bunt?
- Insects in grain
- Fishy odour
- Leaf lesions (spots or stripes)
- Ergot in the grain
- Pink grain
- Partially bunted grain
- Insect feeding damage
- Don’t know

38. Which of the following signs would you associate with Khapra beetle?
- Hairy larvae
- Black-brown beetles
- Bunted grain
- Presence of larvae skins
- Flying beetles
- Beetles larger than 1 cm
- Insect feeding damage
- Fishy odour
- Don’t know

39. Which of the following signs would you associate with Barley Stripe rust?
- Rust pustules on stems
- Bunted grain
- Pink grain
- Rust pustules in stripes on leaves
- Pale green aphids
- Yellow-orange rust pustules
- Insect feeding damage to leaves
- Stripe rust on barley plant
- Don’t know

40. Which of the following signs would you associate with Russian Wheat Aphid?
- Bleached, curled heads and awns
- Insect feeding damage to grain
- Reddish-brown beetles
- Aphid with long antennae
- Rolled up flag leaf
- Pale green aphids
- Streaks on leaves
- Fishy odour
- Don’t know

**Section F: This is about you. The information that you provide is completely confidential.**

41. Which of these categories best describe you?
- Elders agronomist
- Landmark agronomist
- Private agronomist
- Company agronomist
- Please name: ____________________________
- Other: ________________________________

42. How many years have you worked as an agronomist?
- <1 year
- 1-5 years
- 6-10 years
- 11-15 years
- >16 years

43. Your Gender
- Male
- Female
- Other
44. What is the highest level of education that you have completed?
- Completed Year 10 □
- Completed Year 12 □
- Trade qualification □
- Diploma □
- Bachelor’s degree □
- Post-graduate qualifications □

45. Please indicate the age group that you fit into based on your last birthday.
- <21 □
- 22-27 years old □
- 28-33 years old □
- 34-40 years old □
- 41-47 years old □
- 48-53 years old □
- 54-60 years old □
- >60 years old □

46. How many farms would you regularly provide information to on a weekly basis?
- 1-5 □
- 6-10 □
- 10-15 □
- >16 □

47. What type of crops do you work with? (Please tick all that apply).
- Cereals □
- Legumes / pulses □
- No crops are grown □
- Oilseeds □
- Other (Please state):

48. What is the postcode of where you are currently based with work?

49. Which single rainfall zone represents the majority of your clients?
- Low □
- Medium □
- High □

Do you have any comments or questions that you would like to ask? (I will respond by email if you leave your details).

Please provide your details if you are willing to participate in the following training events (select your preference).
- Further discussion in relation to training □
- Training workshops □
- Both □

Name: ___________________________
Phone number: ___________________
Email: ___________________________

(This information will remain confidential and will not be passed onto any 3rd parties)

Thank you for participating in this survey. Your time spent doing this is greatly appreciated. The information collected will provide data to determine training requirements for agronomists.
Appendix C. Information Sheet

Participant Information Sheet

Research title: Are we going against the grain in training? Developing an adult education framework for the rural community

Dear Sir/Madam

This project is being funded by the Council of Grain Growers Organisation (COGGO), the University of Western Australia (UWA) and the Department of Agriculture and Food, Western Australia (DAFWA). The aim of the project is to investigate training requirements for both growers and agronomists, and develop a framework that provides the most effective method for increasing skills and capacity within the rural community.

Dominie Wright (UWA/DAFWA) is the investigator for this project. Data collection techniques in this research will include observations, interviews and survey questions from participants and facilitators of current training programs. Any interviews requested will be done at a time and place that is convenient for the participant.

All information provided by the participants will be treated as strictly confidential and will not be made available to anyone else. The interviews and observations will be digitally recorded and transcribed. All data will be kept in a locked filing cabinet until five years after the completion of the research when it will be destroyed. Any publications resulting from the research will not identify participants.

If you are willing to participate in this research, could you please sign the consent form. Should you wish to withdraw from the research, you may do so at any time without reason or prejudice.

If you wish to know more about this study, contact Dominie Wright via email dominie.wright@agric.wa.gov.au or +61 8 6488 2508. You may also contact the chief investigator Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au or +61 8 6488 3926. The results from this research will be used as the basis of PhD in Science Communication dissertation by Dominie Wright and will be available from Professor Longnecker.

Yours sincerely

Dominie Wright

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or concerns with the investigator at any time.

In addition, any person not satisfied with the response of the investigator may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Research Ethics Office at the University of Western Australia on +61 8 6488 3703 or by emailing hreo-research@uwa.edu.au

All research participants are entitled to retain a copy of any participant information for and / or / participant consent form relating to this research project.
Appendix D. Consent Form

Consent form for Research Participation

Research title: Are we going against the grain in training? Developing an adult education framework for the rural community

I _______________________ (the participant) have read the information provided and any questions that I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.

I understand that all identifiable information that I provide is treated as strictly confidential and will not be released by the investigator in any form that may identify me. The only exception to this principle of confidentiality is if the law requires these documents.

I have been advised as to what data is being collected, the purpose for collecting the data, and what will be done with the data upon completion of the research.

I agree that research data gathered for the study maybe published provided my name other identifying information is not used.

___________________________________________
Name of Participant

___________________________________________
Signature of Participant

Date

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or concerns with the investigator at any time.

In addition, any person not satisfied with the response of the investigator may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Research Ethics Office at the University of Western Australia on +61 8 6488 3703 or by emailing hreo-research@uwa.edu.au

All research participants are entitled to retain a copy of any participant information for and / or / participant consent form relating to this research project.
Appendix E. Interview protocol and questions

Participants Interview Protocol and Questions

This interview will be used to gather in depth information about the participants’ attitudes and behaviours in relation to the training course that they have recently attended.

Protocol

• Introduce myself as the researcher
• Confirm that the participant understands the terms to which they earlier consented. Particularly
  a) The purpose and length of the interview
  b) The nature of confidentiality
  c) That I will be recording the interviews and
  d) That they do not have to answer every question and may withdraw at any time without prejudice
• Ask if they have any additional questions or concerns before we commence
• Ask questions in a semi-structured format, where they do not need to answer in the suggested order if a participant brings up a topic earlier or raises new questions.
• At the conclusion of the interview, thank the participant and check whether they have any further questions.

Questions

1. Why did you enrol in this course?
2. What did you hope to learn from today?
3. What was the most useful session for you today? Why?
4. How will you use the information from this session?
5. Will you use the information learnt today to help make a change or an improvement in your work?
6. Which activity/session did you find the least useful today? Why?
7. Which sessions/activities did you find the most engaging? Why?
8. Can I contact you in 6 months time to discuss if there has been a change or improvement made on the farm in relation to this course? (If answer yes then use the follow up interview protocol).
9. Do you have any further questions or comments that you would like to ask or say in relation to workshops that are being held?

Could you please provide you Phone number and email address if you are happy to be contacted in 6 months time.
Name ____________________________
Phone number: ______________________
Email: ______________________________
Follow up interview question if the participant has agreed.

This interview will be used to gather in depth information about the participants’ attitudes and behaviours in relation to the training course that they have recently attended.

Protocol
- Introduce myself as the researcher
- Confirm that the participant understands the terms to which they earlier consented. Particularly
  a) The purpose and length of the interview
  b) The nature of confidentiality
  c) That I will be recording the interview either by video or by audio (dependent upon your preference) and
  d) That they do not have to answer every question and may withdraw at any time without prejudice
- Ask if they have any additional questions or concerns before we commence
- Ask questions in a semi-structured format, where they do not need to answer in the suggested order if a participant brings up a topic earlier or raises new questions.
- At the conclusion of the interview, thank the participant and check whether they have any further questions.

1. Looking back over the last 6 months, what have you changed in your work / on the farm since attending the course?
2. Could you please describe to me how it was before you attended the course.
3. Could you please describe for me, how things are now?
4. Out of these changes, is there one that stands out more (ie is more significant than the others) and why?
Observation Protocol Key

I will be sitting in and observing currently held training courses to determine what effective strategies are used for engagement with growers and agronomists. I will then be interview a minimum of 25% of the participants and the facilitator.

File identification: Codes for identifying individual observations and research participants are maintained in a codebook by the principal investigator. Data sheets containing identifying information will be stored securely in the same location. Data will be de-identified upon transcription into the database.

Criteria for scoring engagement during program delivery

Student engagement:

1. At least half of the participants are off task, using their phones (texting), or talking about things irrelevant to the program
2. Some participants are showing an interest in the program, but are easily distracted by others
3. Most participants (approx. 65%) are paying attention and occasionally actively participating by asking questions.
4. Most participants are paying attention and are regularly asking questions and participating actively in activities
5. The majority of participants (>80%) are paying attention, and are actively engaged with the course.

Facilitator characteristics:

1. The facilitator shows enthusiasm for the subject
2. The facilitator is able to connect with the participants (eye contact, uses participants names, encourages questions).
3. The facilitator encourages questions from the participants.
4. The facilitator provides relevant activities to enhance the learning experience of the participants
5. The facilitator demonstrates knowledge of the subject

Scoring: Observations are scored on a scale of 1 to 5 with the following general meanings: Observations will be made during each of the sessions held on the training day. 
1 = poor; 2 = marginal; 3 = satisfactory; 4 = good; 5 = excellent
Appendix F. Field day evaluation questionnaires

Field Day Evaluation

Name of field day: ______________________________________________________
Date: ________________________

Occupation: Farmer    Company agronomist    Private agronomist    Chemical rep
University    DAFWA    Other

How many years have you been working? ____

What crops do you work with? ____________________________________________

1. Please place a tick in the response that best describes your knowledge of the topic covered at today’s field day.

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<tr>
<th>Before today</th>
<th>No Knowledge</th>
<th>Some knowledge</th>
<th>Quite a bit of knowledge</th>
<th>Considerable knowledge</th>
<th>Thorough knowledge</th>
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2. Did you learn what you were hoping to learn?

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<th>No, not at all</th>
<th>A little</th>
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<th>Mostly</th>
<th>Yes, Fully</th>
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Comments?

3. Are you planning on using the knowledge that you learnt today? If so how?
(Feel free to use back if necessary.)

Thank you! Your responses provide important data for a PhD study, which will help understand how to provide information more effectively at field days and via other methods. UWA Human Ethics Approval Number: RA/4/1/6607
Appendix F. Field Day evaluations

Community Garden Conference Evaluation

Occupation: Community Gardener    Community Garden Manager
Community Garden Organiser    Other

How many years have you been involved in community gardens? ______

1. What session did you find the most useful? _________________________

2. Please place a tick in the response that best describes your knowledge of the topics covered today.

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3. Did you learn what you were hoping to learn?

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Comments?

4. Are you planning on using the knowledge that you learnt today? If so how?
(Feel free to use back if necessary.)

Thank you! Your responses provide important data for a PhD study, which will help understand how to provide information more effectively at field days and via other methods. UWA Human Ethics Approval Number: RA/4/1/6607
Field Day Evaluation

Name of field day: ________________________________

Date: ________________________________

Occupation: Farmer  Crop consultant  Extension specialist  Chemical rep
             Uni/Govt  Other

How many years have you been working? ______

What crops do you work with? ________________________________

1. Please place a tick in the response that best describes your knowledge of the topics covered at today's field day.

   Before today
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<tr>
<th>No Knowledge</th>
<th>Some knowledge</th>
<th>Quite a bit of knowledge</th>
<th>Considerable knowledge</th>
<th>Thorough knowledge</th>
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   After today
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<tr>
<th>No Knowledge</th>
<th>Some knowledge</th>
<th>Quite a bit of knowledge</th>
<th>Considerable knowledge</th>
<th>Thorough knowledge</th>
</tr>
</thead>
</table>

2. Did you learn what you were hoping to learn?

   No, not at all  A little  Some  Mostly  Yes, Fully

   Comments?

3. Are you planning on using the knowledge that you learnt today? If so how?
   (Feel free to use back if necessary.)
Appendix G. Abstract accepted for 23rd European Seminar on Education and Extension

EVALUATION OF TRAINING AS PART OF THE CAPACITY BUILDING LADDER IN AUSTRALIAN AGRICULTURE

Dominie Wright\textsuperscript{AB}, Ann Grand\textsuperscript{C}, Bill MacLeod\textsuperscript{D} and Lynette K Abbott\textsuperscript{A}.

\textsuperscript{A}School of Earth and Environment, The University of Western Australia, Crawley, Western Australia

\textsuperscript{B}Department of Agriculture and Food, Western Australia, South Perth, Western Australia.

\textsuperscript{C}School of Animal Biology, Science Communication, The University of Western Australia, Crawley, Western Australia

\textsuperscript{D}School of Plant Biology, The University of Western Australia, Crawley, Western Australia

Corresponding author: Ms Dominie Wright. dominie.wright@research.uwa.edu.au ; dominie.wright@agric.wa.gov.au

Paper presentation

Theme: 6 – Upgrading and upskilling extension systems: transformation or new wine in old bottles?

Purpose: This paper reports on the training events that farmers and agronomists prefer to attend and evaluates this training to determine: a) if their knowledge levels increased, and b) how they intend to use this new knowledge.

Context description: It is vital that farmers and agronomists continue to increase their skills and knowledge for Australian agriculture to remain competitive. The capacity building ladder proposed by Coutts and Roberts (2011) provides a model, which shows that training is an important component for participants within the agricultural industry.

Research question and design: A mixed methods approach was used to determine: a) what training farmers and agronomists preferred to attend; b) why they preferred this training; and c) did the knowledge levels of participants increase as a result of attending the training.

Data collection and analysis: A targeted survey was conducted with farmers and agronomists within the Australian grains industry to determine the preferred training events using two separate questionnaires; one for growers and one for agronomists. The distribution of the questionnaires is described in Wright et al. (2016). Data collected from the survey were analysed using non-parametric tests to determine the influence of the demographic characteristics of the participants on training preference. Subsequently, the value of the training events was assessed using a one-page questionnaire and participant interviews. Thematic coding using a combination of templates and an inductive approach was used (Fereday and Muir-Cochrane 2006).

Results: Two major types of training were preferred; field days and workshops. Both farmers and agronomists preferred field days. Farmers preferred field days held on
farmer’s properties because: a) the material presented would be more relevant to their farm, b) informal interactions could occur, and c) the trials demonstrated are visual. In contrast, agronomists preferred and valued formal workshops as found by Miller and Cox (2006). Growers thought workshops were generally redundant. Five workshops and ten field days were evaluated in Australia, and Washington State and Kansas State, USA for their value as training events. In general, knowledge levels increased with participation and was related to the activity that the participant attended.

Conclusion: This research demonstrated farmers and agronomists value field days and workshops as they provide an opportunity for interaction and learning of new information. Both farmers and agronomists preferred to attend field days. However, agronomists preferred to attend formal workshops whereas farmers did not. The evaluation of these activities showed that knowledge levels increased with participation, and that many participants indicated that they would use this new knowledge on the farm or in the workplace. However, further work is required to whether the new knowledge was used.

References


Appendix H. Invited paper for the special issue in the International Journal of Agricultural Extension

Training as Part of the Capacity-Building Ladder in Australian Agriculture

Dominie Wright\textsuperscript{A}, Ann Grand\textsuperscript{B}, Bill MacLeod\textsuperscript{C} and Lynette K Abbott\textsuperscript{A}.

\textsuperscript{A}UWA School of Agriculture and Environment, The University of Western Australia, Crawley, Western Australia

\textsuperscript{B}Department of Primary Industries and Regional Development, Western Australia.

\textsuperscript{C}School of Biological Sciences, The University of Western Australia, Crawley, Western Australia

Corresponding author: Ms Dominie Wright. dominie.wright@research.uwa.edu.au; dominie.wright@agric.wa.gov.au

Abstract

To maintain the efficiency and economy of their farming, Australian farmers and advisers perceive a need to continually update their skills and knowledge by attending informal and formal training activities such as field days, workshops and grower group meetings. Using a mixed methods approach, this research evaluates: a) what types of training events farmers and advisers prefer; b) why they prefer that type; and c) if their knowledge increased as a result of training. The data were analysed using non-parametric tests and inductive thematic coding before triangulating the results. Farmers preferred field days held on farms, because of the relevance of the location and field experiments and the opportunity for informal interactions, but thought workshops were redundant. Advisers preferred formal workshops, because they provided interaction with specialists. Participants liked to attend grower groups because they were local, interactive and informative. However, the majority of grower groups are made up of farmers and only half the advisers surveyed belonged to one. Participants’ knowledge increases after training and is related to the activity attended. Many participants indicate that they would use their new knowledge on their farm or in the workplace. This research shows that the demographic characteristics of farmers and advisers influence the type of training they will attend; this information can be used to refine existing and develop new training events.

Keywords: Field days, workshops, grower groups, farmers, advisers, knowledge levels, evaluation
Introduction

The political, social and economic climate has changed how extension (broadly meaning training and education) reaches Australian farmers (Carberry et al. 2002; Cristovao et al. 2009; Jones and Garforth 1998; Marsh and Pannell 2000). Extension has evolved; in the 1960s it was a government-provided service but by the 1990s it was predominantly delivered by advisers from private and commercial and commercial companies (Keogh and Julian 2014; Marsh and Pannell 2000). However, because state agencies were still providers of research information they remained responsible for the dissemination of information to primary extension agents such as advisers (Marsh and Pannell 2000). These changes correspond to changes in farming in Australia. Farming has become more mechanised and specialised (Keogh and Julian 2014), and farmers now need more specialist advice and targeted information (Cristovao et al. 2009; Jones and Garforth 1998; Marsh and Pannell 2000). Farms have also grown in size since the 1990s. In Western Australia, farm size has trebled (from 1000 ha to 3,500 ha under crop); increases in other states have been lower, to an average size of 1000 ha (Keogh and Julian 2014).

In rural communities, informal education programs enable change in individuals, communities and industries (Feder et al. 2011; Vanclay and Leach 2011). In Australia, since the early 2000s, extension has focussed on capacity-building and community engagement (Coutts and Roberts 2011). This paradigm relies on interactions between five models: a) facilitation and empowerment, b) technological development, c) information access, d) training and e) consultancy. These models can work alone, but are ineffective for capacity-building unless linked (Coutts and Roberts 2011). Vanclay and Leach (2011) argue that extension is only related to the primary industry sector, and yet, as the analogous example of the American university land-grant system shows, it is much more. In the USA, extension not only operates in rural communities but also in cities, and includes nutrition programs, youth programs, community gardens and master gardener programs.

Grower groups in Australia are very popular among the farming community and have increased in number since 1990, when the Australian government encouraged rural communities to work together, initially to protect water, vegetation and soil (Gianatti and Carmody 2007). These groups continue to be productive, conducting research trials, providing local publications and running field days (Anil et al. 2015; Gianatti and Carmody 2007). In Western Australia, there are 40 major grower groups (Grower Group Alliance 2016) and in Victoria there are seven (Victorian Grower Group Alliance 2016).

It has been argued that extension activities such as field days, workshops, seminars and grower group meetings are training activities for farmers and advisers (Keogh and Julian 2014; Coutts and Roberts 2011; Miller and Cox 2006). However, it is not clear which activities farmers and advisers prefer. It is also unclear whether demographic characteristics such as education levels, age and place of residence influence the activities in which they choose to participate. However, any training program should be evaluated to determine its impact and effectiveness (Roberts and Coutts 2011; Alvarez et al. 2004; Dart et al. 1998). For extension activities this includes determining their effectiveness to support capacity building and engage participants.

Alvarez et al. (2004) define effectiveness as the examination of the variables that increase or decrease the success of training at different stages of the program. Haccoun and Hamtiaux (1994) suggest a simple procedure for measuring training effectiveness: using the ‘internal reference’ strategy to assess participants’ knowledge before and after training, on the assumption that training with relevant content will show more change than training with irrelevant content (Salas and Cannon-Bowers 2001). A considerable body of literature...
discusses the successes or failures of extension strategies in developing countries (Amudavi et al. 2009; Yang et al. 2008; van de Berg and Jiggins 2007) but there is very little research on their use in the grains industry of developed countries. This paper discusses the training preferences of Australian grain farmers and advisers and an evaluation of these activities to determine if farmers’ and advisers’ knowledge changed and how they planned to use this knowledge.

Theoretical Background

The capacity-building ladder proposed by Coutts and Roberts (2011) consists of five main components. Three form the legs of the ladder: i) information access; ii) facilitation and empowerment and iii) technological development. The other two, training and consultants, form the rungs of the ladder. These components are complementary, allowing a training participant to ‘climb the ladder’; in other words, to build their skills, abilities and resources. The training model component of the capacity-building ladder is specifically designed to increase the skills and understanding of participants in the agricultural industry. In general, training programs have set curricula and learning objectives and must meet the standards (Llewellyn et al. 2006) required under the National Qualifications Framework in Australia, being part of the Vocational Education and Training (VET) system. VET allows participants to gain accreditation for their learning and training (Coutts and Roberts 2011). However, this training component does not take into account informal training events, such as field days and grower groups, yet informal knowledge is very valuable in agriculture. Previous research (Vanclay 2004; Kilpatrick and Fulton 2003; Kilpatrick and Johns 2003; Wenger 2000) has shown that farmers are social learners, and most of their learning is ‘done on the job’ and through informal training. It might be assumed that advisers’ preferences for training are different to those of farmers; however this assumption has not been confirmed for the Australian grains industry.

Three main frameworks are widely used to evaluate extension programmes: i) Bennett’s hierarchy, ii) Wisemann’s six steps, iii) the MERI (Monitoring, Evaluating, Reporting and Improving) framework (Keogh and Julian 2014; Roberts and Coutts 2011; Crisp 2010; Fulton et al. 2003). Evaluations designed from these frameworks can be designed before the program to help set the priorities and the resources required, or after the program to assess the impact (Keogh and Julian 2014; Maredia 2009) However, none are suitable for evaluating informal training such as field days, because they are designed for formal learning activities where baseline standards have been determined so that the amount of change can be measured (Llewellyn et al. 2006). A common strategy used in the extension industry to evaluate informal learning is the internal reference strategy developed by Haccoun and Hamtiaux (1994) This measures the knowledge levels of participants before and after a training event (Salas and Cannon-Bowers 2001).

Thus, in assessing the effectiveness of extension activities, for example field schools, participants’ knowledge should be tested before and after training, and in some cases behaviour change monitored. Glaze and Ahola (2010) monitored participants’ change in knowledge in a training program by asking them to self-evaluate before and after training using a Likert Scale (Likert 1932). However, Schmitt et al. (2000) found that participants’ education level influenced their perception of their knowledge before a training course; those with higher education levels generally self-ranked lower than those with lower education levels.
Research Methods

This paper reports on part of a larger project examining the training needs of farmers and advisers in the Australian grains industry in relation to pest and diseases in their crops (Wright 2017).

For this study, a farmer was defined as a person who lives and farms land to produce grain crops and an adviser was defined as a person employed by grain farmers to provide technical information and advice for grain crop production (Wright et al. 2016).

Approval for this work was obtained from the Human Research Ethics Committee of The University of Western Australia (RA/4/1/6607).

Data were collected using three different methods: 1) surveys of farmers and advisers in the Australian grains industry to determine what types of training they preferred to attend; 2) evaluation of field days and workshops using questionnaires and semi-structured interviews; 3) contemporaneous field notes of observations of activities and participants at field days and workshops.

Surveys

This paper reports only on the data from the identical sections of the surveys (one for farmers and one for advisers) (see Appendix A), allowing comparisons to be made between the two groups. These sections covered: what type of training they had attended, including field days, workshops, grower group meetings, webinars and seminars (questions 7, 11, 20), what barriers prevented them from attending training events (8, 14), what they liked about the training they had attended (9, 12, 22) and how could it be improved (10, 13, 23), whether they belonged to a grower group (15), how often they attended the meetings (17), and what they liked and disliked about the meetings (18, 19). The final section collected demographic information (39–44).

The questions were designed to be simple and easy to understand and provide reliable and valid measures (Fowler 2009; Dillman et al. 2009). The surveys were tested with colleagues and farmers before distribution (Wright et al. (2016). The surveys were distributed (i) as a link to an online survey (on the Qualtrics platform) sent out via newsletters, (ii) on paper at regional meetings during March 2014 and (iii) posted to farmers and advisers from the Birchip Cropping Group (Wright et al. (2016). Seven hundred paper surveys were distributed by routes 2 and 3. It was not possible to accurately determine the number of people who received the online request, as the link was distributed via newsletters but the Qualtrics data records show that 264 surveys were started and 50% were completed.

Questionnaires and interviews

Data were collected via (i) questionnaires (Appendix B) and (ii) interviews (Appendix C) with participants attending three field days (Esperance Downs Research Station (EDRS), the Liebe Group Field Day and West Midlands) held in Western Australia in September 2014. These locations were selected as they cover a range of cropping systems and low to high rainfall zones. These field days are very popular with farmers and advisers in those regions and more than a hundred people attended each event. Data were also collected from participants in three workshops in Victoria.

To evaluate change in knowledge, a one-page questionnaire (Appendix B) was administered during the events. Participants were asked to self-rate their knowledge using a Likert scale of 1-5; to rate their level of satisfaction with the event (1-5) and how they planned to use their new knowledge (an open answer question). Demographic information was also collected. The
questionnaires were designed to be quick and simple for participants to fill in. Approximately 200 questionnaires were handed out at the three field days and 30 at the workshops. A total of 124 questionnaires was returned.

The interviews were semi-structured, and designed to be casual and ‘chatty’, so that participants did not feel threatened and were happy to answer the questions. The questions were designed to complement the questionnaire. Participants were asked: i) what they hoped to learn, ii) what was the most useful thing they had learned, iii) what was the least useful, iv) what was the most engaging element of the event and (v) how would they use the information learned. Thirty-two people were interviewed; participants were approached at random by the lead researcher (DW) as she walked around at the field days. Consent to participate was recorded verbally. The interviews were recorded on a hand-held digital recorder.

Field notes
At each of the field days the lead researcher (DW) recorded notes on the format of the field day, the approximate number of people present, and how participants interacted during the different sessions.

Data Analysis
Types of training survey
The quantitative data were analysed using SPSS23 (IBM, 2016) using cross tabulation and Pearson’s Chi-Square ($X^2$) to determine the influence of occupation, age, sex, education and location on the types of training attended by participants, and barriers to attending training. If Pearson’s Chi-Square failed the assumption that more than 20% of the cells had a frequency count of less than 5, then the Likelihood ratio statistic test was used in its place. This test is preferred when samples are small and still uses a chi-square distribution (Field 2013).

The response rate for the survey is estimated to be 26%; it was not possible to determine the exact number of requests disseminated online. Forty-seven surveys with incomplete demographic data, such as no postcode, were not included in the analysis. Due to the low number of returns from Queensland, NSW, Victoria and South Australia, the data collected from these states were combined as “Eastern Australia” (EA) which is used in the corresponding cross tabulation and Pearson’s Chi-Square analysis (Wright et al. 2016).

The demographic data formed the 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 or Eastern Australia) and Sex (male, female).

Evaluation questionnaires and interviews
The questionnaire data were split into groups based on whether they came from workshops or field days and which state they were held in. The quantitative data were anyalised using a Wilcoxon Signed Rank test to compare participants’ knowledge before and after training. A Kruskal-Wallis test was used to examine the influence of occupations and length of working on knowledge and on the amount of learning participants felt they received. If the result from the Kruskal-Wallis test was significant, a means test was conducted to determine the median levels of each category. This was followed up with a Mann-Whitney U-test to determine if there were any significant differences between the categories. A Bonferonni adjustment was done on each Mann-Whitney U-test to reduce the type 1 errors.

The qualitative data (the open responses from the questionnaire and the interview data) were themed using an inductive approach informed by previous research and developed
incrementally (Fereday and Muir-Cochrane 2006). Frequency counts were used to determine what participants liked about the training they attended, how the training could be improved and what topics they would like training on. The interview transcripts were analysed using NVivo11 (NVivo 2016). A cross-coding check on six interviews was completed using the coding template; a match of 82% was achieved.

In the following discussion, the interview data are identified thus: the first two letters refer to the location of the training event e.g. WA indicates Western Australia, ‘F’ indicates a farmer and ‘A’ an adviser, and the number refers to the interview number.

Results

Field day attendance

Field days are attended by farmers and advisers. They are held on farms to provide information and demonstrate results from field experiments associated with growing crops, new varieties released, and new cropping practices. In Australia, they are held in conjunction with grower groups and local state departments of agriculture and have specialised speakers based on pertinent topics for that area.

Participants who attended these days were: farmers (62%), advisers (13%), other occupations (11%), government (8%), sales (4%) and university (2%). Participants had been working from less than one year to more than 31 years.

Participants came to field days for a variety of reasons, ranging from compulsion (work-related), wanting a better and deeper understanding on a range of subjects, networking with other farmers, colleagues and specialists, to gaining knowledge and improving skills:

“We’re new to the area yeah we wanted to know a bit more about agriculture in the least high rainfall areas. WAF6

Many participants described field days as informative (22%), interactive (19%), visual (13%) and providing an opportunity for networking (13%).

“Lets you keep up to speed with anything that’s happening in the area” WAF3.

“50-50 get it in the paper, read it and here you pick up a lot of visual” WAF1.

The demographics of the participants influenced their attendance at field days. Men participated in four or more field days compared to women (X² (n= 245), 2, = 9.356, p ≤ 0.05) (Figure 1A). A greater proportion of participants from Western Australia (WA) attended more than four field days, whilst a greater proportion of Eastern Australia (EA) participants attended between one and three field days (Likelihood ratio X² (n= 241), 2, = 9.289, p ≤ 0.05) (Figure 1B). Participants who had completed higher education were more likely to attend field days than those without high-level qualifications (Likelihood ratio X² (n= 248), 2, = 10.746, p ≤ 0.05) (Figure 1C). Only 12% of advisers surveyed did not attend any field days while 56% attended 4 or more field days during the season (Likelihood ratio X² (n= 248), 2, = 14.386, p ≤ 0.001) (Figure 1D). The only demographic variable that did not influence attendance was participants’ age (p > 0.05).
Figure 1. Demographic influences on numbers of field days attended. A) Sex B) Location (Eastern Australia or Western Australia) C) Education level D) Occupation

Field notes of participants at field days showed a number of similarities:

1. Some participants tended to stand to one side, only interacting amongst themselves or with speakers after the talks. They did not interact with other farmers.

2. Where speakers did not have a microphone, or a loud voice, only those who were standing directly in front of the speaker were able to hear what was being said. In these situations, participants towards the back tended to form small groups speaking to each other rather than listening.

3. Speakers were able to catch the attention of the participants by using props, having a loud voice, or being enthusiastic about what they were showing and talking about.

Participants expressed a range of views about what they hoped to learn, ranging from broadening knowledge to gaining new ideas and techniques:

The major barrier to attending field days was lack of time (16%). Some participants did not find field days useful (7%) and some felt the topics were irrelevant (7%). Location had a significant negative impact on attendance; participants in EA experienced this more than those in WA.
Figure 2: Percentage of farmers and advisers and the number of formal workshops attended between January 2013 and June 2014. Significant differences were seen between farmers and advisers at $p \leq 0.001$ or $* \ p \leq 0.05$
**Figure 3.** Influence of age on participation of farmers and advisers in workshops between January 2013 and June 2014. There was a significant difference between age groups at $^*p \leq 0.001$ or $^*p \leq 0.05$

**Formal workshop attendance**

Workshops are formal training events, with set learning outcomes and generally focussed on a specific topic, and led by topic specialists. Workshop formats include lectures and practical sessions. Participants liked workshops that were informative (40%), interactive (12%) and local (12%). The attendance of farmers and advisers at formal workshops varied significantly (Figure 2); a higher proportion of advisers (54%) attended three or more workshops on agronomy compared to 27% of farmers attending this many workshops ($X^2 (n= 216), 2, = 19.15, p \leq 0.001$). Only 4% of advisers did not attend any workshops on agronomy, compared to 16% of farmers. For every other topic at least 37% or more did not attend any workshops, indicating that agronomy workshops were most highly valued. The most frequent reasons given for not attending workshops were: (i) lack of time (60%), (ii) distance from venue (35%) and (iii) perceived irrelevance of topics (31%).
Participants’ age had a significant influence on the number and type of workshops attended (Figure 3). Farmers and advisers who were less than 30 years of age attended workshops more frequently than other participants.

The number of years a participant had been working had a significant influence on attendance at the disease identification (Likelihood ratio $\chi^2$ $(n=188 (6), = 16.308, p \leq 0.05$), farm management (Likelihood ratio $\chi^2$ $(n= 196 (6), = 15.967 p \leq 0.05$) and pest identification workshops (Likelihood ratio: $\chi^2(n= 200 (6), = 18.875, p \leq 0.05$).

Three workshops in Victoria were examined in detail by observation and interviews with participants. These workshops were formal training events using lectures and practical exercises to teach advisers about soil testing, interpreting results from soil testing and understanding fertiliser regulations. Participants in the course were either in sales (63%) or were advisers (37%); no farmers attended these courses. The majority of participants came to these workshops because it was compulsory:

*My branch manager thought it was a good idea for me to come. And then obviously when he explained what it was I thought it was a good idea as well. Just basically to broaden my knowledge on the whole fertiliser soil aspect of the job which I am currently working in.*  

BPA3

Participants hoped for a variety of outcomes, from broadening knowledge, to achieving accreditation, to learning new ideas and techniques:

*I hoped to learn about soil science but also to gain the accreditation of being Fert. Care accredited.*  

BPA7

*I wanted to come away with a lot more understanding of fertilisers, soil testing, and all that sort of thing which I think I have a good base knowledge now. I need to go away and put a little bit more of that into practice, working with [name] the economist at work.*  

BPA9

Many of the participants said the information or new skill they learnt at these workshops would be used every day at work, or applied to the farms for which they were consultants. Some felt that they had become more aware of issues or had a greater understanding of issues faced by their clients:

*Hopefully it will make it a bit more useful for the farmer, hopefully he will get more useful information out of me rather than just hand ball it over to somebody else that deals with it.*  

BPA2

The majority of participants at the workshops thought it helped to increase their knowledge, especially in how to solve problems such as controlling weeds and pests in crops, and that they could use this new knowledge to improve crop growth.

**Grower group meetings**

Participants liked attending grower groups because they are local (26%), interactive (17%) and informative (17%). Some participants (15%) said that they enjoyed networking in these groups. There was a significant difference between farmers and advisers in their membership of grower groups: the majority of farmers (82%) who responded to the survey belonged to a grower group, while only 52% of advisers did $(\chi^2(n=242 (1) = 24.93 p \leq 0.001$).

The age of the participants influenced membership of a grower group. A smaller proportion of participants (51%) who were less than 31 years of age belonged to a grower group,
compared to a larger proportion (73%) of those that were older than 31 ($X^2 (n=242 (2) = 7.786 p \leq 0.05$).

Place of residence of the participant also influenced membership; a smaller proportion (23%) of WA participants belonged to a group compared to 41% of participants from EA ($X^2 (n=235 (1) = 9.35 p \leq 0.05$). Place of residence also influenced the frequency of attending the grower group meetings; 42% of participants located in EA attended at least 25% of the meetings, while only 22% of those located in WA attended 25% or more of the meetings. Thirty-four per cent of participants from WA attended at least 75% of the meetings while only 19% of participants from EA attended 75% of the meetings ($X^2 (n=162 (4) = 12.73 p \leq 0.05$).

Some participants (29%) said that time constraints prevented them from attending grower group meetings. Others (12%) noted that the distance they had to travel had a strong impact on their ability to attend; some meetings were more than 100km from where they lived. Some participants (12%) would like to see more structure provided in the meetings, while 5% felt that the invited speakers needed to improve their presentation skills. A frequent comment made in the open responses was that participants felt that the meetings tended to be repetitive.

**Other training events**

The other types of training events attended by participants included; (i) meetings (9%), (ii) updates (regional and agribusiness) (32%), (iii) seminars (23%), (iv) informal workshops (23%) and (v) webinars (14%). These events were mostly attended by advisers (71%) rather than farmers (44%) ($X^2 (n=242 (1) = 18.07 p \leq 0.001$).

The majority of participants found these types of training to be informative (55%). Some (21%) liked the fact they were held close to home and so required less travel (or for webinars, no travel at all). A small proportion (7%) enjoyed the opportunity for interaction and networking.

The level of education influenced attendance; only 39% of those who had secondary school as their highest level of education attended other events compared to 64% of university-educated participants ($X^2 (n=242 (2) = 10.896 p \leq 0.05$).

**Change in knowledge levels at field days**

A Wilcoxon Signed Rank Test showed a significant increase in participants’ knowledge levels after participating in field days ($z = -7.64 p \leq 0$ with a large effect size (0.40)). The 25th percentile of participants’ knowledge increased from ‘some knowledge’ ($Md = 2$) to ‘moderate knowledge’ ($Md = 3$). The 50th and 75th percentiles stayed the same, at moderate and considerable respectively (Figure 4).

A Kruskal-Wallis test showed that occupation significantly influenced change in knowledge before and after field days. (Knowledge before $X^2 (n= 116), 5 = 15.80 p \leq 0.05$; knowledge after $X^2 (n= 116), 5 = 14.21 p \leq 0.05$). Government employees ranked the lowest for knowledge after the field day; their median score was the same as those who identified as farmers ($Md = 2$, moderate level). Advisers and sales people had a median knowledge of 3 (considerable) while university participants had a knowledge level of 2.5. Advisers had a significantly higher median score than government participants (Mann-Whitney U-test, $U = 27.5, z = -3.04, p = 0.007$, Bonferroni adjustment = 0.01). There were no significant differences between government participants and other occupations.
The effect of education was not significant. University participants (mainly students) ranked themselves lowest in knowledge before the field day; their median knowledge was 1.5 (a little knowledge) compared to all other occupations, which had a median knowledge of 2 (some knowledge). However, a Mann-Whitney U test conducted on this showed that the differences between university participants and other occupations were not significant ($p > 0.01$ with the Bonferroni adjustment).

The length of time working had a significant influence on knowledge (Kruskal-Wallis test ($X^2 (n=110), 4 = 11.06 p < 0.05$)). Participants who had worked for 11 to 20 years had a higher mean rank than the other participants, however, the Mann Whitney U test conducted showed that there were no significant differences ($p > 0.012$, Bonferroni adjustment) between this group and other groups.

![Figure 4](image.png)

**Figure 4.** Knowledge levels of participants before and after training events (field days and workshops) held in different locations. Each box corresponds to the 25th and 75th percentile of scores while the bar within the box represents the median (50th percentile score). Whiskers on each box indicate the range of scores (1.5* inter-quartile range). Circles denote outliers.
Discussion

This research demonstrates that farmers and advisers value training events for the opportunity they offer for interaction with other farmers, specialists and advisers, and as a space to gain new knowledge that they can take back to the farm or workplace. Field days are known to be an effective route for learning, providing opportunities for farmers, advisers and other people in rural communities to assess new technologies, including crop varieties and farm equipment suitable for use in their area (Wortmann et al. 2011; Amudavi et al. 2009). Miller and Cox (2006) argue that field days and workshops are the best methods for transferring information to farmers. However, this research shows that farmers prefer interactive events, such as field days, to formal workshops. Field days are also very popular with advisers, with the majority attending four or more a year. Farmers have been characterised as social learners, who prefer informal methods of learning that use a ‘hands on’ approach, and interacting with other farmers and researchers (Anil et al. 2015; Franz et al. 2010; Kilpatrick and Johns 2003; Wenger 2000). Such informal interaction allows them to compare views and values before making a change on their farm (Eckert and Bell 2006; Kilpatrick and Johns 2003).

Absolutely, we’re doing it all now but just wanted confirmation what we’re doing is the right thing that we’re doing. WAF5

Miller and Cox (2006) showed that farmers thought field days that demonstrated small plot field experiments (e.g. those held in research stations) were not indicative of what might occur on their own farms but if these same experiments were held on a farm, other farmers were more interested in the results.

Farmers thought that workshops were redundant because of when they were held, and tended to carefully choose which they attended. Farmers preferred workshops in which they could interact with other farmers (Miller and Cox 2006), and attending specific workshops may not provide this desired interaction. This supports the findings of Miller and Cox (2006); farmers placed a higher value on agronomy workshops (84% attendance) compared to workshops on pest and disease identification, herbicide application, and other topics (63% attendance). This may be related to the relationship between advisers and farmers; in the Australian grains industry, advisers are generally employed in relation to the cropping phase of the farm system, providing advice to farmers about specific issues such as pest and diseases in crops and the use of herbicides. Farmers may feel they have no need to attend workshops on these specific topics because the advisers they employ provide this knowledge.

These observations demonstrated most participants’ preferred informal interaction amongst themselves or with the speakers rather than the formal knowledge transfer that would be used in a workshop.

Kilpatrick (1997) suggested that attending training, and planning to attend training, is related to participants’ education level, arguing that people with a lower level of education generally do not see a need to attend formal training, which could be due to their lack of confidence and lower literacy levels (Kilpatrick 2000). This research shows education level had no influence on participation in formal workshops. However, those with a university education were more likely to attend webinars. Such technology-mediated events can support people spread across a large geographical area but they do not allow the informal networking opportunities that farmers prefer (Anil et al. 2015; Wenger 2000).

This research has uncovered new data on the influence of participants’ age, education levels, occupation and location on the likelihood of them belonging to a grower group. Grower groups can be considered a community of practice (Anil et al. 2015; Gianatti and Carmody 2007; Wenger 2000; 2009) that provides an effective learning opportunity (Kilpatrick and
Johns 2003). Membership of grower groups is very popular, as they create a network of like-minded people who might be facing the same or similar problems on their farms. The interactions at grower groups thus offer an opportunity for reassurance that a participant’s farming practices are correct. Gianatti and Carmody (2007) found that many farmers in WA belong to more than one group; they may belong to a small local group, a larger, regionally-focused group and a state-wide group. Anil et al. (2015) found the proportion of farmers who actively participated in the groups varied but was related to where the farmer lived, and whether the grower group was a large state-wide group with a very widely dispersed membership or an active local group. Lack of time and having to travel a long distance certainly constrain attendance but grower groups, especially local groups, are valued for the interaction with other members and the informal exchange of information.

Coutts and Roberts (2011) capacity-building model places high importance on using training to increase farmers’ skills and knowledge but there is little research on capacity-building for advisers, and no evaluation of knowledge gain or how advisers intend to use new knowledge after training. It is clear that Coutts and Roberts (2011) based their deductions on formal training events, with set curricula and specific learning objectives, whereas informal learning events are flexible in their content and objectives (Malcolm et al. 2003; Marsick and Watkins 2001; Merriam 2001). Most participants preferred informal interaction amongst themselves or with the speakers, rather than the formal knowledge transfer that would be used in a workshop. Kilpatrick and Johns (2003) argue that farmers use a variety of informal learning to educate themselves and increase their capacity and skills. Australian field days very much fit into this informal learning pattern and both farmers and advisers who attended informal events showed an increase in knowledge. The knowledge gained during training benefits participants in some way, whether on the farm or at work, for example to improve crop production or control weeds but there are also benefits in simply having time to think and ponder the issues they face. Further research is needed to determine if participants did subsequently use their new knowledge in the ways they planned but it is clear that informal training events should form part of the capacity-building ladder.

Conclusion

This research is the first study to evaluate the impact of training events such as field days and workshops on the knowledge levels of farmers and advisers in the Australian grains industry. Farmers and advisers see training as engaging, useful and important for capacity-building. Participants’ knowledge increased after attending training and most participants feel they will be able to use their new knowledge on their farm or in their consultancy.

Training events can be categorised as formal (e.g. workshops) or informal (e.g. field days). Preferences for training types and topics vary considerably between farmers and advisers. Farmers prefer to attend informal, interactive events such as field days, which represent conditions similar to those on their farm. Such informal interaction allows farmers to compare their new knowledge to existing values and beliefs. Advisers are more likely than farmers to attend formal workshops that offer them an opportunity to network with colleagues, researchers, specialists and farmers.

Demographic characteristics such as sex, location, occupation and length of working life affect participation in training. Greater understanding of the influence of demographic characteristics and preferences for type of event should be used to improve the design and relevance of training events.
Conflicts of Interest:
No potential conflict of interest are reported by the authors.

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References


Likert, R. 1932. A technique for the measurement of attitudes. *Archives of psychology*.


Wright, D. 2017. Are we going against the grain in training; developing an information and training framework for farmers and agronomists in australia. PhD, The University of Western Australia.


Appendix A: Training preferences survey

7. In the last 12 months how many field days have you attended?

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8. What prevented you from attending any field days? (Tick all that apply)

- Distance to travel was too far ☐
- I do not find field days useful ☐
- Lack of childcare facilities / help ☐
- No field days were held in my district ☐
- No time available to attend ☐
- Time of day was inconvenient ☐
- Topics were not relevant to my situation or me. ☐
- Other: ___________________________________________

9. What did you like about the field days?

a. ____________________________________________

b. ____________________________________________

c. ____________________________________________

10. Do you have any suggestions on how the field day(s) could be improved?

a. ____________________________________________

b. ____________________________________________

c. ____________________________________________

11. In the last 12 months how many times have you attended workshops on the following subjects?

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<td>Farm business training</td>
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<td>Farm management</td>
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<td>Herbicide application</td>
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<td>Precision agriculture</td>
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<td>Other:</td>
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</table>

12. What prevents you from attending these workshops?

- Cost of attending was too high ☐
- Distance to travel was too far ☐
- I do not find workshops useful ☐
- Lack of childcare facilities / help ☐
- No time available to attend ☐
- None were held in my district ☐
- Time of day was inconvenient ☐
- Topics were not relevant to my situation or me. ☐
- Other: __________________________

13. What did you like about these workshops?

a. __________________________

b. __________________________

c. __________________________
14. Do you have any suggestions on how the workshop(s) that you attended could be improved?
   a.__________________________________
   b.__________________________________
   c.__________________________________

20. Have you attended any other seminars / learning events / information events in the last 12 months?
   Yes ☐ ☐ Please go to Q 21
   No ☐ ☐ Please go to Q 24

21. Please name these events
   a.__________________________________
   b.__________________________________
   c.__________________________________

22. What did you like about these events?
   a.__________________________________
   b.__________________________________
   c.__________________________________

23. Do you have any suggestions on how the events that you attended could be improved?
   a.__________________________________
   b.__________________________________
   c.__________________________________

41. Gender
   Male ☐
   Female ☐
   Other ☐

43. What is the highest level of education that you have completed?
   Completed Year 10 ☐
   Completed Year 12 ☐
   Trade qualification ☐
   Diploma ☐
   Bachelor’s degree ☐
   Post-graduate qualifications ☐

44. Please indicate the age group that you fit into based on your last birthday.
   <21 ☐
   22-27 years old ☐
   28-33 years old ☐
   34-40 years old ☐
   41-47 years old ☐
   48-53 years old ☐
   54-60 years old ☐
   >60 years old ☐

47. What is the postcode of where your farm is located?
   ____________________________________
14. Do you have any suggestions on how the workshop(s) that you attended could be improved?
   a. ____________________________
   b. ____________________________
   c. ____________________________

20. Have you attended any other seminars / learning events / information events in the last 12 months?
   Yes ☐  Please go to Q 21
   No ☐  Please go to Q 24

21. Please name these events
   a. ____________________________
   b. ____________________________
   c. ____________________________

22. What did you like about these events?
   a. ____________________________
   b. ____________________________
   c. ____________________________

23. Do you have any suggestions on how the events that you attended could be improved?
   a. ____________________________
   b. ____________________________
   c. ____________________________

41. Gender
   Male ☐
   Female ☐
   Other ☐

43. What is the highest level of education that you have completed?
   Completed Year 10 ☐
   Completed Year 12 ☐
   Trade qualification ☐
   Diploma ☐
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44. Please indicate the age group that you fit into based on your last birthday.
   <21 ☐
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   28-33 years old ☐
   34-40 years old ☐
   41-47 years old ☐
   48-53 years old ☐
   54-60 years old ☐
   >60 years old ☐

47. What is the postcode of where your farm is located?
   ________________________________
Appendix B: Field day evaluation

Name of field day: ____________________________________________
Date: __________________________
Occupation: Farmer ☐ Crop consultant ☐ Extension specialist ☐ Chemical rep ☐ Uni/Govt ☐ Other ☐
How many years have you been working? _______
What crops do you work with? ________________________________________________

1. Please place a tick in the response that best describes your knowledge of the topics covered at today’s field day.

<table>
<thead>
<tr>
<th>No Knowledge</th>
<th>Some knowledge</th>
<th>Quite a bit of knowledge</th>
<th>Considerable knowledge</th>
<th>Thorough knowledge</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th>No Knowledge</th>
<th>Some knowledge</th>
<th>Quite a bit of knowledge</th>
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</tbody>
</table>

2. Did you learn what you were hoping to learn?

<table>
<thead>
<tr>
<th>No, not at all</th>
<th>A little</th>
<th>Some</th>
<th>Mostly</th>
<th>Yes, Fully</th>
</tr>
</thead>
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Comments?

3. Are you planning on using the knowledge that you learnt today? If so, how? (Feel free to use the back if necessary.)
Appendix C: Interview questions

1. Why did you come along to the field day / or workshop?

2. What did you hope to learn from today?

3. What was the most useful session for you today? Why?

4. How will you use the information from this session?

5. Will you use the information learnt today to help make a change or an improvement in your work?

6. Which activity/ session did you find the least useful today? Why?

7. Which sessions / activities did you find the most engaging? Why?
**Glossary**

**Accommodation:**

The process where existing schema change to make sense of new ideas and knowledge (Scales et al., 2013).

**Action learning:**

Is a learning and problem solving strategy for organisations, private, government, commercial or non-profit. It is based on solving a real problem, that is important and critical using a diverse team of people. It is a process that promotes curiosity, enquiry and reflection. When using action learning it is a requirement that solutions are found and that the group has a commitment to learning. In many cases a “coach” will be used to help the group (Study guides and strategies). [http://www.studygs.net/actionlearn.htm](http://www.studygs.net/actionlearn.htm)

**Agronomist:**

An agronomist provides technical information to the grower in relation to crop production on the farm. This information can include fertiliser regimes, fungicides and herbicides spray programs and even financial information.

**Assimilation:**

Is the process in which new information and ideas are added to existing schema, thus increasing knowledge (Scales et al., 2013). The schema does not change but grows to add the new knowledge.

**Blog:**

A form of social media. It allows for people to have discussions using a diary-style text entry. They can be informational and have multi-users interacting. Are usually hosted via a web page. [https://en.wikipedia.org/wiki/Blog](https://en.wikipedia.org/wiki/Blog)

**Capacity Building:**

Capacity building defined by FAO; increasing knowledge, skills and understanding of participants within an agricultural industry through education and training to enable change (Srinivas, 2016).

**Facebook Inc:**

Online social media and social networking service

**Grower:**
Someone who lives and farms land to produce crops for human and animal consumption. The grower usually pays the agronomist for this information.

**Persuasive mode of extension:**

Persuasion occurs when an individual or a group make a favourable or unfavourable attitude towards an innovation (Rogers, 2003). If an innovation is made such as a predetermined technical or managerial improvement or there is policy is change, it is up to people in extension to increase the rate of adoption (Coutts, 1995).

**Participatory model of research:**

Growers / farmers are involved in the decision making processes from the beginning of the research, including the setting of the research objectives, and establishment of indicators used to assess the success of the research. The benefit of this type of research is that the development of new technology meets the users needs and preferences. Thus the research tends to be location specific rather than general (van de Fliert & Braun, 2002).

**Podcasts:**

A digital audio file made available on the Internet for downloading to a computer or mobile device, typically available as a series, New instalments can be received by subscribers automatically via a web syndication. [https://en.wikipedia.org/wiki/Podcast](https://en.wikipedia.org/wiki/Podcast)

**Survey fatigue:**


**Systems thinking:**

This was a more holistic approach to extension and looking at the farm as a whole instead of small parts dealt with individually (Coutts and Roberts 2011).

**Twitter:**

A social networking service. Allows users to post and read messages restricted to 140 characters. These are called “tweets”. Registered users can post and read tweets, however those unregistered can only read. [https://en.wikipedia.org/wiki/Twitter](https://en.wikipedia.org/wiki/Twitter)

**Webinars:**

A seminar conducted over the Internet
References


The Survey Coach. Perth.


FARMSCAPE approach to decision support: Farmers', advisers', researchers' monitoring, simulation, communication and performance evaluation. *Agricultural Systems, 74*(1), 141-177. 10.1016/S0308-521X(02)00025-2


Education, D. o. (2016). Schools and You


Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and


Hammond, N. E. B. (2010). *Evaluation of emergency plant pathogen surveillance and surveillance methods for demonstrating pest freedom in Western Australia.* (Doctor of Philosophy), Murdoch University, Western Australia.


Kilpatrick, S., & Fulton, A. (2003). *Developing effective learning programs: What extension can learn from the field of adult*


Knowles, M. S., Holton, E. F., & Swanson, R. A. (2012). *The Adult Learner: the definitive classic in adult education and*


Likert, R. (1932). A technique for the measurement of attitudes. *Archives of psychology.*


Marshall, E. (2002). Environmental information for agronomists 2002: needs and provision *A report by the Farmed Environment Company for Crop Protection Association UK Ltd. and UKASTA.*


Wright, D. (2017). *Are we going against the grain in training; developing an information and training framework for farmers and agronomists in Australia*. (PhD), The University of Western Australia.

