PT336
Implementation of IPM in Northern Australian potato production

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Know-how for Horticulture™

PT336

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A survey of major pest problems, chemical usage, knowledge and practices of IPM of potato growers in NSW and Queensland.

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Abstract.
A survey was conducted between May and June, 1994, to ascertain major pest problems, chemical usage, knowledge and practices of IPM of potato growers in NSW and Queensland. Of 510 surveys, 105 useable surveys were returned. Response rate was 22 percent. The growers consisted of 3 categories - certified seed growers 7 percent, fresh table potato growers 82 percent, and processing potato growers 12 percent. Responses showed a wide variety of pest problems and control methods used. All growers ranked potato moth, aphids, thrips, jassids, caterpillars, white-fringed weevil and African black beetle to be important invertebrate pests. Chemical pesticides form the basis of most control strategies, especially for certified seed growers because of virus vectors such as aphids, (green peach aphid, *Myzus persicae Sulzer*; potato aphid, *Macrosiphum euphorbiae Thomas*), and thrips, (*Thripidae*). However, 25 percent of all growers are attempting to change this chemical regime by implementing IPM.

Key words: IPM, potatoes, monitoring, NSW, Qld, surveys.

Introduction.

The Potato is the principal vegetable crop grown in Australia, now ranking as the largest horticultural industry in Australia (ABS, 1994). Disease and insect pests are a continuous threat to this industry (Biggs, 1993; HRDC, 1993; Whitten, 1991; McKinley, 1988). At the same time, there is community concern about chemical residues in food crops and the use of pesticides to control pests and diseases, because of possible environmental degradation (Brough, 1993; Williams, 1993; Spooner-Hart, 1990). For this reason, *Integrated Pest Management (IPM)*, would offer the best strategy for potato growers but as Brough (1993) noted, IPM is a complicated concept and adoption by growers has proceeded slowly. Brough's study focussed on community perceptions of IPM (Brough, 1993). In IPM, emphasis is placed "not on pest elimination, but on the maintenance of populations at levels below those causing economic damage" (Spooner-Hart, 1990). IPM seeks to integrate appropriate chemical and

mycocidal spray programs with other methods of control. Bacteria, nematodes, fungi, insect predators and parasites can be used as biological control agents for pests and diseases.

The use of pheromones, monitoring emergence patterns, evaluating insect pest numbers, are important features in an IPM program (Rajakulendran, 1994; pers. comm.). These approaches are combined with other techniques such as plant breeding for resistance (Perlak and Fischhoff, 1990). Wearing (1988) suggests that this complexity of IPM is a key reason for poor rates of adoption of IPM by growers but notes that: "a lack of education on the part of IPM developers about the perceptions of farmers is probably more important than the reverse".

Some studies have sought to assess the current practices in IPM but these are not crop-specific. Williams (1993) reported that growers were asked to rank nine services of importance to them. Weekly monitoring of pests was the most important, with 91 percent of clients ranking this as number 1; weekly summary of pest status was next important, with 86 percent respondents as ranking this as next important; and advice on spray timing was the third important.

A number of studies describe some aspect of an IPM approach to potato growing but these focus on the efficacy of particular predators for biological control (Tesoriero, 1994; Cant and Spooner-Hart, 1993; Horne, 1993; 1992; Matthiesssen and Learmonth, 1993; Ralph, 1992; Robert, 1992; Pitt, 1990; Schroder and Athanas, 1989; Trudgill, Phillips and Alphey, 1987; Slack, 1987).

Cultural management methods are described by Learmonth and Matthiessen (1990), who examined the resistance of insect pests, especially the African black beetle, *Heteronychus arator (Fabricius)* (Coleoptera: Scarabaeidae) to organochlorine insecticides and researched strategies that might rely less on the use of chemical insecticides. Horne (1992) found a highly effective combination in using both biological control agents (the wasp parasites) and cultural management methods.

Cultural management practices include removing self-sown potato plants, which prevents the build-up of potato moth early in the season, and hilling and irrigation to maintain a soil barrier between the tubers and the moth. Overhead irrigation closes up cracks that develop and protects tubers. The amount of insecticide can be significantly reduced. In addition, pheromone traps will indicate when the wasp parasites should be released. This research has shown for the first time that moths can be controlled without insecticides. Host plant resistance studies have emphasized the need for an IPM approach to pest management. Gurr (1994, pers. comm.) reported host plant resistance to the potato moth. The research was based on the breeding of different *Solanum* spp. to resist oviposition by adult females of the potato moth.

Gurr (1994) also investigated tuber resistance and found that adult counts were significantly lower on cv.*Sequoia* than on cv.*Kennebec* and cv.*Tarago*. Two studies surveyed growers and pesticide usage - one in South Australia, (Dillard, Wicks and Philp, 1993), and one in Tasmania (Hill, 1994). Dillard, Wicks and Philp (1993) found that the most frequent pest control strategies were spraying whenever a pest was present (29 percent of respondents); spraying when moderate pest levels were present (25 percent of respondents); spraying routinely (calendar schedule) irrespective of pest levels (17 percent of respondents); and spraying when

a pest was present and relying on past experience (14 percent of respondents). The results are being used as a guideline for planning additional research and extension programs in IPM for potatoes grown in South Australia and will provide baseline data to measure the future success of IPM programs. Hill (1993) found that potato moth is the only widespread regular pest and that pest management strategies were changing to an IPM approach.

The purpose of this study was to assess potato growers' knowledge, understanding and use of IPM in relation to their major pest problems, chemical pesticide use, and methods and types of pesticide applications. Once the baseline for decision-making is established, progress in the adoption of IPM can be monitored as well as the success or otherwise of further stages in the research project, i.e. the success of trapping/monitoring services set up in major potato growing districts and the success of workshops and consultancies to increase growers' knowledge and use of IPM.

Materials and Methods.

A questionnaire was developed to gather information about three broad areas, each with questions designed to elicit specific information. These areas were:

* demographics and nature of the enterprise; i.e. whether certified seed, fresh or potatoes for processing were grown.

* pesticide use, type, application, and level of interest in reduction of pesticide use;

* knowledge, understanding and use of Integrated Pest Management (IPM) strategies,

* pest and beneficial insect recognition.

This questionnaire had a variety of questions. Most used ranking scales; some were closed "yes" and "no" questions and a number were open-ended questions. Space was provided for

additional comments at the end of the survey, because it was felt that additional information could provide further valuable insights.

The questionnnaire had a covering letter attached to it, signed by both the Principal Researcher, Robert Spooner-Hart and the Research Assistant, Hilton Redgrove. The covering letter explained the purpose of the survey, undertook to maintain confidentiality of individual response, and named the funding bodies who were interested in the results (APIC and HRDC). It was explained that respondents would receive a summary of the results as soon as the data had been analysed. This detailed explanation was given to encourage a high return rate. Pre-paid envelopes were provided for all surveys. Names of growers were provided by the Principal Researcher, who had obtained them from a variety of sources, such as the Departments of Agriculture in New South Wales and Queensland.

The survey was distributed in April, 1994, by mail to growers. The names of growers were chosen at random from appropriate mailing lists. Districts ranged from the coastal and tablelands areas of southern NSW to mid-north Queensland. This included Guyra, Dorrigo, Robertson, Crookwell, Blayney, Bathurst and Finley in N.S.W and Gatton, Ravenshoe, Atherton and Tolga in Queensland. In all, 510 questionnaires were distributed. The survey was analysed, using the statistical capabilities of *Excel*.

Results of Survey.

The bulk of the questionnaires were returned by growers between May and June, 1994, although a few were returned as late as August. Out of the 510 surveys sent out, 25 were received back as "incorrect address" surveys, giving a base of 485 surveys, of which 105 useable surveys were returned. This gave a response rate of 22 percent total for both N.S.W. and Q.L.D.

Section 1. Question Analysis.

Q1. Where is your property?: District and postcode.

This question asked for the geographic location of the growers' properties, and only required a district name and postcode. This question was intended as a "warm-up" question to enable respondents to feel comfortable about filling in the questionnaire. This information was also used to group growers for some of the questions in this survey.

The survey yielded a total of 105 useful completed questionnaires, which equalled a response rate of 22 percent. Such a level of response is considered acceptable for this type of survey, where mail-out surveys often receive a response rate as low as 5 percent.

Districts ranged from Southern New South Wales to Mid-North Queensland. This included Guyra, Dorrigo, Robertson, Crookwell, Balldale, Narrandera, Finley, Blayney, Orange, Bathurst and in Queensland Gatton, Ravenshoe, Atherton, Tolga. This gave a good coverage of the different environments (climates, varieties, ethnic backgrounds and practices). Unfortunately, growers in some districts, such as Windsor, N.S.W. did not participate in this survey. Refer to Chart 1.

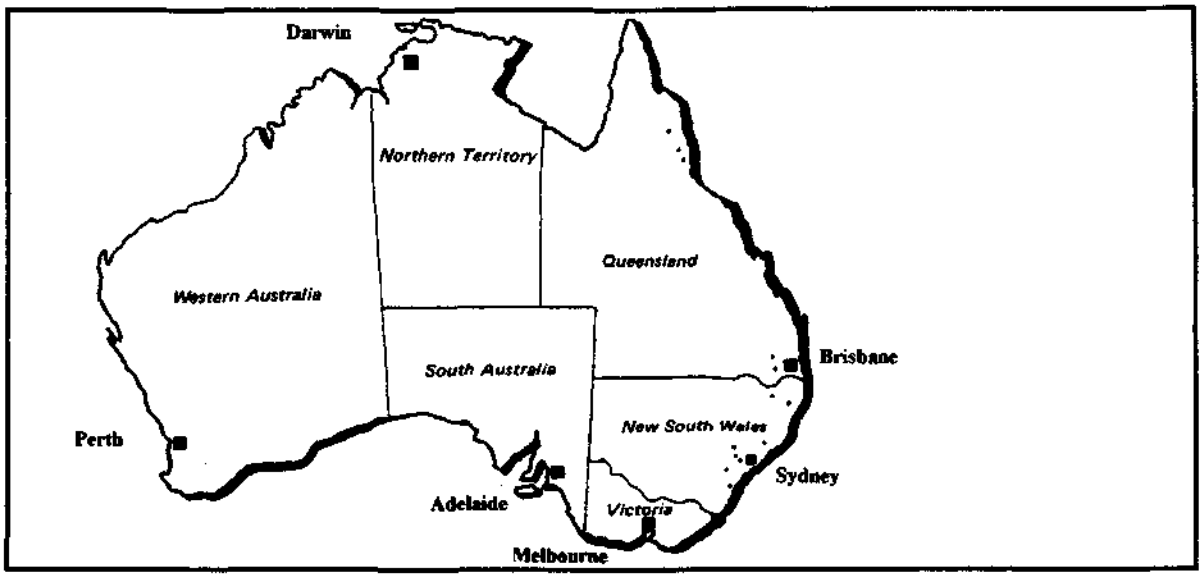

Chart 1. Potato Growing Districts Surveyed. Key: •

Q2. Which of the following varieties do you grow?: Sebago, Pontiac, Kennebec, Atlantic, Other. - please name. (Tick all appropriate boxes).

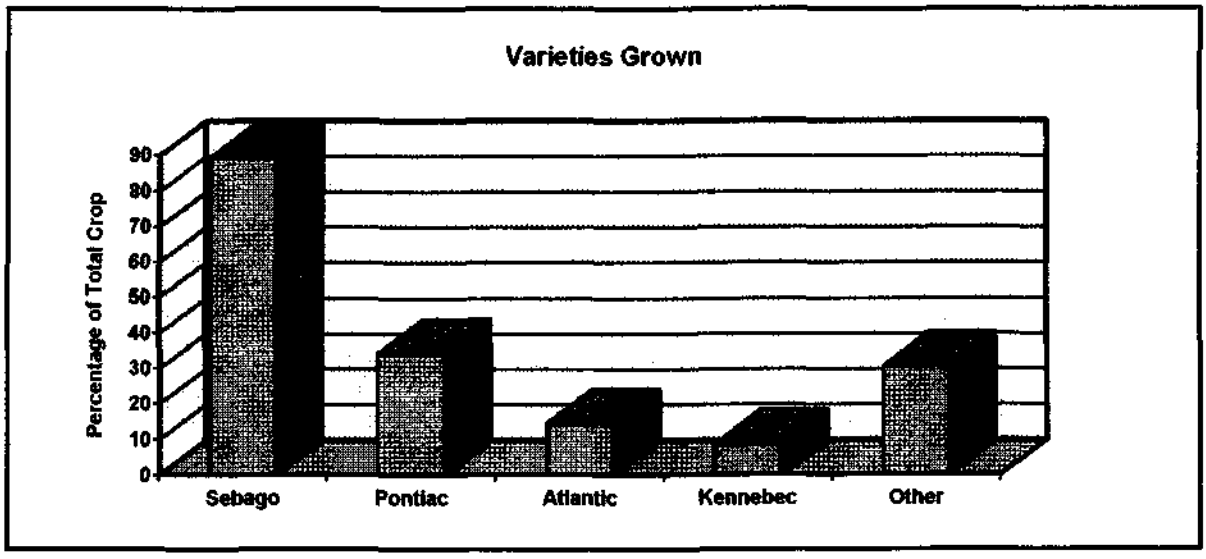

Figure 1

This question asked which varieties were grown out of a list of four major ones. A space was provided for other varieties. Respondents indicated that *Sebago* was the most popular grown

(90 percent), with *Pontiac* (34 percent), *Atlantic* (15 percent) and *Kennebec* (9 percent), respectively. Other varieties, which include *Bintje* and *Crystal* together totalled 31 percent of the varieties grown (see Figure 1). The result of finding that *Sebago* was the most popular grown (90 percent), was expected, because many of the respondents had emphasized during personal interviews that they had little choice, but to grow at least some *Sebago* since this variety is in greater demand and therefore easier to sell. This situation is unfortunate for many farmers, who indicated that they preferred not to grow this variety, since it is more susceptible to several insect pests and viruses, while other varieties such as *Atlantic* are not. This was true for the geographic regions and especially where potatoes are being grown for many years. In such a situation one grower may have lower infestation, whilst the grower on a neighbouring property may have high levels of infestation. It is recommended that a certain proportion of growers diversify their varieties or target a particular market niche. However, it is not the purpose or intent of this survey to examine economic or market-related issues.

Q3. What area of your property was planted with potatoes in the latest growing season?: In hectares or acres.

This question asked what area of the growers property was planted with potatoes in the latest growing season. Respondents indicated that 1117 hectares and 5227 acres were utilized, giving a converted total of 3232 hectares. There was a wide range of property sizes.

Q4. How much of the area was grown for?: certified seed potatoes, fresh table potatoes, processing potatoes. In hectares or acres. Please name which is used.

This question asked how much of the areas specified for growing potatoes was grown for a particular purpose. The purpose of this question is to enable categorisation of growers into the three main divisions that exist within the potato growing industry, so that all following information could be correlated to a particular category. The results were certified seed potatoes 7 percent, fresh table potatoes 82 percent, and processing potatoes 12 percent (see Figure 2).

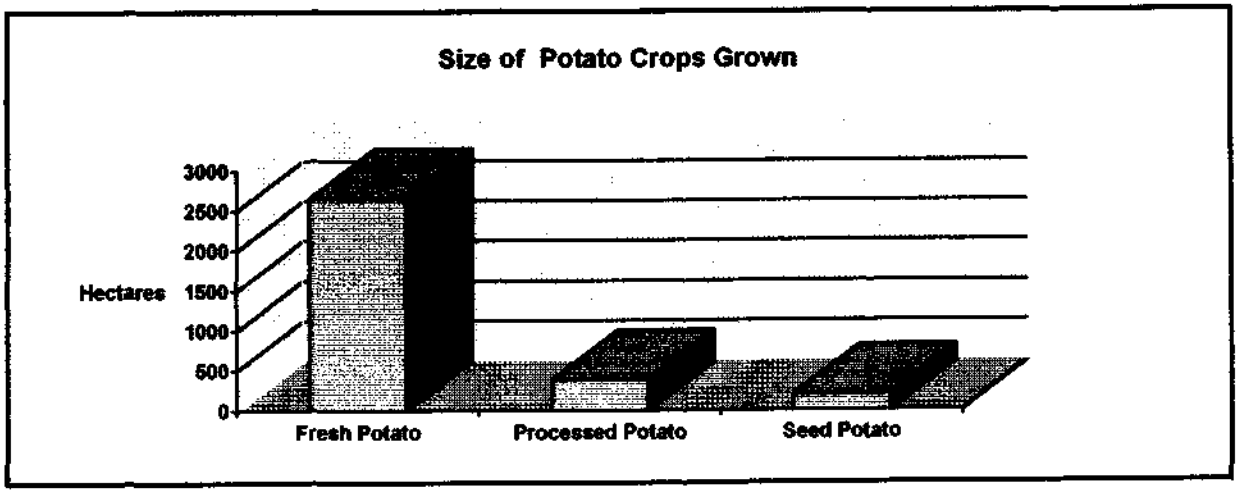

Figure 2

Q5. Do you export any of your potatoes?: Yes or No.

This was included to assess the importance of exporting as perceived by NSW and QLD growers. It was expected that this response would be very low, and almost nil, however 5 percent of growers indicated that they did export some potatoes, with 93 percent indicating that they did not. This left 2 percent unaccounted for as non-response error. However, it was found that most of this export was seed potatoes, such as micro-tubers from Crookwell or

processing potatoes from QLD. It was included in order to indicate awareness of export opportunities which may exist in the industry.

Q6. What are the insect pests in your potato crops?: Potato moth, aphid, thrips, jassid; caterpillar, white-fringed weevil, African black beetle, Other - please name. (Put "1" for the most important pest, "2" for the next most important pest and "3" for the next most important pest and so on).

The purpose of this question was to record growers' perception about the importance of insect pests, that is the ability to inflict the most damage to the crop. It is important whilst evaluating the results that the rankings given are seen as perceived values of the grower, and may be subject to personal bias.

From the grand mean percentage *(see Appendix G)*, it can be seen that the general trend is that potato moth was of the most concern with 20 percent, followed by aphids with 19 percent, thrips with 13 percent and jassid 12 percent. Both the potato moth and aphids were regarded by growers as very important pests (based on the rank of 1 and 2 only), though the potato moth ranked slightly higher than aphids across all 3 categories (seed, fresh table, processing). Growers of fresh table potatoes and growers of processing potatoes ranked them important, followed by seed growers. However, thrips and jassids/hoppers were ranked more important by seed growers than by the growers of fresh table or processing potatoes. This is probably because of the viruses they transmit (tomato spotted wilt and purple top virus). Caterpillars were regarded more important by growers of seed potatoes, followed by growers of fresh table potatoes, then by growers of processing potatoes. White-fringed weevil was more important to growers of fresh table potatoes followed by growers of processing potatoes and then growers

Seed Potato Pests Ranked by Perceived Importance.

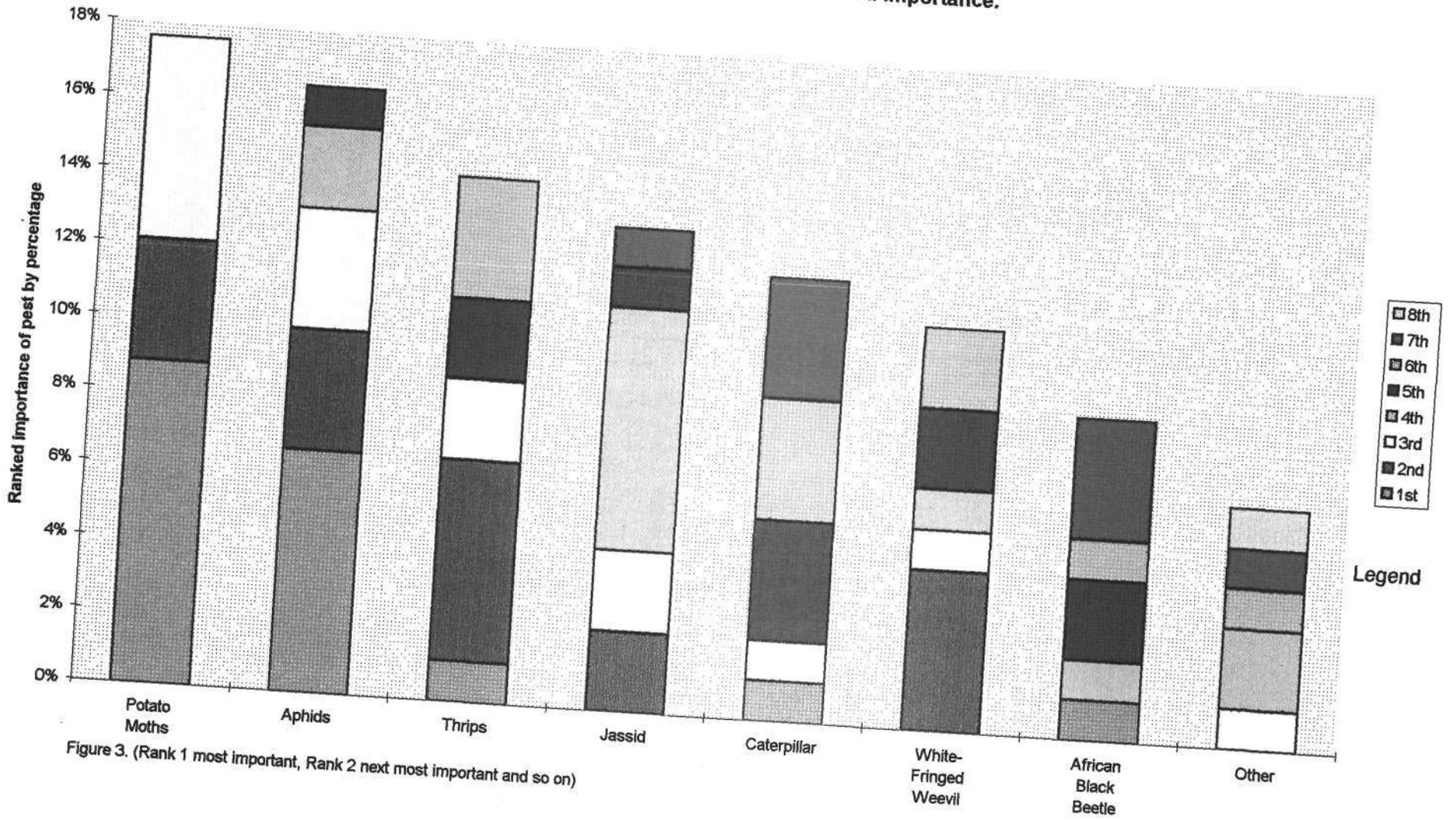

Figure 3. (Rank 1 most important, Rank 2 next most important and so on)

Pest of

Processed Potato Pests Ranked by Perceived Importance.

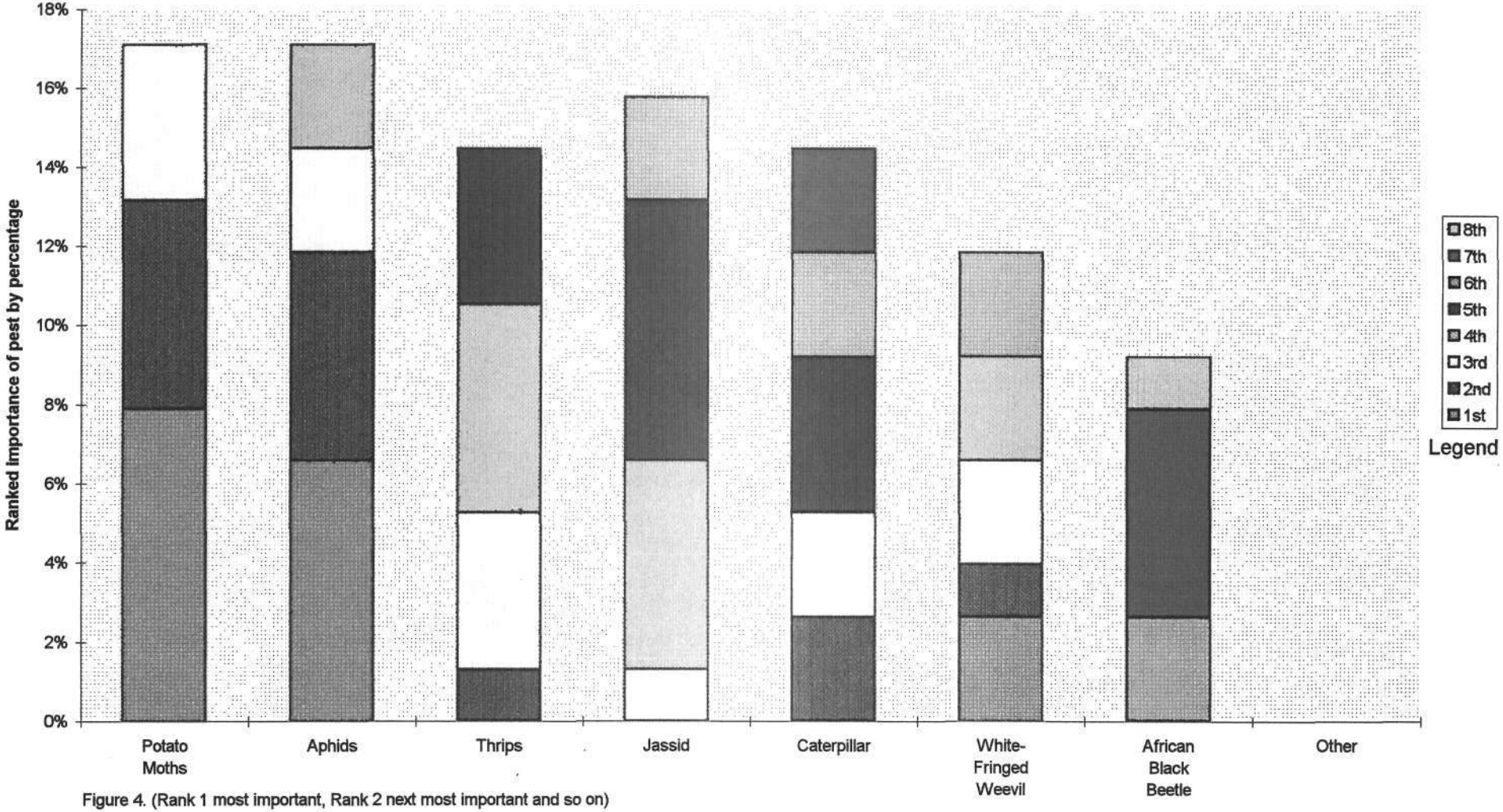

Figure 4. (Rank 1 most important, Rank 2 next most important and so on)

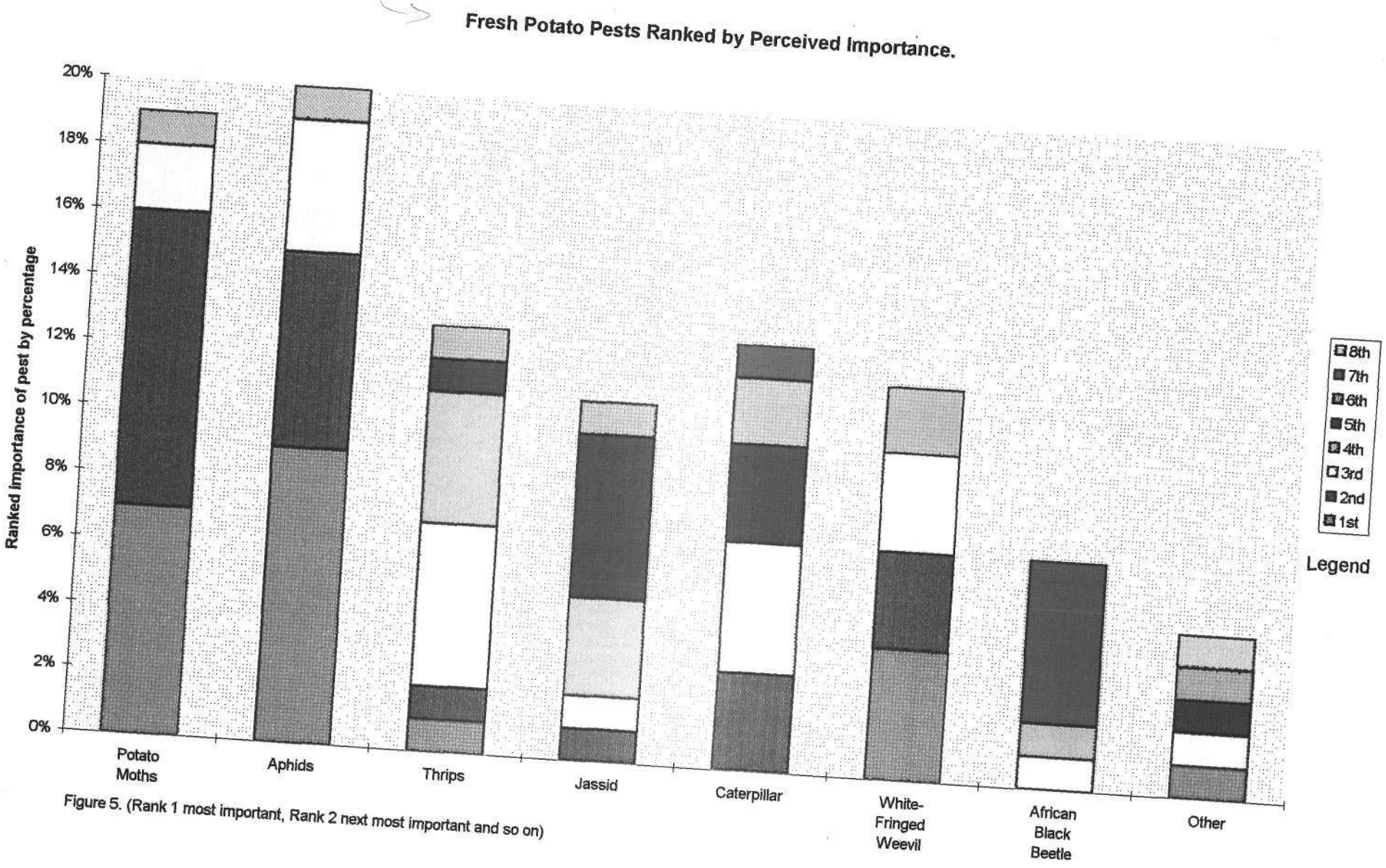

Figure 5. (Rank 1 most important, Rank 2 next most important and so on)

of seed potatoes. African black beetle was more important to growers of seed potatoes. followed by growers of fresh table potatoes and then growers of processing potatoes (see figures 3, 4 and 5).

Q7. How important are pesticides to your overall pest control program?: Very important - main control, Quite important, Relatively unimportant - minor factor, Unimportant - not used at all. (Tick one box only).

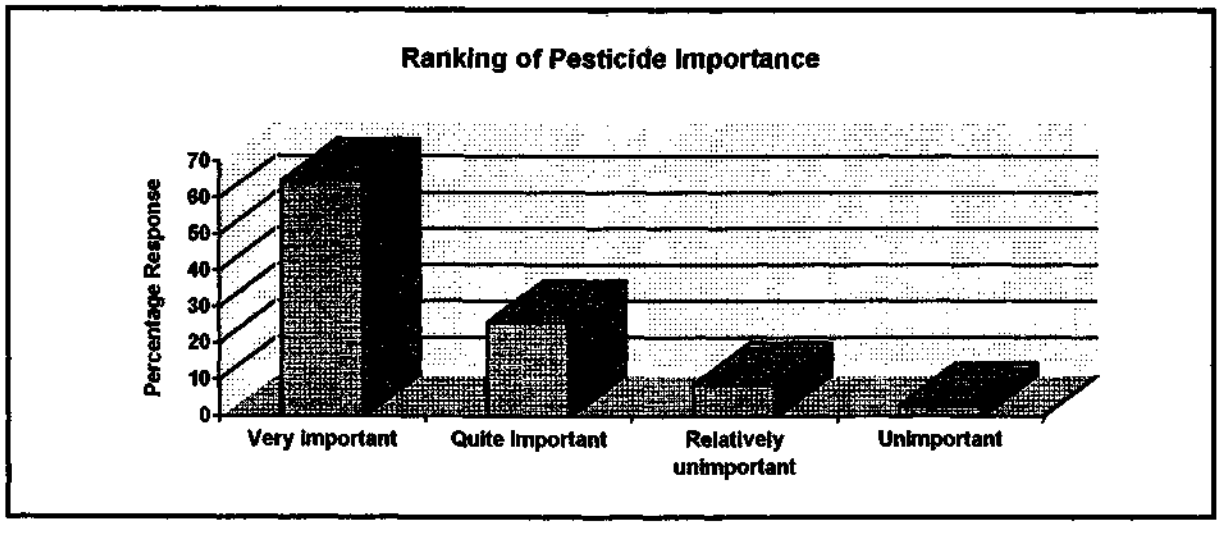

Figure 6

The aim of this question was to assess the overall importance of pesticides to the growers' pest control strategy. 65 percent of respondents indicated that pesticides were very important as the main control method, a further 26 percent rated them as quite important. Only a small numbers of growers stated that pesticides were relatively unimportant at 9 percent, or unimportant at 3 percent (respondent error of 3 percent). The majority of the growers therefore have not been innovative and have continued to rely on traditional pesticide strategies (see Figure 6).

Q8. Which pesticides do you use to control potato insect pests?: "Monitor" "Perfect" and "Nitofol" (methamidophos), "Thiodan" (endosulfan), "Gusathion" (azinphos-methyl), "Thimet" (phorate), "Permasect" "Ambush" (permethrin), "Lorsban" (chorpyrifos), "Pirimor" (pirimicarb), Other - please name. (Tick all appropriate boxes).

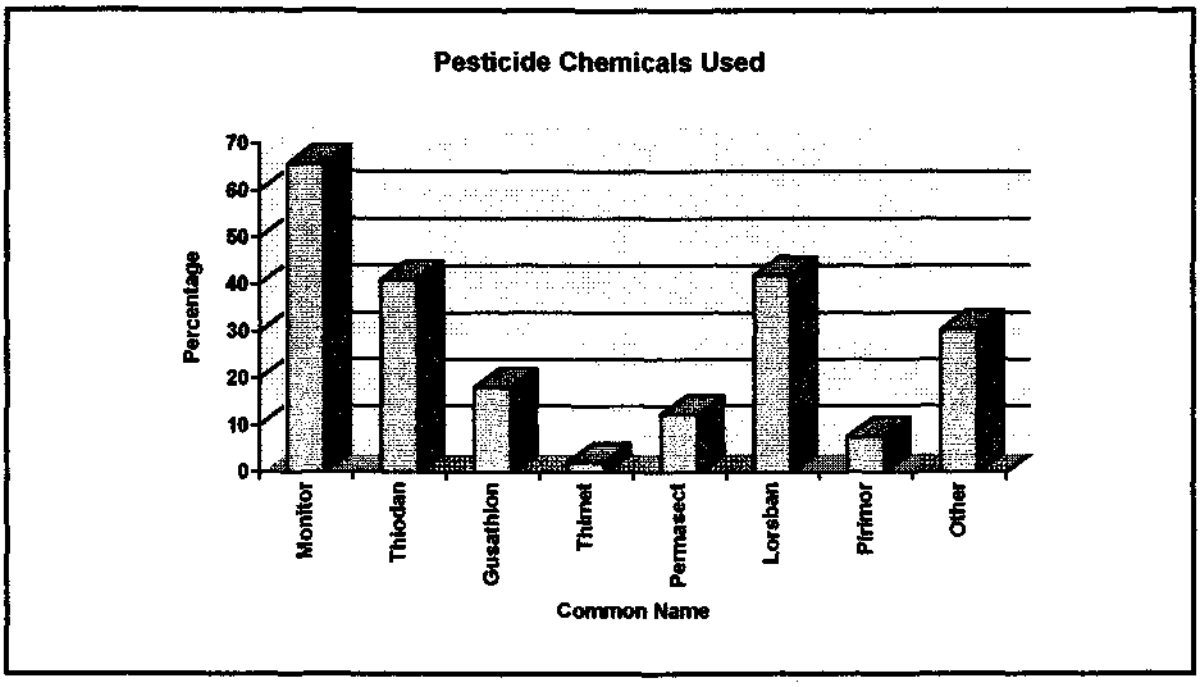

Figure 7

This question required the growers to indicate the pesticides they use to control their various pests. 66 percent of growers used methamidophos (brand names "Monitor" "Prefect" and "Nitofol"). A further 41 percent used endosulfan ("Thiodan") and 42 percent used Chorpyrifos ("Lorsban"). Refer to Figure 7. and Table 1.

Table of Common Pesticide Usage (Q8).

Chemical Applied.	percentage	Chemical Applied	percentage
i. Monitor (Methamidophos) OP	66%	v. Permasect (Permethrin) SP	12%
ii. Thiodan (Endosulfan) OC	41%	vi. Lorsban (Chorpyfos) OP	42%
iii. Gusathion (Azinphos-methyl) OP	18%	vii. Pirimor (Pirimicarb)	8%
iv. Thimet (Phorate) OP	2%	viii. Other	31%

Table 1

This question revealed that the three most commonly used chemicals are methamidophos ("Monitor") 66 percent, endosulfan ("Thiodan") 42 per cent and chorpyrifos ("Lorsban") 42 percent [disproportional percentage]. Such broad spectrum chemicals are inhibitive to an IPM system, since natural predators will only occur in small populations.

Q9. What methods of pesticide application do you use?: Boom spray, Aerial spraying, Pellet / dust, Other - please name. (Tick all appropriate boxes).

Along with the chemicals used, application methods were also surveyed. Respondents stated that 90 percent used boom spray equipment, 44 percent used aerial spraying, and 7 percent used pellet/dust application, (respondents could tick all methods). It was surprising to find that aerial spraying percentage was so high because this is a very costly method of application and if the spray is applied without monitoring in place, this method of application besides being costly is ineffective. Also it is only cost-effective for very large acreages because of the cost structures in the crop grown.

Unfortunately the survey did not ask the growers the frequency at which they applied their spray strategy, which would have been useful in determining specific spray volumes per crop.

Q10. Are you interested in reducing your pesticide use?: Yes, No or Unsure. Why?

This question asked the level of interest in reduction of pesticide use, in order to assess receptiveness by the growers to alternative pest control strategies. It can be seen from Q10 that growers are interested in reducing pesticide use, with 90 percent responding positively. Only 7 percent indicated that they were not interested, mostly because they thought that they

did not use much or any pesticide. Three percent of growers were unsure if they wanted to reduce pesticides. These growers may well intend to reduce pesticide use, but this intention had not been translated into specific action. The key concept involved in this question was the use of the term "reducing" which is clearly different from anything that would imply a total cessation of the use of pesticides. This indicates a need for a strategy such as IPM.

Q11. Have you heard of Integrated Pest Management (IPM)?: No (please go to Q19), Yes (Please go to Q12).

This is the first of the questions concerning IPM. It was designed as a skip-type question to divide the growers into growers who have heard of IPM and those who had not. Responses indicate that 39 percent had not heard of IPM, while 60 percent had heard of IPM with a 1 percent response error. This indicates that the majority of growers have heard of IPM from some source and therefore have some access to information. This factor would explain why many growers use chemicals as their main form of control. However, there is a possibility that some growers may be using IPM without recognizing it as such. This could be when cultural control is used as well as some natural predator control.

Q12. How well do you think that you understand what IPM is?: Not at all, Only a little, Quite a lot, Understand it well. (Tick one box only).

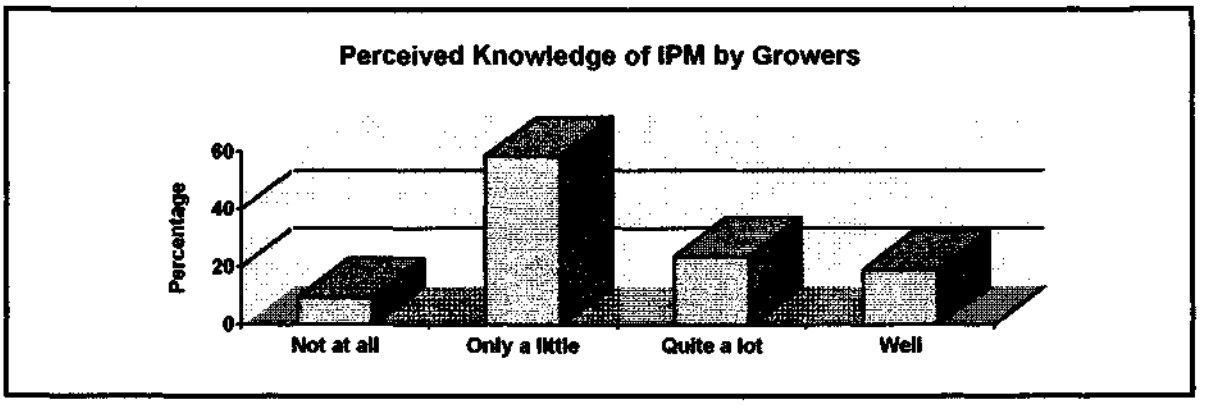

Figure 8

It should be noted that because the above question was a skip question, only the respondents who answered "yes" to that question will be answering this question. The respondents are assumed to have heard of IPM (60 percent of respondents to Q11).

The aim of this question was to assess respondents' understanding of IPM. Respondents indicated that even though they had heard of IPM, 10 percent replied that they had no understanding of IPM and a further 59 percent stated that they only had a little amount of understanding. 24 percent stated that they thought that they had quite a lot of understanding and only 19 percent stated that they thought that they understood it well (see Figure 8).

There was a 12 percent respondent error.

These percentages are reasonably pleasing however all options contain an unknown level of incorrect or biased information because those 70 percent of growers who had indicated that they had little or no understanding of IPM, had also indicated that they had heard of IPM.

Q13. Where did you obtain your knowledge of IPM?: Industry associations, Dept. of Agriculture, other grower(s), trade journal(s), general newspapers/magazines, television/radio, professional consultants, contractors (eg: crisping groups), other - please name/(tick all appropriate boxes).

This question asked about the source of the growers' knowledge of IPM, to ascertain if there was a single important source. As it can be seen from the Table 2 below that Industry associations appear to be the most important source at 41 percent. This was almost 10 percent above the next most nominated option which was the Department of Agriculture at 32 percent. Other growers and newspaper/ magazines came close at 30 percent.

Table of source of IPM knowledge of growers.

i. Industry associations	41%	vi. Television/radio	3%
ii. Dept. of Agriculture	32%	vii. Professional consultants	24%
iii. Other grower(s)	30%	viii.Contractors (e.g.Crisping groups)	22%
iv.Trade journals	25%	ix. Other	14%
v.General newspapers/magazines	30%		

Table 2 This table indicates the range of sources of information utilized by growers to obtain knowledge of IPM and their relative importance.

These results point to the fact that personal contact is an extremely important form of communication, as this would happen in the three largest categories - Industry associations, Dept. of Agriculture, professional consultants and contractors. It could also point to the fact

that cost of communication could be an important factor as there would be no cost involved (apart from the required levies) in the two highest categories - Industry associations and Dept. of Agriculture. It is pleasing to note these high categories because this would indicate that growers are showing professional responsibility in relation to sources of information used.

Q14. Have you used IPM?: Yes or No. (If "Yes" then go to next question, if "No" then go to question 18.)

This is the second skip-type question aimed at identifying those who have used IPM. From a total of 60 percent of growers who stated that they had heard of IPM, 58 percent indicated that they had not used IPM, leaving 43 percent who had both heard of and used IPM. From this it can be seen that the total grower base who take IPM seriously is diminishing. This is of concern since IPM should not be seen as an alternative, but as the mainstay of pest control.
Sixty-seven growers attempted to answer this skip question, but only 63 should have responded. This resulted in a 4 percent error for this question hence 29 "yes" responses were corrected to 27 and 38 "no" responses to 36 "yes" responses.

Q15. How long have you been using IPM?: Less than six months, Six months to one year, One year to three years, More than three years, Did use it - but no longer do so. (Tick one box only).

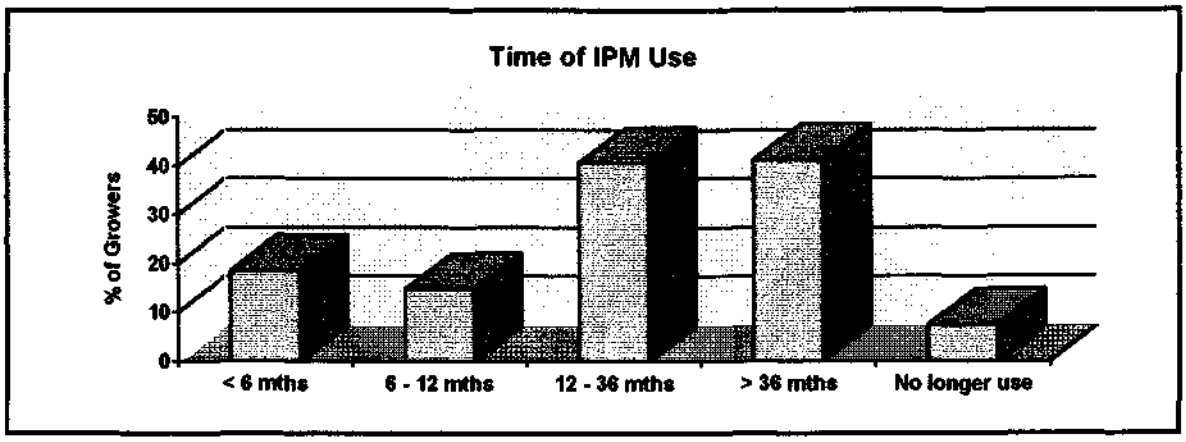

Figure 9

This question sought to gain the level of acceptance of IPM amongst the growers.

In the two categories of those who either had heard of IPM or used IPM, it is encouraging to note that 41 percent have been using IPM for 1-3 years, with a further 41 percent of growers using it for more than 3 years. 19 percent indicated they had been using IPM less than six months and 15 percent stated that they had been using IPM for between six months to 1 year. In addition, 8 percent indicated they had used IPM but no longer did so. Unfortunately the exact reason for this was not recorded. It should also be noted that there was a 4.8 percent respondent error for all components in this question, e.g. 24 percent of respondents filled out more than the one box applicable to them.

Q16. How important is IPM to your overall pest control program?: Very important - main control, Quite important, Relatively unimportant - minor factor, Unimportant - not used at all. (Tick one box only).

This question was included to ascertain the importance of IPM to the overall pest control program. Respondents replied by stating it was very important being the main control for 30 percent of them, quite important for 67 percent of them and relatively unimportant for 19 percent of them. 7 percent indicated it was unimportant - not used at all. This shows that the majority of growers thought IPM should be quite important to them (see Figure 10).

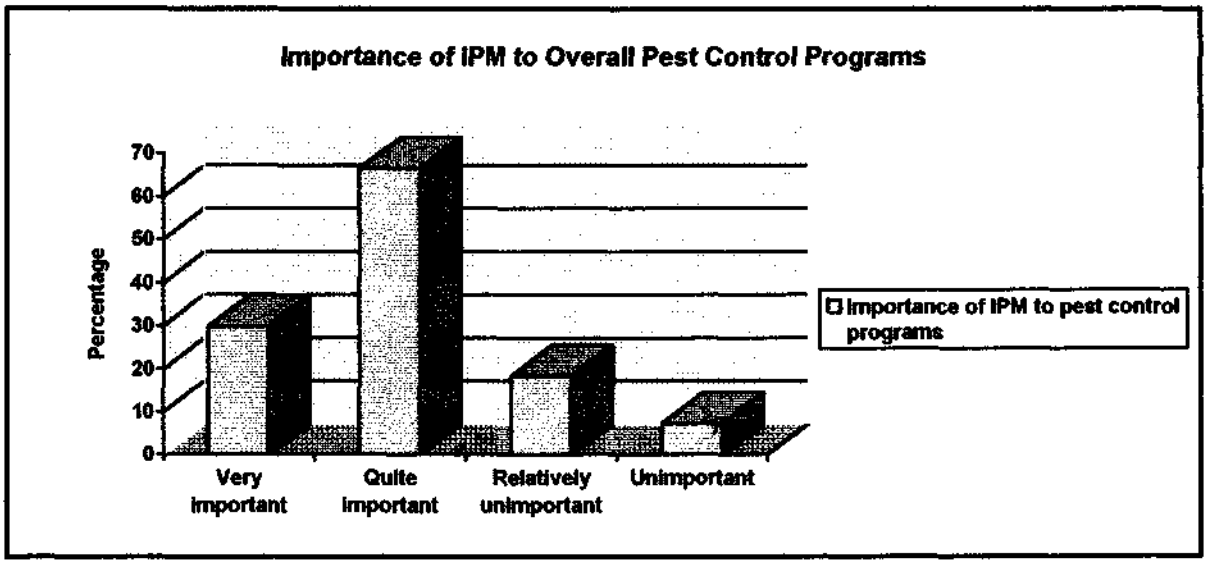

Figure 10

Q17. Against which insect pests do you use IPM practices?: Potato moths, thrips, aphids, Other - please name. (Tick all appropriate boxes).

This aimed to identify the range of pests for IPM control practices. 81 percent indicated potato moths, 41 percent indicated thrips and 71 percent aphids. "Other" received 26 percent. Thus potato moths and aphids were the pests targetted by most of IPM practices. This is in line with

other research findings (Horne, 1993) and also reinforces the findings in Question 6 (i.e. that the potato moth and thrips are of the greatest concern to growers).

Q18. Which techniques do you believe are important in IPM?: Cultural practices / irrigation, beneficial / predator insects; Non-calendar spraying / low pesticide usage, Pest monitoring devices / practices, Other - please name. (Tick all appropriate boxes).

This question represents a major dividing question enabling the determination of the proficiency of the growers with regard to IPM, thus a cross reference between this question and other questions can identify the genuine user of IPM. All categories received almost equal support: cultural control/irrigation 68 percent, beneficials 65 percent, non-calendar spray/low spray 62 percent and pest monitoring 67 percent. and other 8 percent. It was disconcerting to see non-calendar spray/ low spray perceived as the least important strategy because these answers indicate a misconception of IPM. It is evident that growers perceive IPM in terms of being "green" that is that IPM as a strategy uses mainly biological control, monitoring, trapping but not chemicals.

This question was designed to assess the methods of pest control which growers believe to be an integral part of IPM. 57 percent believed that three of the stated four components were necessary before someone was using IPM, while 27 percent believed that all four of the components were an integral part of IPM. Some growers gave additional points which they believed were important. Standard practice would suggest that all parts are necessary.

Q19. Do you use any of the following to monitor insect presence in your crop?: crop or sample plant inspection, pheromone trap, light trap, sticky traps (blue, yellow or white). (Tick all appropriate boxes).

Since monitoring forms such an important part of all pest control strategies including IPM, it was decided to identify methods used. Growers were asked if they used any of the methods named above to monitor insect pests .

77 percent said that they carried out sample plant inspection, 11 percent used pheromone traps, 1 percent used light traps, 10 percent used yellow sticky traps and no-one used blue or white sticky traps. It is pleasing to note that monitoring is carried out by the vast majority, however, a response rate of 100 percent would have been expected. The 23 percent who did not acknowledge monitoring, that is, using crop or plant inspection, may have thought that crop or plant inspection implies professional inspections or bagged samples/ laboratory examinations. The low percentages using trapping devices point to a lack of familiarity with the basic tools of professional crop monitoring systems.

Q20. Do you monitor any of the following insect pests in your crop?: Potato moths, thrips, aphids, Other - please name. (Tick all appropriate boxes).

This question asked if the respondents monitored any of three insect pests, that is, potato moths, thrips, aphids. 86 percent stated that they did monitor potato moth, 45 percent monitored thrips and 65 percent monitored aphids. Other pests accounted for 16 percent. Again, the significance of the potato moth as a pest of major concern is indicated, as has been shown elsewhere in this survey and in other scientific work (Horne, 1993). The significance of

aphids as the next pest of major concern is also indicated. The significance of these pests and the ranking attached to them validate other scientists' results (Wicks, 1992; Matthiessen & Learmonth, 1993; Hill, 1991; Horne, 1993; Dillard, Wicks & Philp, 1993).

Q21. Do you think that you have beneficial insects in your crop?: Yes, No or Unsure. (Tick one box only).

This question sought to assess the perceived level of knowledge or expertise in beneficial insect identification and recognition. 44 percent of respondents replied that they do think that they have beneficials in their crop and 22 percent replied that they did not think there were any beneficials in their crop. However, 31 percent were unsure of their presence. This level of uncertainty about the presence of beneficial insects could point to either an inability to recognise beneficials or to the growers' ability to recognise them but that they were indeed absent due to other factors such as heavy chemical spraying. Either way, this level of uncertainty is disconcerting. There was a 3 percent respondent error.

Q22. If you answered "Yes" to question 21, please name any beneficial insects that you think are present.

This question sought to elaborate on the above question (Q21) of the beneficials recognized by the grower. This was an open-ended question giving growers the opportunity to present their own examples and thus indicate their level of ability to recognize beneficials. Examples given by growers included bees, spiders, ladybirds, lacewings, wasps and worms.

The growers who gave worms, bees and spiders as beneficials showed a lesser knowlege of potato crop beneficials than did the growers who named ladybirds, lacewings and wasps.

Q23. Are you confident you can identify common (i) Pest insects?: Yes or No (ii) Beneficials?: Yes or No.

This was a closed question in order to specify confidence in the ability of the grower to recognize pest insects in general and beneficials, in particular. Results show that 76 percent of growers think that they can identify insect pests and 19 percent believe they cannot. The respondent error of 5 percent indicated that 5 percent of growers could not decide on their level of confidence in identifying common insect pests. This lack of confidence is disturbing.

In the case of beneficials insect identification, 22 percent of growers indicated that they could identify beneficials.This was an unexpectedly low rate of confidence in identification. The majority of growers (56 percent) indicated they were not confident of identifying them. Again, this was a disappointment. The large respondent error of 22 percent resulted from this percentage of respondents not providing an answer.

It seems many growers do not have a good understanding or confidence in the identification of beneficial insects and this would point to the need for a better information/education program for farmers. The request for a photographic kit of pests and beneficial insects given in Q24 would support this identified need.

Q24. Thank you for your time in filling out this survey. If you would like to make any additional comments that you feel could assist the research, please write in the space below.

A total of 43 comments were collected in this open-ended question.These were able to be grouped into five distinct themes. These were:

1. Comments on insects: pests and beneficials and IPM.

2. Comments on the use of chemicals.

3. Comments on research.

4. Comments on the potato industry.

5.Comments on the questionnaire.

The comments by respondents have been quoted verbatim in the *Appendix*, i.e. direct quotes as given in question 24. They have been transcribed as they appeared on the questionnaires. The questions seemed to show a consensus of opinion as to the following key requirements, some of which could be acted on as a result of this survey.

In summary, growers of potatoes:

* wanted more information/education with regard to the identification/recognition of pests and beneficials. A photo identification kit ("same as the Queensland crisping growers") was thought to be useful. This should be easy enough to produce and made available to all growers.

* displayed a positive attitude to IPM,

* expressed a desire to reduce pesticides,

* requested more research to be carried out,

* expressed dissatisfaction with market prices for potatoes,

* expressed the hope that the survey results could be used to produce an improvement in the industry.

This type of qualitative data is an extremely valuable source of information and added to the information obtained in the quantitive analysis of this survey. Please refer to the *Appendix* for a complete list of comments.

Section 2. Cross Tabulation Analysis.

In order to gain further insight into the statistics gathered from the survey, it was decided to cross-tabulate the results from individual questions against those of other key questions. This technique of analysis can lead to extremely valuable additional information that would not be available otherwise.

State vs. state comparisons were carried out and it was found that there was no statistical difference between the responses of New South Wales growers of potatoes and those of Queensland growers of potatoes.

The first cross-tabulation required question 15 and question 18 to be compared.
Since question 15 dealt with the length of time growers had been using IPM and question 18 dealt with the various techniques (strategies) employed in IPM, this cross reference should show ideally, that increased time in using IPM results in increased proficiency.

A grower with a knowledge of IPM should have recognized the importance of all components, i.e. this person should have ticked all four choices in question 18 and could have ticked the fifth choice of "Other" in question 18.

The null hypothesis is that there is no difference between the level of knowledge of IPM and the length of time that the user has practised it. Our results clearly show that the null hypothesis is rejected (result value 0.17 < chi squared value of 12.84). That is, the alternative hypothesis that there is a correlation between length of time of IPM practice and proficiency is accepted. An examination of the data suggests the interesting result that the farmers with the best knowledge are those who have started using IPM most recently, apart from those who have had less than six months experience with IPM. This would suggest that the earlier adopters of IPM have not kept up to date with IPM techniques, and that one crop is necessary as a learning experience. Although the sample size for those farmers who had used IPM, but given it up, is too small to statistically extrapolate results applicable to the population at large, it would seem to indicate that these users' understanding of IPM was flawed, and hence led them to the posssibly erroneous conclusion that IPM did not work.

It can be seen that the two most knowledgeable grower groups are those who have been using IPM for 6 months to 1 year and secondly less than 6 months and thirdly 1 year to 3 years. It is interesting to note that the less than 6 months group had different views on IPM than the greater than 3 years group.

This suggests poor understanding of what IPM is by some growers who claim to be "old hands" at IPM, and thus more experienced at using it. It is disappointing to see this trend amongst the oldest claimed IPM practitioners (see Figure 11)

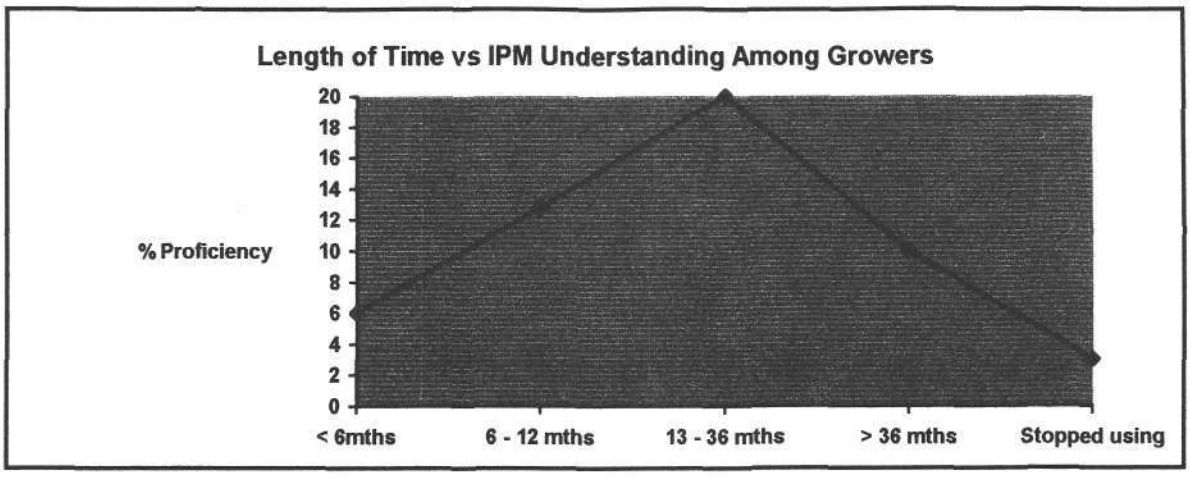

Figure 11

To gain further insight into the statistics gathered from the survey, it was decided to cross-tabulate the results gained from question 4 with those of question 7.

Since question 4 dealt with the type of market for which the potatoes were grown (certified seed potatoes, fresh potatoes, processing potatoes) and question 7 dealt with how important the growers felt the use of pesticides were to them, as an over-all pest control strategy, the cross-reference should reveal which category group most uses pesticides and if any category group tends to use little or no pesticides.

Using a chi squared analysis, the null hypothesis to be tested is that there is no difference between the perceived importance of pesticide and the type of potato crop grown. This hypothesis is rejected (chi squared result of 12.00 > table value of 5.99) at the 5 percent level when only looking at the breakdown between the various types of crop grown and a pesticide ranking of "Very important." That is, perceived importance of pesticides does differ between growers of different crops. However, when the two categories "Very important" and "Quite important" are combined into one category, it is revealed that there is no statistical difference (chi squared result of 1.97 < table value of 5.99) between the various groups of growers as far

as importance of pesticides is concerned. A conclusion that can be drawn is that all classes of growers would seem to rank pesticides as being important to their pest control programs, in statistically equal numbers. However, at the upper end of the scale it appears that a cost-benefit analysis becomes apparent, with the trade off between the expense of the pesticides themselves and the savings from reduced pest damage, being reflected in the higher rating given to pesticides by the growers of certified seed potatoes, rather than for fresh or processing potatoes. Results gained by interview would seem to bear out this belief that this relationship does indeed exist.

Table of Category Group vs Pesticide Use.

Pesticide importance	Certified seed	Fresh table	Processing
i. Very important (main control)	75 percent	69 percent	44 percent
ii. Quite important	19 percent	23 percent	33 percent
iii. Relatively unimportant (minor factor)	6 percent	5 percent	22 percent
iv. Unimportant (not used at all)	0 percent	3 percent	0 percent

Table 3 (Cross tabulation, Q4 and Q7)

The analysis revealed that growers of certified seed potatoes, as expected (because of virus vectors) depended heavily on chemicals with 75 percent of them indicating they formed the main control-very important strategy, 19 percent indicating that they were quite important and only 6 percent indicating that chemical pesticides were relatively unimportant- minor factor.

There were no recorded growers of certified seed potatoes, who ranked pesticides as unimportant- not used at all.

Growers of fresh table potatoes used pesticides slightly less, but pesticide usage still ranked high as a strategy, with 69 percent of growers of fresh table potato indicating that they formed the main control-very important strategy and with 23 percent indicating that they were quite important. Only 5 percent of growers of fresh table potato indicated that chemical pesticides were relatively unimportant- minor factor. There was however, a 3 percent group of respondents, who ranked pesticides as unimportant- not used at all. This was pleasing even if this group represents a very small part of the total percentage.

Growers of processing potatoes used pesticides less than the other two groups. This group may use pesticides less than the growers for other markets because of varieties grown or higher economic thresholds. These factors are determined by end-use requirements in processing.

44 percent of respondents indicated that they formed the main control-very important strategy, 33 percent indicated that they were quite important and 22 percent indicated that chemical pesticides were relatively unimportant- minor factor. There were no recorded growers of processing potatoes, who ranked pesticides as unimportant- not used at all.

The findings given above are that the production of certified seed potatoes has the highest use of pesticides (because of the virus-free index certification scheme) with the production of fresh table potatoes being the next highest user of pesticides, followed by the production of processing potatoes, this being the lowest user.

Another finding is that all three "purpose categories" (seed potatoes, fresh potatoes, processing potatoes) have relatively little adoption of low/no pesticide application. It seems pesticide application is still used as an insurance policy.

It should be the aim of all growers to reduce the use of pesticides because of the obvious benefits, by using such strategic approaches as IPM

Discussion.

Responses showed a wide variety of pest problems and control methods used. Chemical pesticides form the basis of most control strategies. This was especially so for growers of certified seed potatoes, because of virus vectors such as aphids, (green peach aphid, *Myzus persicae Sulzer*; potato aphid, *Macrosiphum euphorbiae Thomas*), and thrips, (*Thripidae*). However, 25 per cent of all growers are attempting to change this chemical regime by implementing IPM, even if it does deploy the use of chemicals to control such outbreaks.

The survey revealed many crop protection practices and pest problems. Some of the most significant findings are:

1. Pesticides are still the most widely used control strategy by the growers.

This is hardly surprising given the situation that most growers are placed in, whereby they have a broad range of pests to control. These include potato moths *(Phthorimaea operculella),* virus vectors such as aphids (*Macrosiphum euphorbiae & Myzus persicae*), thrips (*Thripidae*), the common brown plant hopper (*Cicadellidae),* tuber pests such as white fringed weevil (*Graphognathus leucoloma*) and African black beetle (*Heteronychus arator*). However, because of the dynamics of these pests, many growers, especially growers of fresh table and

processing potatoes, have employed a low frequency spray strategy to combat these pest problems (Ryland, personal communication). In such a case, growers may be complacent about the level of control they are getting. By applying a few late spray applications, they are actually missing most of the major pests, because it is then that they infest the crops (Ryland, personal communication).

That sort of situation lends itself ideally to the principles of IPM, and it is unfortunate that many growers have not accepted what IPM has to offer. It is, however, pleasing to find that 25% of all growers of potato crops, are attempting to implement IPM. It is hoped that this practice will continue. The major benefits are that when these potato pests develop resistance to the current group of insecticides being used (OPs, OCs, Carbamates & Pyrethroids), growers of potato crops will have a system in place, which will be least susceptible to entire failure.

Close to 65 percent of all respondents claimed that pesticides were their major control strategy. Unfortunately the survey did not ask the growers the frequency at which they applied their spray strategy, which would have been useful in determining specific spray volumes per crop. Pesticide application is largely by boom spray equipment (89.percent) followed by aerial spray (44 percent) use. It was also revealed that the 3 most commonly used chemicals are Methamidophos ("Monitor") 66 percent, Endosulfan ("Thiodan") 42 percent and Chorpyrifos ("Lorsban") 42 percent [disproportional percentage]. Such broad spectrum chemicals are inhibitive to an IPM system, since natural predators will only occur in small populations. A better strategy, as mentioned earlier, is possibly the use of these beneficials earlier in the crop cycle and then the use of such chemicals late in the season, with low frequency spraying to

control the occurrence of potato moths, aphids, thrips, white fly, white-fringed weevil and African black beetle.

IPM has been promoted for many years and while adoption has been slow, (25 percent of all growers), 60 percent of all growers have been made aware of IPM, with 39 percent unaware of the approach of IPM. This in part is encouraging but surprising in this age of communication, that 39 percent of potato growers have remained isolated from such an important strategy as IPM for pest control. Even more important, is the finding that only 19 percent of the 60 percent who claimed to have heard of IPM indicated they thought they understood the principle of IPM well. This finding indicates that there is still a lot of training required for IPM practitioners. As shown in a cross tabulation above, the most knowledgeable IPM growers are those who have been using IPM for 6 months to 3 years. The growers who have been using IPM the longest, i.e. 3 years or more were found to have a poorer understanding of IPM principles. Clearly, some degree of misunderstanding has taken place. Though this is important, it must also be remembered that this is only a general trend and does not relate to all growers who have been using IPM for more than 3 years.

As a strategy of IPM, pest monitoring forms a very important component, however, the majority of growers only use plant inspections. This reinforces the finding that 75 percent of growers do not use IPM, so it seems the growers who do use IPM, are not fully utilising monitoring aids, such as sticky traps, light traps, and pheromone traps. This is critical in assessing the infestation level in a crop and in decision-making as to what action to take.

A question was included to assess interest in reducing pesticide use and it was gratifying to note that 91 percent of growers are interested in "alternatives" that can reduce their pesticide use. The key concept involved in this question was the use of the term 'reducing" which is clearly different from anything that would imply a total cessation of the use of pesticides: i.e. the growers are interested in what IPM has to offer. In thier comments to question 24, growers expressed a desire to reduce pesticides and wanted an effective alternative to chemical pesticides. However, because of the nature of the problem with seed potatoes (virus vector insects), chemical strategies are the only ones for immediate control of pests.

2. There is a significant level of misunderstanding amongst growers of what IPM entails.

It is unclear, however, where this misunderstanding originates, because it seems that most growers have reasonable access to information sources such as grower newspapers and journals, such as *Good Fruit and Vegetables, The Land, The Weekly Times, The Potato Journal*, as well as personal contact with consultants, and agricultural officers from the Department of Agriculture. From the survey results, it can be seen that many growers have preconceived notions about what an alternative strategy involves. Even amongst IPM users. the survey showed that IPM knowledge is insufficient.

Some of the most common misconceptions about IPM are:

1. It involves the use of no chemical pesticides.
2. It involves the use of only biological control agents.
3. It is expensive, complicated, time consuming and often doesn't work.

All of these misconceptions are incorrect, however, proving this to growers is not an easy task and the adoption of IPM by growers of potato crops, as in the case of many other crops, has been slow. Thus a very big emphasis needs to be placed on training and education. In their comments to question 24, growers showed that they wanted more information/education with regard to the identification/recognition of pests and beneficials. A photo identification kit ("same as the Queensland crisping growers") was thought to be useful. This should be easy enough to produce and made available to all growers.

It seems that the growers who actively seek knowledge of improving their production systems, that is, the early adopters of innovation, such as is the case of those growers adopting IPM, will reap the benefits, as opposed to those growers who rely solely on pesticide applications.

The comments by the growers of potato crops covered five distinct themes and these comments demonstrated a consensus of opinion as to the key issues of concern to growers of potato crops. It would not be too difficult to address some of these concerns. This type of qualitative data is an extremely valuable source of information adding to the data obtained in the quantitive analysis of this survey. The positive attitude displayed by the majority of the comments relating to IPM were gratifying as the following example shows: "The concept of IPM is very sound. The effective extension of the principles and actual practice of IPM has been sadly lacking". The requests for more research is also encouraging, as for example: "This work has to be extended on as widely possible in order for growers to gain the rewards from dollars spent on R & D".

Survey Effectiveness.

The survey has been an important first stage in the process of formulating strategies to help combat potato pests in NSW and Queensland and it is thought that it has been successful in its original aim. The questions contained in this survey have targetted and collected the type of information that was thought to be important and useful, whilst being fairly simple to complete. The data collected by the survey is relevant and contains many important insights into pest management strategies by the potato growers. The co-operation of the growers is fully appreciated.

Future Research.

The most important component of an IPM program is its implementation. It is hoped that this research effort leads to the development of suitable, practical strategies that will enable the effective control of pests of potato crops, but most importantly, will be accepted by the growers, since there is no use in strategy formulation, without implementation. The next stage of research, which is currently being conducted, involves visiting specific growers from a variety of districts, in order to follow-up some of the findings through more in-depth interviews. This program of visits is intended to establish personal contact with growers of potato crops. This should enable field visits to be conducted to take measurements such as pest counts and the collection of insects for identification.

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APPENDIX

Appendix A.

University of Western Sydney,Hawkesbury
School of Horticulture

POTATO GROWER'S SURVEY

Dear Grower,

As you may be aware, Australian potato growers, through APIC, together with the Horticultural Research and Development Corporation (HRDC), are interested in developing strategies to reduce reliance on continuous applications of pesticides for pest control in potatoes. This survey forms the first part of a jointly funded APIC/HRDC project assessing the current status of insect pest control in NSW and Queensland, and the potential for development of alternative control strategies. In these states, there has not been an accurate survey of the major insect pests of potatoes in different growing districts. As a result, it makes development of relevant strategies difficult.

We are seeking your help to assist us in obtaining accurate information on your major insect pests, and the methods that are commonly used to control them. We are also interested in identifying the extent of Integrated Pest Management (IPM) practices currently used in the potato industry. This is so that we can better target our future work and make it of maximum benefit for you.

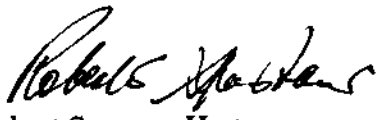
We understand you might be thinking "another survey !", and response rates to mail surveys can often be low. However, the more data that is returned, the more realistic picture we can get. We also hope later in the year to visit a number of districts, and to meet a number of you personally to further discuss pest control in your area.

All questions in this survey refer to the latest growing season. In questions where there is a choice of answers, please tick (√) the appropriate box(es).In some questions, you can give more than one answer.

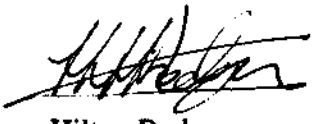
Please return the completed survey in the pre-paid envelope provided. The summary of the survey will be made available to you as soon as it has been analysed.

PLEASE NOTE THAT INDIVIDUAL RESPONSES TO THIS SURVEY ARE CONFIDENTIAL

Thank you for your assistance,



Robert Spooner-Hart
Principal Researcher



Hilton Redgrove
Research Assistant

University of Western Sydney, Hawkesbury, in conjunction with the Horticultural Research & Development Corporation (H.R.D.C.) and the Australian Potato Industry Council (A.P.I.C.).

Potato Growers' Survey.

Please Tick appropriate boxes or fill in spaces provided.

1. Where is your property : i. District: _____

_____

ii. Postcode: ☐☐☐☐

2. Which of the following varieties do you grow?:
(Tick all appropriate boxes.)

i. Sebago ☐
ii. Pontiac ☐
iii. Kennebec ☐
iv. Atlantic ☐
v. Other - please name _____

3. What area of your property was planted with potatoes in the latest growing season?

In hectares: _____
OR in acres: _____

4. How much of the above stated area was grown for:
(Give answer in hectares OR acres, please name which is used.)

i. Certified seed potatoes? _____
ii. Fresh table potatoes? _____
iii. Processed potatoes? _____

5. Do you export any of your potatoes? Yes ☐
No ☐

6. What are the insect pests in your potato crops?

(Put "1" for the most important pest, "2" for the next most important pest and "3" for the third most important pest & so on.)

PEST	Potato Moth	Aphid	Thrips	Jassid	Caterpillar	White-fringed Weevil	African Black Beetle	Other - (Please Name)
Rank (1,2,3 etc).								

7. How important are pesticides to your overall pest-control programme?
(Tick one box only.)

i. Very important - main control ☐
ii. Quite important ☐
iii. Relatively unimportant - minor factor ☐
iv. Unimportant - not used at all ☐

8. Which pesticides do you use to control potato insect pests?
(Tick all appropriate boxes.)

i. "Monitor"/ "Prefect"/ "Nitofol" (Methamidophos) ☐
ii. "Thiodan" (Endosulfan) ☐
iii. "Gusathion" (Azinphos-methyl) ☐
iv. "Thimet" (Phorate) ☐
v. "Permasect" / "Ambush" (Permethrin) ☐
vi. "Lorsban" (Chorpyrifos) ☐
vii." Pirimor" (Pirimicarb) ☐
viii. Other - please name _____

9. What methods of pesticide application do you use?
(Tick all appropriate boxes.)

i. Boom Spray ☐
ii. Aerial spraying ☐
iii. Pellet / dust ☐
iv. Other - please name _____

10. Are you interested in reducing your pesticide use?

i. Yes ☐
ii. No ☐
iii. Unsure ☐

Why? _____

11. Have you heard of Integrated Pest Management (IPM)?

i. No (Please Go to Q19.) ☐
ii. Yes (Please Go to Q12.) ☐

12. How well do you think that you understand what IPM is?
(Tick one box only)

i. Not at all ☐
ii. Only a little ☐
iii. Quite a lot ☐
iv. Understand it well ☐

13. Where did you obtain your knowledge of IPM?
(Tick all appropriate boxes.)

i. Industry associations
ii. Dept. of Agriculture
iii. Other grower(s)
iv. Trade journal(s)
v. General newspapers / magazines
vi. Television / radio
vii. Professional consultants
viii. Contractors (eg: Crisping groups)
ix. Other - please name _____

14. Have you used IPM?
(If "Yes" then go to next question, if "No" then go to question 18.)

i. Yes
ii. No

15. How long have you been using IPM?
(Tick one box only.)

i. Less than six months
ii. Six months to one year
iii. One year to three years
iv. More than three years
v. Did use it, but no longer do so

16. How important is IPM to your overall pest-control programme?
(Tick one box only.)

i. Very important - main control
ii. Quite important
iii. Relatively unimportant - minor factor
iv - Unimportant - not used at all

17. Against which insect pests do you use IPM practices?
(Tick all appropriate boxes.)

i. Potato moths
ii. Thrips
iii. Aphids
iv. Other - please name _____

18. Which techniques do you believe are important in IPM?
(Tick all appropriate boxes.)

i. Cultural practices, irrigation
ii. Beneficial / predator insects
iii. Non-calendar spraying / low pesticide usage
iv. Pest monitoring devices / practices
v. Other - please name _____

19. Do you use any of the following to monitor insect presence in your crop?
(Tick all appropriate boxes.)

- i. Crop or sample plant inspection ☐
- ii. Pheromone trap ☐
- iii. Light trap ☐
- iv. Sticky traps:
  - a. Blue ☐
  - b. Yellow ☐
  - c. White ☐

20. Do you monitor any of the following insect pests in your crop?
(Tick all appropriate boxes.)

- i. Potato moths ☐
- ii. Thrips ☐
- iii. Aphids ☐
- iv. Other - please name _____

21. Do you think that you have beneficial insects in your crop?
(Tick one box only.)

- i. Yes ☐
- ii. No ☐
- iii. Unsure ☐

22. If you answered "Yes" to question 21, please name any beneficial insects that you think are present:

_____

_____

23. Are you confident you can identify common :

- i. Pest insects ? Yes ☐ No ☐
- ii. Beneficials ? Yes ☐ No ☐

24.Thank you for your time in filling out this survey. If you would like to make any additional comments that you feel could assist the research, please write in the space below.

_____

_____

_____

_____

_____

_____

_____

_____

Appendix B.

Comments to the open-ended question 24.

Q24. Thank you for your time in filling out this survey. If you would like to make any additional comments that you feel could assist the research, please write in the space below.

The following comments by growers are quoted here verbatim, i.e. direct quotes as given in question 24. They have been transcribed as they appeared on the questionnaires. The questions seemed to fall into into five areas and are grouped accordingly.

1. Comments on insects: pests and beneficials and IPM.
2. Comments on the use of chemicals.
3. Comments on research.
4. Comments on the potato industry.
5.Comments on the questionnaire.

1. Comments on insects: pests and beneficials and IPM.

The concept of IPM is very sound. The effective extension of the principles and actual practice of IPM has been sadly lacking.

I don't know what IPM is.

This is the first crop we haven't used any pesticides on. We are monitoring this method.

Some beneficial feeding on the thrip?

By having bees and birds insect population reduced.

A photo identification kit for pests & beneficials same as Queensland Crisping growers, would be very handy.

Would like to monitor insects with light traps etc. and know how to evaluate results.

Any form of control for White Fringed Weevil would be invaluable to the seed potato industry.

Root Knot nematode control would also benefit the industry.

Life cycle charts are particularly important.

Mountain brown grasshoppers are sometimes a problem in early part of season.

Potato moth sometimes can be a problem. When this happens I keep the crop well irrigated as potato moth do not like moisture. When no pesticides are used slugs can be a problem and eat holes in the tubers.

Crookwell Potato Association Inc. are more than happy to co-operate in sampling field observations etc.

HIPMS monitored our crops this past year and in her reports the following is interesting. We grow Nuclear plant and mini tubers to produce G1 material and have to follow a calendar spraying program 10-14 days. Monitor and Thiodan usually. Our next door neighbour grew on some G1 from last year and didn't spray at all. His thrip count was a fraction of ours according to reports given me.

For a number of years I have been preplanting oats or rye grass and then plough it in to mulch down would appear to be controlling white fringe weevil and African Black beetle with reasonable success. But still have to spray Lorsban and irrigate in for full control. Only been spraying insecticide when absolutely have to which in last few years has only been once or twice.

The further into the tropics, the less effective it (i.e. IPM) seems to be.

Smiths Snackfood Co. encourages to use IPM but we still have to use some insecticides. We mainly use Endosulphan but when Aphid numbers get too high we have to use Monitor or for Tuber Moth we sometimes use Gustathion.

African black beetle and white fringed weevil are the biggest problem in our areas and I feel these problems have not been sufficiently addressed as using Lorsban with fertilizer at planting is not effective, and to my knowledge this is the only control measure available.

White fringed weevils have been extremely active since about 1980.

2. Comments on the use of chemicals.

I would like to have all chemical use cut down to a minimum. Until more research has been undertaken producers will be using chemicals for a long time to come.

We would all like no use i.e. NIL (sic) pesticide because they are almost the greatest expense but when the insect pressure is on you have NO (sic) choice.

The use of pesticides in the Riverina would be much lower than other areas. We would spray once only in our spring crop. Mostly not at all. If so then it is for moth and in our autumn crop occasionally for Heliothis or looper.

We only use chemicals when necessary and do not always maintain a regular spray programme.

We do spray potatoes for weed and grass control with Tesfan(sic) and Lorsban.

Most concerned about chemical resistance in the control of thrip etc.

We do spray for crickets at planting time with Lorsban, otherwise you get potatoes with holes in, and then they are not suitable for processing, or marketing, and your losses could be as high as 50%.

We also only plant the SPRING (sic) crop and not the autumn crop. We found that this eliminates most diseases and pests , which would otherwise carry over, and always use insecticide seed.

Low returns make it uneconomical to spray. Most years [the potatoes are] used for sheep feed.

I would like to see a new powder or dip for the control of Rhizoctonea (sic) as Rezolex is ineffective and expensive.

3. Comments on research.

This work has to be extended on as widely as possible in order for growers to gain the rewards from dollars spent on R&D.

We need more research into potatoes.

We need more research into controlling pests in potatoes.

More research into the marketing and processing of potatoes.

MORE (sic) research into NEW (sic) varieties of potatoes.

I have read your application to HRDC on IPM as I am a member of the Potato R&D committee. We are hoping to learn more from your work.

4. Comments on the potato industry.

More resources allocated to Dept. of Ag.as for example the Dorrigo area has one field officer for horticulture who also has to cover all other horticulture crops in the Coffs Harbour area.

PS Maybe research on why the price for horticulture has stayed static for the past 15 years to growers of most commodities.

On the marketing side - maybe some education of consumers to explain perfect produce may have to be from crops that have been insecticide treated, tubers with "horses" (sic) may have to be tolerated in future to be able to be insecticide free.

A more knowledgeable education from well-trained and practical people. (NO help has been received from Dept. AG for 10 years). When visiting Victoria this help always seems to be available - from readily available, top class scientists.

The main problem in potato crops are the low prices. Guyra last week $6-7 for a 50kg bag. This below cost of harvest. Do people around you have a bag in the house (cheap living) or do they

spend $15 on a big Mac or KFC for one meal? Remember big lawyers earn $10,000 a day and we work 12-15 hours a day to lost money - this will not last.

5. Comments on the questionnaire.

I want to see something constructive and responsible done with the information you get from growers.

I don't and never have grown potatoes. Please do your research on who really grows potatoes and then your survey maybe correct and not [be] "wasteful" (sic) on paper ("trees") (sic) .

This form deals with insect pests only, our major problems are fungus and virus.

End of comments.

Appendix C.

Final Report to Potato Growers. - A survey of major pest problems, chemical usage, knowledge and practices of IPM of potato growers in NSW & Queensland.

Dear Grower,

We have much pleasure in sharing with you the results of the survey, in which you participated.

As you know, the survey tried to find out what the major pest problems were, chemicals used by growers, and grower awareness of IPM (Integrated Pest Management).

We sent out 485 surveys between April to June, this year. Districts ranged from the coastal and tablelands areas of southern NSW to mid-north Queensland. This included Guyra, Dorrigo, Robertson, Crookwell, Balldale, Narrandera, Finley, Blayney, Orange, Bathurst and in Queensland Gatton, Ravenshoe, Atherton, and Tolga. We were able to use 105 surveys for data analysis. This meant that our survey was based on a response rate of 22 percent. Growers were grouped according to district name/postcode. The areas sown to potatoes totalled 3,232 hectares (7,986 acres). Of this area, 82 percent was used for fresh table potatoes, 12 percent for processed potatoes and 7 percent for certified seed potatoes. Most (92 percent) was for domestic purposes, with 5 percent being for export. Most of this export was seed potatoes, such as micro-tubers from NSW (Crookwell) or processed potatoes from QLD. *Sebago* was the most common grown (90 percent) with *Pontiac* next (34 percent), then *Atlantic* (15 percent) and *Kennebec* (9 percent), respectively. Other varieties, which include *Bintji, Crystal* etc. together totalled 31 percent of the varieties grown (disproportional percentage).

The potato moth was of the most concern to all growers followed by aphids, then thrips, jassids, white-fringed weevil and African black beetle. Seed growers ranked aphids, thrips and jassids/hoppers more important as pests than did the fresh table or processing growers. This was probably due to viruses they transmit (Tomato Spotted Wilt, Purple Top and Leaf-roll virus). Caterpillars and the African black beetle were ranked next in importance by seed growers, whereas both the fresh table and processing growers ranked the white-fringed weevil next.

The use of pesticides was thought of "very important" as the main control method by 65 percent of growers. Only a small number of growers (12 percent) stated that pesticides were unimportant. The main chemical used was methamidophos (brand names "Monitor", "Prefect", and "Nitofol") (66 percent of growers). The next most used chemical was chorpyrifos ("Lorsban") (42 percent) followed by endosulfan ("Thiodan") (41 percent). The main application method used was boom spray equipment (90 percent). Aerial spraying was used by 44 percent. Only 7 percent (disproportional percentage) used pellet/dust application.

Most growers (91 percent) were interested in reducing pesticide use mainly because of cost, although some growers mentioned safety and environmental issues as reasons for wanting to reduce usage. It was good to find that 60 percent of growers have heard of IPM, although surprising that 39 percent had not. Of the 60 percent of growers, who had heard of IPM, 43 percent had a good understanding of IPM, with 59 percent having a little understanding. Only 10 percent replied that they had "no understanding" of IPM. Industry associations were the most important source of grower awareness (41 percent) (disproportional percentage). The next most important source was the Department of Agriculture (32 percent). It was interesting to note that information was shared by growers with 30 percent of them hearing of IPM through other growers. Trade journals was the next most important category. However, the most important professional source to reach growers are the contractors and consultants, making up 46 percent, thus the main source of information, if these two are grouped together.

Of concern was the fact that although 60 percent of growers had heard of IPM, only 15 percent of all growers surveyed used IPM. However, of these, most growers (97 percent) said that IPM was the main control or quite important for them. Potato moth and aphids were the target pests of most IPM practices.

Of those growers who had heard of IPM, there is a fair understanding of IPM practices, although this understanding is not thorough. Non-calendar spray/low spray plays an important role in an IPM approach to pest management but by ranking this as lower than other strategies, it is apparent that growers have an incomplete or perhaps biased understanding of IPM. Almost all growers (99 percent) monitored their crop, with 22 percent using a specific IPM method for monitoring (Pheromone traps, light traps, sticky traps). Pheromone traps were used the most (11 percent). Potato moths were the major target of monitoring programs (86 percent), with aphids next (65 percent), followed by thrips (45 percent).

Fewer than half of the growers believed that they have beneficial insects in their crops (44 percent), with over half believing that they have no beneficials in their crop or being unsure of their presence (52 percent). Competence in insect recognition was questioned and 76 percent of growers believed that they could identify insect pests. However, 56 percent believed they could not identify beneficial insects. Only about one fifth of those surveyed (22 percent) believed they could identify beneficials. Overall, competence in identifying beneficials is low. However, examples of beneficials given were bees, spiders, ladybirds, lacewings, wasps and worms. An interesting result from the survey was that those growers who have adopted IPM most recently, are more proficient in their understanding of IPM.

What do the above results tell us?

1. Pesticides are still the most widely used control strategy by growers, with certified seed growers being most heavily dependent on chemicals. However, because of the dynamics of potato pests, many growers, especially fresh table and processing growers, have employed a low frequency spray strategy to combat pest problems. However, the broad spectrum chemicals used are inhibitive to an IPM system, since natural predators will be eradicated or only occur in small populations. A better strategy, is possibly the use of these beneficials earlier in the crop cycle and then the use of such chemicals late in the season, with low frequency spraying to control the incidence of potato moths, aphids, thrips, white-fringed weevil and African black beetle.

2. Potato growing lends itself ideally to an IPM approach and it is pleasing to find that 15 percent of all potato growers are attempting to implement IPM. It is hoped this use continues. The major benefits are that when these potato pests develop resistance to the current products being used (OPs, OCs, carbamates & pyrethroids) growers will have in place a system which is less susceptible to entire failure.

3. IPM is not well understood. Nearly 80 percent of monitoring needs to include specific IPM monitoring strategies, such as using pheromone traps, light traps and sticky traps. Monitoring is a critical phase in an IPM strategy. Some of the most common misconceptions about IPM are: 1. It involves the use of no chemical pesticides. 2. It involves the use of only biological control agents. 3. It is expensive, complicated, time consuming and often doesn't work. These views are incorrect and the adoption of IPM for potato growing, as for many other crops, has been slow. A lot of work is required to teach and promote the concept of an IPM approach to pest management. New adopters of IPM understand the approach best.

4. Almost all growers are interested in alternatives to chemical spraying (91 percent) and would be interested in knowing more about IPM.

Please note:

a) "disproportional percentage" means that growers could tick all choices and this led to overlap between categories and thus did not equal the number of respondents in the survey;

b) socio-economic problems were not part of this survey;

c) pests such as nematodes, bacterial & fungal pathogens were not part of this survey.

What is IPM?

In IPM, emphasis is placed not on pest elimination, but on the maintenance of populations at levels below those causing economic damage. IPM seeks to integrate appropriate chemical and mycocidal spray programs with other methods of control. The use of pheromones, monitoring emergence patterns, evaluating insect pest numbers, are important features in an IPM program. Cultural management practices include hilling and irrigation to maintain a soil barrier between the tubers and the moth and removing self-sown potato plants (rogueing), which prevents the build-up of insect pests early in the season. Overhead irrigation closes up cracks that develop and protects tubers. The amount of insecticide can be significantly reduced. Bacteria, nematodes, fungi, insect predators and parasites can also be used as biological control agents for pests and diseases. These approaches are combined with other techniques such as plant breeding for resistance. Host plant resistance studies have also emphasized the need for an IPM approach to pest management.

What will happen next?

We are interested in following up this survey by visiting and talking to growers. As the potato is the principal vegetable crop grown in Australia, it is important that disease and insect pests are controlled in an effective, yet environmentally sound manner. There is also community concern about chemical residues in food crops. For this reason, Integrated Pest Management (IPM), would offer the best strategy for potato growers but IPM is a complicated concept. This complexity of IPM could be a key reason for poor rates of adoption of IPM by growers.

We believe we have now obtained a clearer picture of current practices in insect pest control in NSW and Queensland. This has given us a firm baseline for decision-making. We believe that the results of this survey have demonstrated a real need to devise alternative strategies to pest control and to put programs in place to meet the need of potato growers for a better understanding of IPM. Hopefully, with this clearer understanding, a greater adoption of IPM will follow. We intend to monitor progress in the adoption of IPM as well as the success or otherwise of further stages in the research project such as workshops & consultancies to increase growers' knowledge and use of IPM. We thank you for your participation in this research project, look forward to working with you in the future and welcome any comments from you.

Yours sincerely,

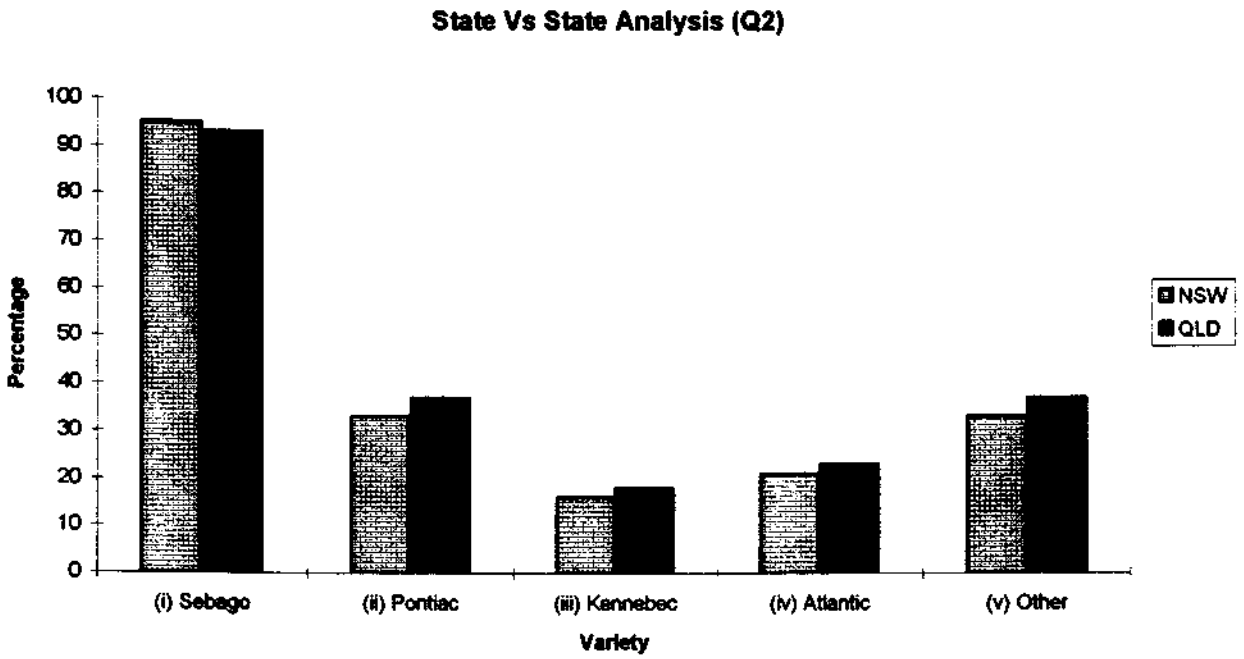
R.Spooner-Hart.
Principal Researcher.

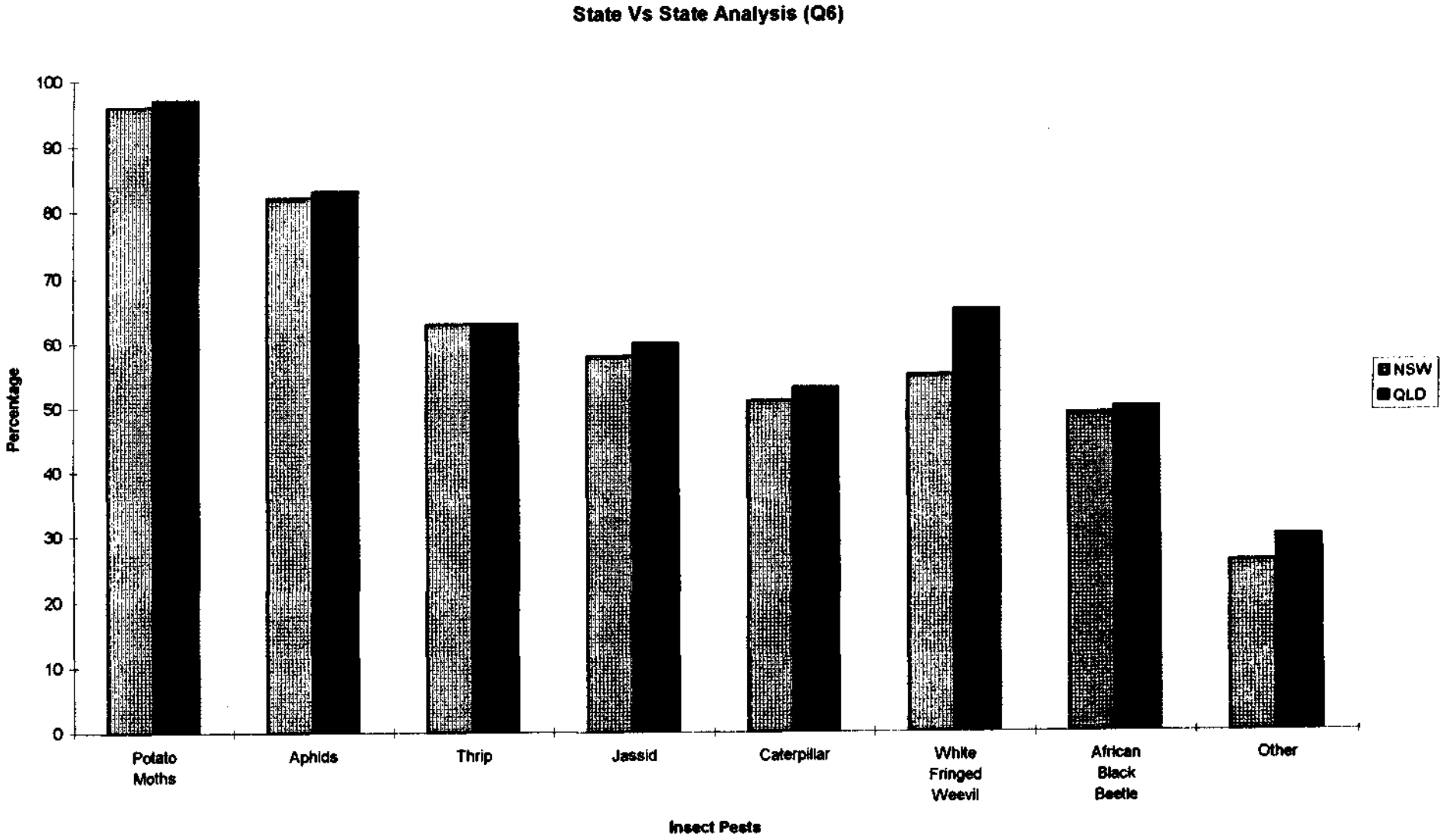
H.L.H.Redgrove.
Research Assistant.

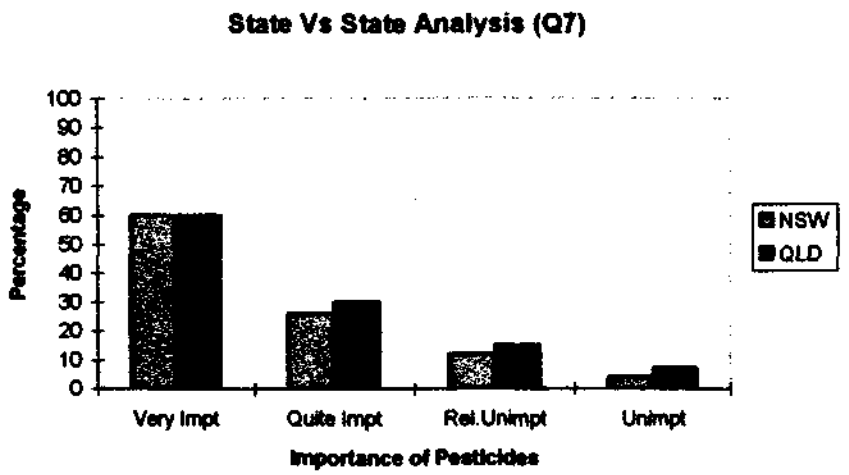
University of Western Sydney, Hawkesbury, School of Horticulture, Richmond, N.S.W. 2753. Australia. November, 1994.

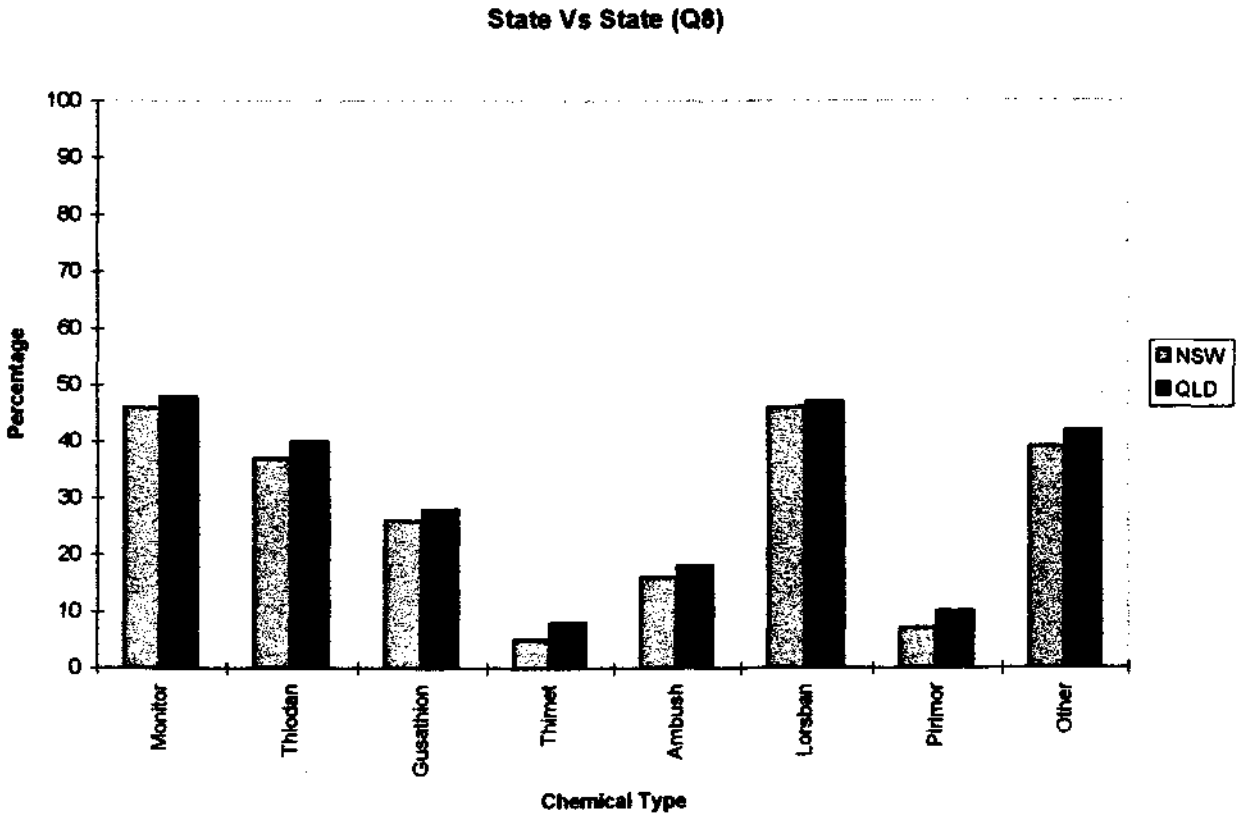
The research was funded by APIC and HRDC whose assistance is gratefully acknowledged.

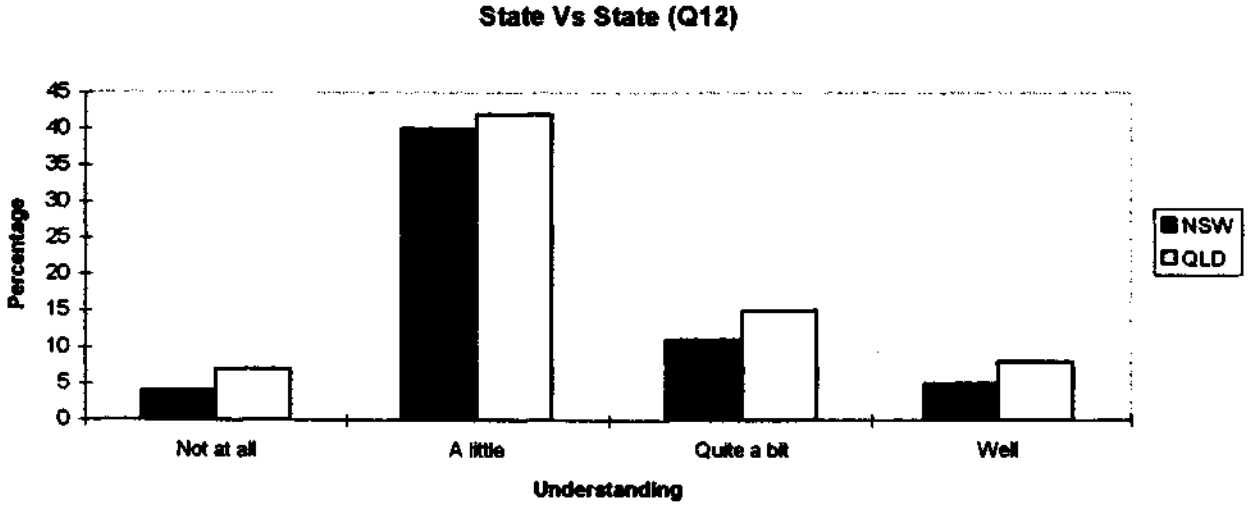
Appendix D.

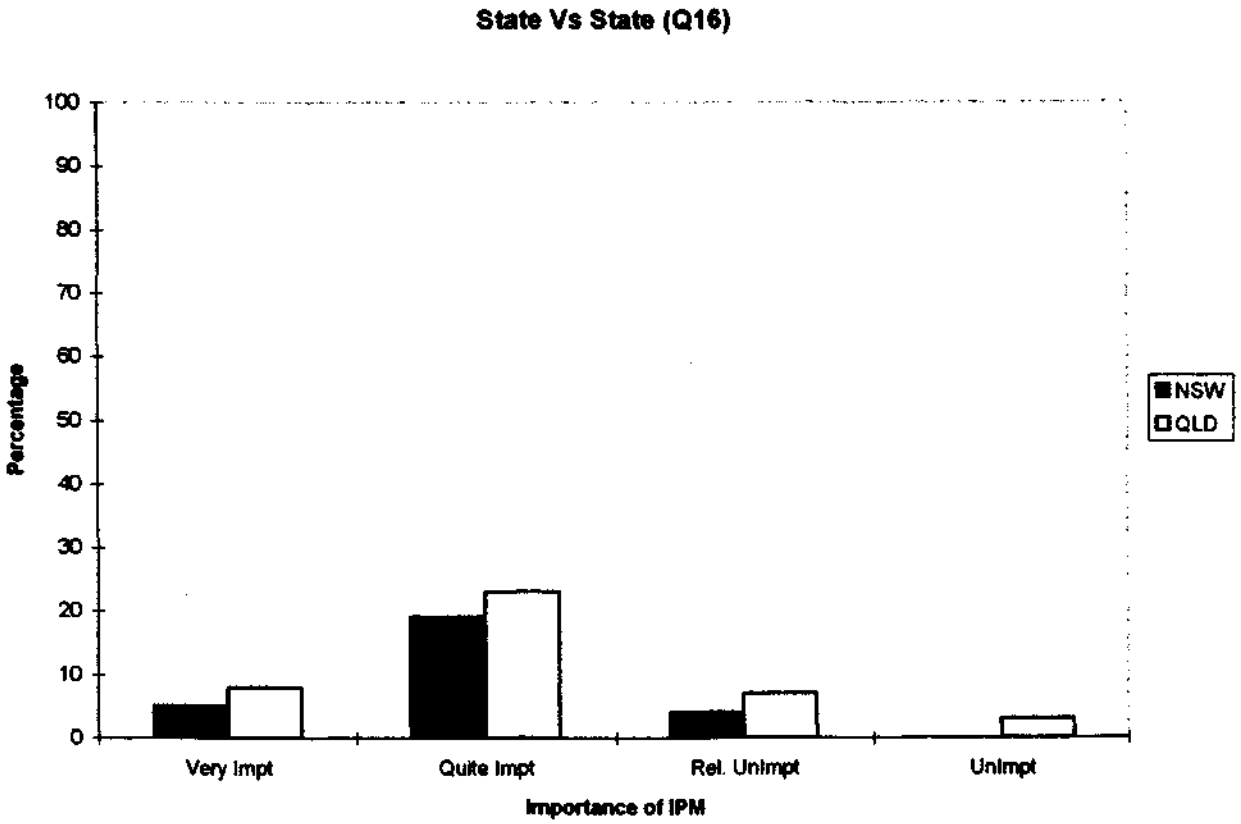

State Vs State Analysis (Q2)
100
90
80
70
60
50
40
30
20
10
0
Percentage
(i) Sebago
(ii) Pontiac
(iii) Kennebec
(iv) Atlantic
(v) Other
Variety
NSW
QLD

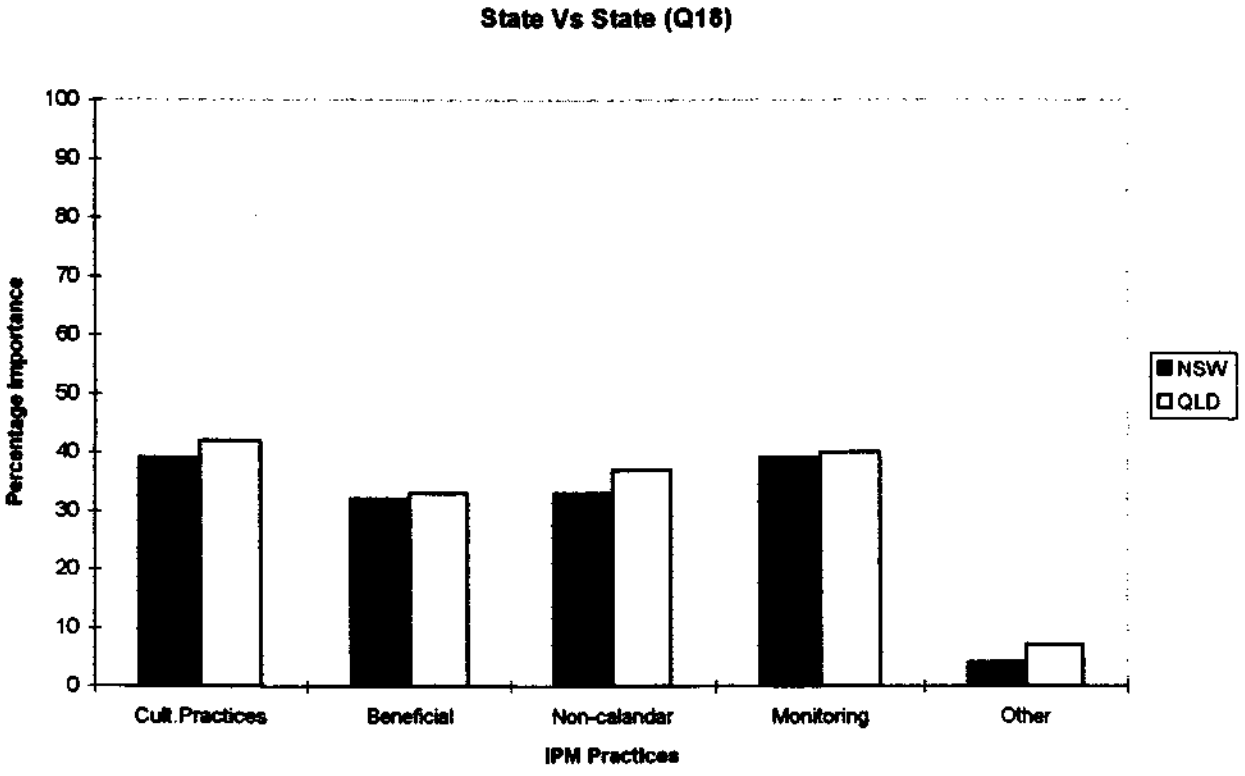

State Vs State Analysis (Q6)
Percentage
100
90
80
70
60
50
40
30
20
10
0
Potato Moths
Aphids
Thrip
Jassid
Caterpillar
White Fringed Weevil
African Black Beetle
Other
Insect Pests
NSW
QLD


State Vs State Analysis (Q7)
100
90
80
70
60
50
40
30
20
10
0
Percentage
NSW
QLD
Very Impt
Quite Impt
Rel.Unimpt
Unimpt
Importance of Pesticides


State Vs State (Q8)
Percentage
100
90
80
70
60
50
40
30
20
10
0
Monitor
Thiodan
Gusathion
Thimet
Ambush
Lorsban
Pirimor
Other
Chemical Type
NSW
QLD


State Vs State (Q12)
Percentage
45
40
35
30
25
20
15
10
5
0
Not at all
A little
Quite a bit
Well
Understanding
NSW
QLD


State Vs State (Q16)
100
90
80
70
60
50
40
30
20
10
0
Percentage
Very Impt
Quite Impt
Rel. Unimpt
Unimpt
Importance of IPM
NSW
QLD


State Vs State (Q18)
Percentage Importance
100
90
80
70
60
50
40
30
20
10
0
Cult.Practices
Beneficial
Non-calandar
Monitoring
Other
IPM Practices
NSW
QLD

Appendix E.

Survey Evolution.

1994 NSW and Qld. Potato Growers Survey.

A survey of major pest problems, chemical usage, knowledge and practices in IPM of potato growers in NSW & Queensland.

The following survey drafts contained herewith are the result of many months of precise question analysis to attain a survey document of high quality and relevance to the purpose of collecting information on NSW and Qld. potato growers' chemical usage, knowledge insect recognition and identification.

The survey went through 10 major draft stages with many minor detail changes per draft.

The research was funded by HRDC and APIC and was carried out by the Principal Researcher, Robert Spooner-Hart with the assistance of Hilton Redgrove, Research Assistant.

Hilton L.H.Redgrove.

Research Assistant.

November, 1994.

Appendix F.

TALLYSRT.XLS

	P.C.	2i	2ii	2iii	2iv	2v	3H	3A	4iH	4iiH	4iiiH	4iA	4iiA	4iiiA	5Yes	5No
2	137	2315	1				4			4						1
3	24	2365	1				2.5			2.5						1
4	34	2365	1	1			20			20						1
5	40	2365	1				10			10						1
6	41	2365	1					10					10			1
7	43	2365	1				2		2							1
8	46	2365	1				9		9							1
9	47	2365	1					46					46			1
10	102	2365	1					10				10				1
11	103	2365	1				10			10						1
12	107	2365	1	1		1		15					15			1
13	108	2365	1					6					6			1
14	162	2365	1	1				20					20			1
15	15	2453	1					120					120			1
16	16	2453	1				25			25						1
17	18	2453	1					40					40			1
18	19	2453	1					15					15			1
19	21	2453	1					60					60			1
20	23	2453	1				3			3						1
21	28	2453	1				12			12						1
22	121	2453	1					36					36			1
23	128	2453	1					15					15			1
24	26	2577	1	1	1	1	1		100				50	50		1
25	31	2577	1				5			5						1
26	37	2577	1			1	1		100			5	30	65		1
27	38	2577	1				10			10						1
28	39	2577	1	1	1		1		32				32			
29	42	2577	1	1			13			13						1
30	45	2577	1	1	1	1			50				25	25		1
31	105	2577	1	1			15			15						1
32	13	2583	1	1	1	1	1	1.5		1.5						1
33	17	2583	1	1		1	1	22		22					1	
34	27	2583	1	1	1		1		100			60		40		1
35	29	2583	1	1		1	1	33		33					111	
36	44	2583	1	1	1				23			23				1
37	101	2583	1			1	1	7		7						1
38	104	2583	1					1.5		1.5						1
39	4	2646	1				1	100			100					1
40	5	2646	1			1	1		270				270			1
41	8	2680	1	1					320			100	220			1
42	7	2700	1	1			1		1000				1000			1
43	11	2700	1			1			1250				1120	130		1
44	3	2707	1	1			1		80				80			1
45	35	2707	1	1			1		140				140			1
46	1	2710	1					30			30					1
47	2	2710	1					100			100					1
48	14	2710	1					17			17					1

TALLYSRT.XLS

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
	6Pest M	6Aphid	6Thrips	6Jassid	6Cater	6White	6Africa	6Other	7i	7ii	7iii	7iv
2	1								1			
3	1								1			
4	2	3			4	1	5			1		
5	3					2	1		1			
6	4		1	2		3						1
7	1	5	6	7	3	2	4		1			
8	1	3	5	4	6	2	7		1			
9	2	4	3			1			1			
10	1	4	6	3	7	2	5		1			
11	2	3		4	5	1			1			
12	1					2		3			1	
13	1	5	7	8	3	2	6	4		1		
14	2	3	3	3		1			1			
15		4			3	2	1		1			
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17		4	3			2	1		1			
18	4	3	3	3	5	2	1		1			
19	2	1	2		3	1	1			1		
20	3					1	2		1			
21	3					2	1		1			
22	5	4	3			2	1		1			
23	1	3				4	2		1			
24	3	2	4	5	6	1	7			1		
25	1					2		1	1			
26	1	4	5	3	7	2	6		1			
27	1	3				2			1			
28	1	2	3								1	
29	3	5	2	1	6	4	7	8	1			
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31	2					1	3		1			
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33	3	1	2	4		5			1			
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35	2	1	6	8	7	3	5	4	1			
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37	2	3	1	5	6	4		7		1		
38	1	2	3					4	1			
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41	3	3	2	2	1		1			1		
42	1		2		3						1	
43	1	3	4	5	2					1		
44	1	2			3			1	1			
45	1	2			3				1			
46	2	1	3									1
47	2	4	3	1				1		1		
48	1	3		2	4						1	

	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	8i	8ii	8iii	8iv	8v	8vi	8vii	8viii	9i	9ii	9iii	9iv	10Yes	10No	10Maybe	11No
2			1						1	1	1		1			1
3			1							1	1		1			1
4			1			1				1			1			1
5		1								1		1	1			1
6									1	1			1			1
7	1		1			1				1			1			
8			1							1	1		1			1
9			1			1			1	1		1	1			1
10	1								1	1			1			1
11					1	1	1		1	1			1			
12			1			1				1				1		1
13						1				1				1		1
14			1		1	1				1			1			1
15		1	1			1				1			1			
16		1				1				1			1			1
17		1				1				1			1			
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19	1	1			1					1			1			
20		1					1			1			1			1
21		1				1			1	1	1		1			
22		1				1				1			1			
23	1	1								1			1			
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26	1					1			1	1			1			
27	1					1				1				1		1
28									1	1			1			
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41					1	1				1	1		1			1
42									1			1		1		1
43	1										1				1	
44		1				1				1			1			
45									1			1	1			
46											1			1		
47			1						1		1		1			1
48									1	1			1			

	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH
1	11Yes	12i	12ii	12iii	12iv	13i	13ii	13iii	13iv	13v	13vi	13vii	13viii	13ix	14Yes
2															
3															
4															
5															
6															
7	1		1						1						
8															
9															
10															
11	1		1							1					
12															
13															
14															
15	1		1					1	1						1
16															
17	1		1					1							1
18	1		1				1	1		1	1				1
19	1		1					1						1	1
20															
21	1				1								1	1	1
22	1		1				1	1		1					
23	1		1							1					
24	1		1										1	1	1
25	1		1					1					1		
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27															
28	1		1							1					
29	1		1							1					
30			1										1		1
31															
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35	1			1		1									1
36	1		1				1						1		1
37	1		1			1	1								1
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39															
40	1		1			1									
41															
42		1													
43	1		1												
44	1				1	1	1	1	1	1					
45	1	1								1					
46															
47															
48	1		1						1						1

	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX
1	14No	15i	15ii	15iii	15iv	15v	16i	16ii	16iii	16iv	17i	17ii	17iii	17iv	18i	18ii
2																
3																
4																
5																
6																
7	1															
8																
9																
10																
11	1															
12															1	1
13																
14																
15				1				1								
16														1	1	
17					1			1								
18					1			1			1	1	1	1	1	1
19					1			1			1	1	1	1	1	
20																
21					1			1						1	1	
22	1															
23	1															
24		1						1			1			1	1	
25	1															
26	1														1	1
27																
28	1															1
29	1														1	1
30			1					1			1				1	1
31																
32	1														1	1
33				1					1		1				1	1
34				1				1			1				1	
35				1				1			1		1		1	1
36			1				1				1	1	1			1
37		1					1				1	1	1		1	1
38																
39																
40	1														1	1
41																
42																
43	1															
44	1															
45	1															
46																
47																
48					1				1		1				1	

	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK
1	18iii	18iv	18v	19i	19ii	19iii	19ivBlue	19ivYellow	19ivWhite	20i	20ii	20iii	20iv
2				1						1			
3										1			
4										1			
5				1						1			
6				1						1			
7		1		1						1			
8				1						1	1	1	
9													
10										1			
11		1				1				1			
12				1						1			
13													
14				1						1	1	1	
15				1						1		1	
16				1						1	1	1	
17	1	1	1	1						1	1	1	1
18		1		1						1	1	1	1
19				1						1	1	1	1
20				1									
21				1						1	1	1	1
22													
23													
24		1				1				1			
25	1	1		1						1			
26	1	1		1		1				1			
27				1						1			
28				1						1	1	1	
29	1	1		1						1	1	1	1
30	1	1				1				1			
31				1						1			
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33	1	1	1	1		1			1	1	1	1	
34	1	1		1		1			1	1	1	1	
35	1	1		1					1	1	1	1	
36	1	1		1						1	1	1	
37	1	1		1						1	1	1	
38										1	1	1	1
39				1						1	1	1	
40				1						1			1
41				1						1	1	1	1
42				1						1	1		
43		1											
44	1			1						1	1	1	1
45				1						1			
46				1						1	1	1	
47				1						1	1		1
48	1			1									

	CL	CM	CN	CO	CP	CQ	CR
1	21Yes	21No	21Maybe	23iYes	23iNo	23iiYes	23iiNo
2				1	1		1
3	1				1		1
4				1			
5	1				1	1	
6				1	1		
7		1			1		1
8		1			1		
9				1	1		1
10	1				1		1
11	1				1	1	
12	1				1	1	
13		1			1		
14	1				1		1
15	1				1		1
16		1			1	1	
17	1				1		
18	1				1		1
19	1				1		
20				1		1	1
21				1	1		1
22		1			1		1
23							
24	1				1		1
25				1		1	
26	1					1	1
27		1			1		1
28				1		1	1
29				1	1		
30	1					1	1
31		1			1		1
32	1					1	1
33	1					1	1
34	1				1		1
35	1				1		1
36				1	1		1
37	1					1	1
38	1					1	1
39	1				1		1
40				1	1		1
41				1	1		
42		1			1		
43	1				1		1
44		1			1	1	
45				1	1		1
46		1			1	1	
47		1			1		
48					1	1	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
49	169	2712	1	Berrigan NSW				114			74	40					1
50	9	2713	1	Finley NSW			1		40					40			1
51	12	2714	1	Tocumwal. NSW.				49			49						1
52	30	2714	1						120					120			1
53	6	2798	1	Bathurst.				60			12	48					1
54	48	2798				1	1		31						25		1
55	10	2799	1		1		1	1		1							1
56	168	2799		Blayney		1	1		80				8		72		1
57	20	2800	1	Orange.					5.5				2	3.5			1
58	36	2804				1			103						103		1
59	124	4123		1			1		14					14			1
60	160	4160					1		4		4						1
61	163	4164					1		80				80				1
62	122	4165	1	1			1	20			20						1
63	132	4165					1		16					16			1
64	140	4165	1				1										1
65	130	4309	1					5			5						1
66	153	4309	1					2			2						1
67	129	4311	1			1		27				27					1
68	134	4311				1			45						45		1
69	151	4311	1						20					20			1
70	125	4343	1	1			1	92			92						1
71	131	4343	1					16			15						1
72	133	4343	1	1				100			80	20					1
73	154	4343	1	1					10					10			1
74	156	4343	1	Galton Qld.			1		11					11			1
75	167	4343	1						7					7			1
76	170	4343	1	1				8			8						1
77	171	4343	1	1					8					8			1
78	155	4500	1						400					400			1
79	123	4702					1	32			32						1
80	159	4702	1				1		40					40			1
81	22	4872	1	Ravenshoe				8			8					111	
82	33	4872	1					8			8						1
83	127	4872	1					8			8						1
84	136	4872	1						35								1
85	139	4872	1	Atherton Kairi Dstrct.					16					16			1
86	141	4872	1	1					35								1
87	150	4872	1	1				10			10						1
88	152	4872		1					6					6			1
89	106	4882		Toga, Qld					60						60		1
90	138	4882	1	1				11			11						1
91	142	4882	1				1		30					30			1
92	143	4882	1						30					30			1
93	144	4882	1					12			12						1
94	145	4882	1					5			5						1
95	146	4882	1					20			20					11	
96	147	4882	1	1			1		40					40			1

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
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51	3	2		1				4	1			
52	2	1		3						1		
53	2	1				3			1	1		
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60							1		1			
61	1	2							1			
62	1	2						3		1		
63	1	3	2							1		
64											1	
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73	1	3		2					1			
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78	1	1			1			2	1			
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81	1	2									1	1
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91	3	1	4	5	6	2			1			
92	3	2	4	5	6	1	7		1			
93	2	3				1			1			
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95	1	1	2	2	2	1	3		1			
96	2	1	3	3	3	2			1			

	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
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69	1	1						1	1	1			1			1
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76	1		1			1			1	1			1			
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	BF	BG	BH
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56	1		1
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86			
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91	1		1
92			
93			
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95			1
96			

	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX
46				1				1			1				1	1
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70					1			1					1		1	1
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86	1														1	1
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92																
93																
94						1				1			1			
95				1							1	1	1		1	
96																

	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK
49	1	1		1	1	1			1	1			
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84				1						1			
85				1						1		1	
86	1	1		1						1	1	1	
87	1	1		1						1	1	1	
88				1						1	1	1	
89				1	1				1	1	1	1	
90													
91	1	1		1					1	1	1	1	
92				1						1	1	1	
93				1						1		1	
94				1						1	1	1	
95	1								1	1	1	1	
96				1						1	1	1	

	CL	CM	CN	CO	CP	CQ	CR
49	1				1		1
50				1			
51		1		1			
52			1	1			1
53	1			1		1	
54			1	1			1
55	1				1		1
56	1			1		1	
57	1				1		1
58			1	1			1
59		1		1			1
60		1		1			1
61	1			1		1	
62			1	1			1
63		1		1			
64			1		1		1
65							
66		1		1			1
67	1			1			1
68			1	1			
69			1	1			1
70	1			1		1	
71		1		1			
72	1				1		1
73			1	1			1
74	1			1			1
75	1			1		1	
76			1	1			1
77	1			1		1	
78		1		1			1
79	1			1		1	
80			1	1			1
81	1						
82			1	1			
83		1		1			
84	1			1			1
85		1		1			
86	1			1		1	
87			1	1			1
88			1		1		1
89	1			1		1	
90	1				1		1
91	1			1		1	
92			1	1			1
93		1		1			1
94	1			1		1	
95	1			1		1	
96	1			1		1	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
97	148	4882	1						14					14			1
98	165	4882	1	1				12			12					1	
99	166	4882	1	Tolga . QLD.				2			2						1
100	25	4883	1	1			1		95					95		111	
101	32	4883	1	1					28					28		111	
102	126	4883	1	1				10			10						1
103	135	4883	1	Atherton.					25					25			1
104	149	4883	1					8			8						1
105	158	4883	1					2			2						1
106	164	4883	1	1				20			20						1

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
97	2	1				3				1		
98	3	2	1						1			
99	1	2			3				1			
100	2	1	3	4	5	6	7	8	1			
101		1				2			1			
102	1	2	3							1		
103	1	2			3		4	5	1			
104	2	1	4	5	6	3	7		1			
105	2	1	3	4	5	6	7			1		
106	2	1						3	1			

	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
97	1						1		1	1			1			
98	1					1			1	1			1			
99	1							1	1	1	1		1			
100	1	1				1			1	1			1			
101	1								1	1			1			
102	1	1							1	1			1			
103	1					1		1	1	1			1			1
104	1	1							1				1			1
105	1	1							1				1			
106	1									1			1			

	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH
97	1		1					1				1			
98	1		1					1				1			
99	1		1			1								1	
100	1				1	1	1	1							
101	1		1			1									
102	1			1		1	1								1
103															
104															
105	1			1										1	1
106	1		1					1							

	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX
97			1		1				1		1	1
98												1
99												1
100											1	1
101												1
102	1			1			1				1	
103												
104												
105	1			1			1	1	1		1	
106											1	1

BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK

97					1		1	
98	1	1		1	1	1	1	
99	1	1	1	1	1		1	
100	1	1	1	1	1	1	1	1
101	1			1		1		
102			1	1	1	1	1	
103					1		1	
104				1	1		1	
105				1	1	1	1	
106	1	1			1		1	

	CL	CM	CN	CO	CP	CQ	CR
97			1	1			1
98			1	1			1
99	1			1			1
100	1			1			1
101			1				1
102	1			1		1	
103		1		1			
104		1		1			1
105			1		1		1
106			1	1			1

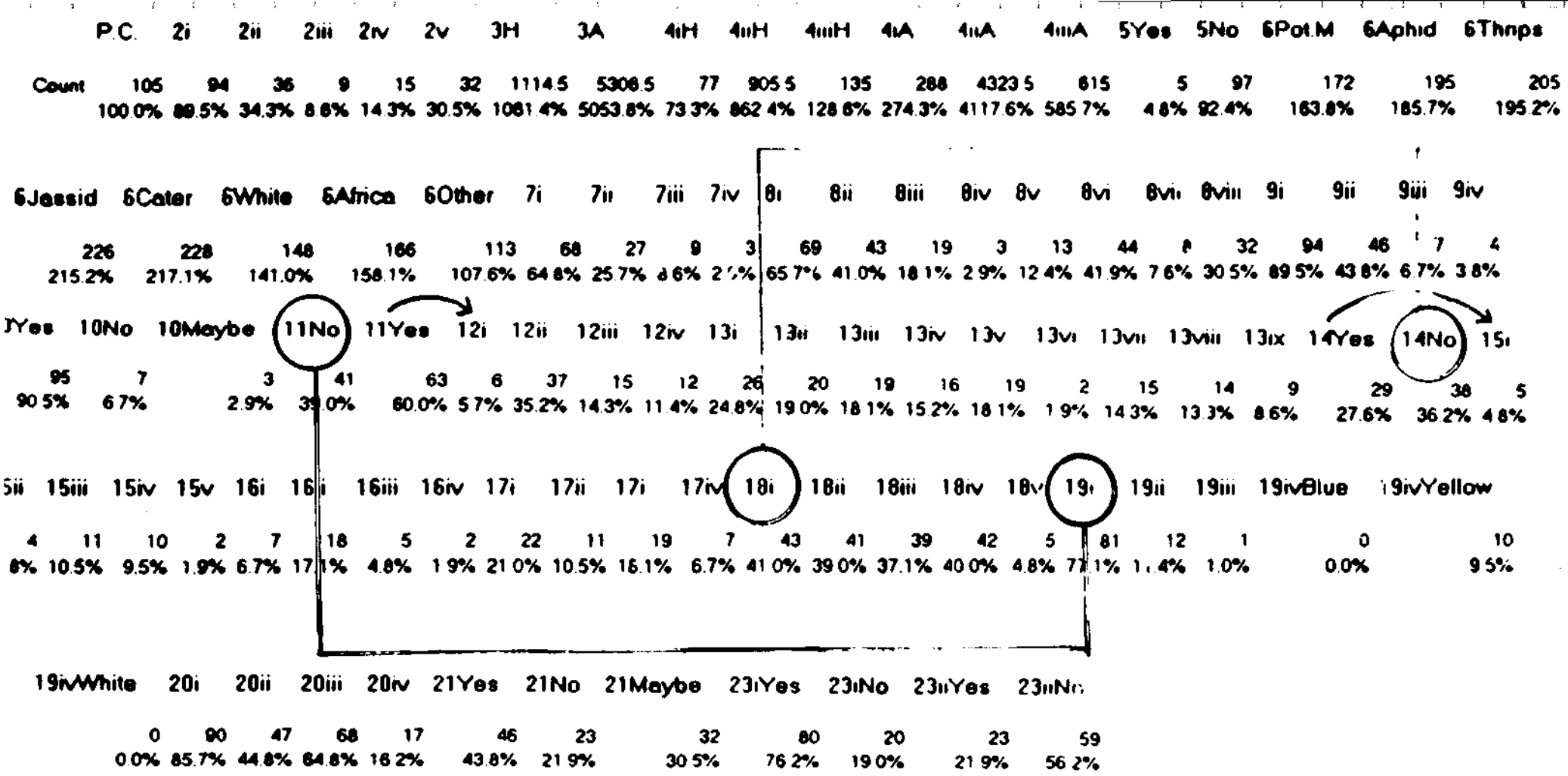
Appendix G.

TALLYDAT.XLS

	6Pot.M	6Aphid	6Thrips	6Jassid	6Cater	6White	6Africa	6Other	Total
1	46	33	3	3	2	12	11	6	116
2	29	27	14	7	4	20	2	3	106
3	16	19	21	13	13	8	2	5	97
4	3	9	10	16	6	5	2	5	56
5	1	3	8	13	12	2	4	1	44
6			4	3	10	7	3	5	32
7			1	1	5		13	1	21
8				1			1	3	5
									477
	95	91	61	57	52	54	38	29	477

	6Pot.M	6Aphid	6Thrips	6Jassid	6Cater	6White	6Africa	6Other	Total
1	39.66%	28.45%	2.59%	2.59%	1.72%	10.34%	9.48%	5.17%	100.00%
2	27.36%	25.47%	13.21%	6.60%	3.77%	18.87%	1.89%	2.83%	100.00%
3	16.49%	19.59%	21.65%	13.40%	13.40%	8.25%	2.06%	5.15%	100.00%
4	5.36%	16.07%	17.86%	28.57%	10.71%	8.93%	3.57%	8.93%	100.00%
5	2.27%	6.82%	18.18%	29.55%	27.27%	4.55%	9.09%	2.27%	100.00%
6			12.50%	9.38%	31.25%	21.88%	9.38%	15.63%	100.00%
7			4.76%	4.76%	23.81%		61.90%	4.76%	100.00%
8				20.00%			20.00%	60.00%	100.00%
	19.92%	19.08%	12.79%	11.95%	10.90%	11.32%	7.97%	6.08%	100.00%

The above line of data is the grand mean percentage, as calculated by the computer package *Excel.*



Raw results as computed by Excel, showing skip-type questions paths. It should be noted that this spreadsheet has not been calibrated to take into account a variable respondent base that has been created by the skip-type questions.