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The principles of an integrated framework for sustainable vegetable production

A report prepared for
Fresh Vegetable Sector, New Zealand Vegetable and Potato Growers' Federation

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CROP & FOOD RESEARCH
Mana Kai Rangahau

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CONTENTS

Page

1 EXECUTIVE SUMMARY

- We outline the principles of an integrated framework which identifies the interactions between various components of sustainable vegetable production.

- The framework includes the components relating to crop management (i.e. soil, water, air, pests, diseases and weeds). Economic and social factors are also very important but these are outside the scope of this report.

- The concept of the framework was developed following a workshop attended by growers, Vegfed staff and Crop & Food Research scientists.

- The framework can be used to:

  - identify gaps in our knowledge and areas where further research is required,

  - check for 'fish hooks' in proposals for changes in crop management and in research proposals,

  - develop best management practices for sustainable vegetable production.

- The best management practices identified from this framework could be expanded into a code of practice for sustainable vegetable production in New Zealand.

- The next step is to make the framework accessible and easy to use. The framework would be best stored in a computer database with keywords to retrieve the information. The information could be stored on a crop basis.

2 INTRODUCTION

Sustainable production is a 'core competency' of the New Zealand vegetable industry (New Zealand Vegetable Industry Foresight Project, 1998). Growers are under increasing pressure to assure customers that their crops meet quality, safety and sustainability standards. To help meet this demand and to maintain profitability, it is important that growers ensure their production systems are sustainable. This involves managing vegetable production systems so that they:

- are profitable,
- conform to market specifications of quality and safety,
- conserve New Zealand's soil and water resources for future production,
- meet environmental regulations.

Sustainability of vegetable production is dependent on a number of biological, physical, economic and social factors. Developing sustainable systems involves understanding all the components of the production system. This includes a knowledge of crop production and how it is affected by the environment (soil and climate). Economic and social factors are also very important but these are outside the scope of this report.

Many aspects of crop production are connected, so changing one management practice may affect another aspect of the crop and the change may be positive or negative. For example, growing a green manure crop like mustard between vegetable crops will add organic matter to the soil which is beneficial for soil structure. But are there any negative impacts on the subsequent crop that we should be aware of? Will the mustard host pests and diseases (e.g. clubroot) that affect the following vegetable crop? The answer to this question is not straightforward as it depends on climate, soil type and which vegetable crops are grown. Developing sustainable systems is complex and requires an overview of all the various components and how they interact.

In this study, we outline the principles of a simple framework which identifies the interactions between the various components of sustainable crop production. The framework can be used for:

- identifying gaps in our knowledge and where further research is required,
- checking for 'fish hooks' in proposals for changes in crop management and in research proposals,
- developing best management practices for sustainable vegetable production.

The initial concept was discussed at a workshop in Wellington in February 1999 with growers and Vegfed staff (Appendix). This report summarises the outcomes of the workshop and provides an outline of a simple framework for sustainable vegetable production.

3 GENERAL OVERVIEW OF FRAMEWORK

The workshop discussed the key factors that influence sustainable production. The discussion has been summarised in the diagram below (Figure 1). The centre of this diagram shows the crop/produce that has been grown on the farm moving through the buyer/wholesaler to the consumer. Surrounding this pathway are the key factors influencing crop yield. These fall into two different categories — those growers can influence through their management decisions (e.g. pest and disease control) and those which are more difficult to influence directly (e.g. Resource Management Act (RMA), consumer attitudes). This report concentrates on the factors that growers can influence directly by their management decisions.

The key components of land management identified in this study are:

- soil
- air
- water
- pests, diseases and weeds

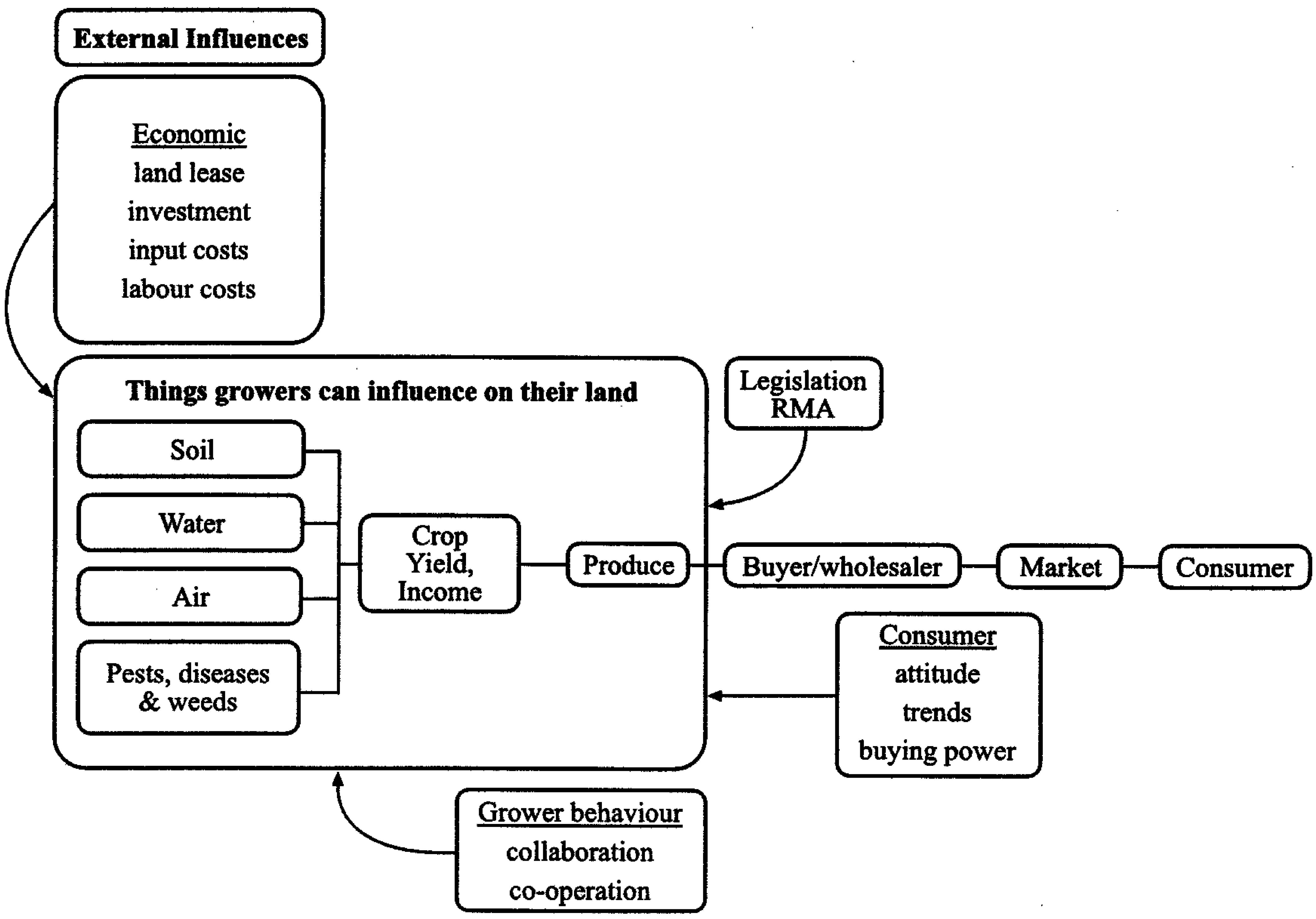


Figure 1: Key factors influencing sustainable vegetable production.

3.1 Soil

High quality vegetable production requires fertile soil with good structural, biological and chemical properties. Under intensive vegetable production, issues like soil compaction, erosion, soil structure deterioration, nutrient imbalances and heavy metal contamination can lead to reduced crop yields and other problems like increased risk from diseases and environmental contamination. These issues can be avoided by practising good soil management including understanding suitability of soil type, appropriate tillage techniques, and good irrigation, fertiliser and soil organic matter management.

3.2 Water

Water is essential for crop growth. It is important to use water efficiently so that the quality and quantity of our water resource is not compromised. Irrigation systems should deliver water when the crop needs it. Application of excess water can lead to soil erosion and drainage into groundwater. Nutrients and chemicals carried in the excess water can lead to environmental contamination. Furthermore, waterlogging reduces plant growth and irrigation water can spread diseases. Management practices that influence the water resource include irrigation design, scheduling crop water requirements and drainage.

3.3 Air

Contaminants can be released into the air from a variety of sources including pesticides, odours, dust and burning plastic. These contaminants are an environmental concern and may also affect crops grown nearby. Noise can also be a major issue in certain areas. The extent of these problems is very dependent on climatic factors (e.g. wind), tillage, chemical application, disposal of plastic and use of buffer zones and shelter belts.

3.4 Pest, disease and weed control

The control of pests, diseases and weeds is an important part of crop management. Without adequate control, crop quality and yield are affected. While chemical control is a useful practice, there are a number of non-chemical controls that are very effective. Biological control, crop rotation, use of resistant cultivars, cultivation methods and soil fertility are all examples of non-chemical control methods. Good pest, disease and weed management strategies usually include a combination of these methods.

4 FRAMEWORK

Th factors influencing sustainable vegetable production are interrelated. For example, applying fertiliser to a crop will increase its yield. The fertiliser may also encourage a particular weed species, thus increasing the need for herbicide. If the weed is not successfully controlled, crop yield may suffer despite the fertiliser application. The increased weed population may also mean that extra cultivation is required after the crop has been harvested or the crop rotation may have to be changed. So applying fertiliser can have other effects beside simply increasing crop yield. The type of interactions that can occur between fertiliser, pest, disease and weed control and cultivation are shown in Figure 2. The complexity of potential interactions is obvious - and this diagram does not include irrigation management, climate factors, soil type, etc. Including these interactions in Figure 2 would make this diagram very difficult to interpret on a single page.

Our approach is to develop a list of keywords for each main factor identified in section 3. The keywords are in Tables 1-4. This approach does not show the interactions but you can assume that all the keywords listed are potentially interrelated in some way. This provides a checklist designed to alert users to potential interactions.

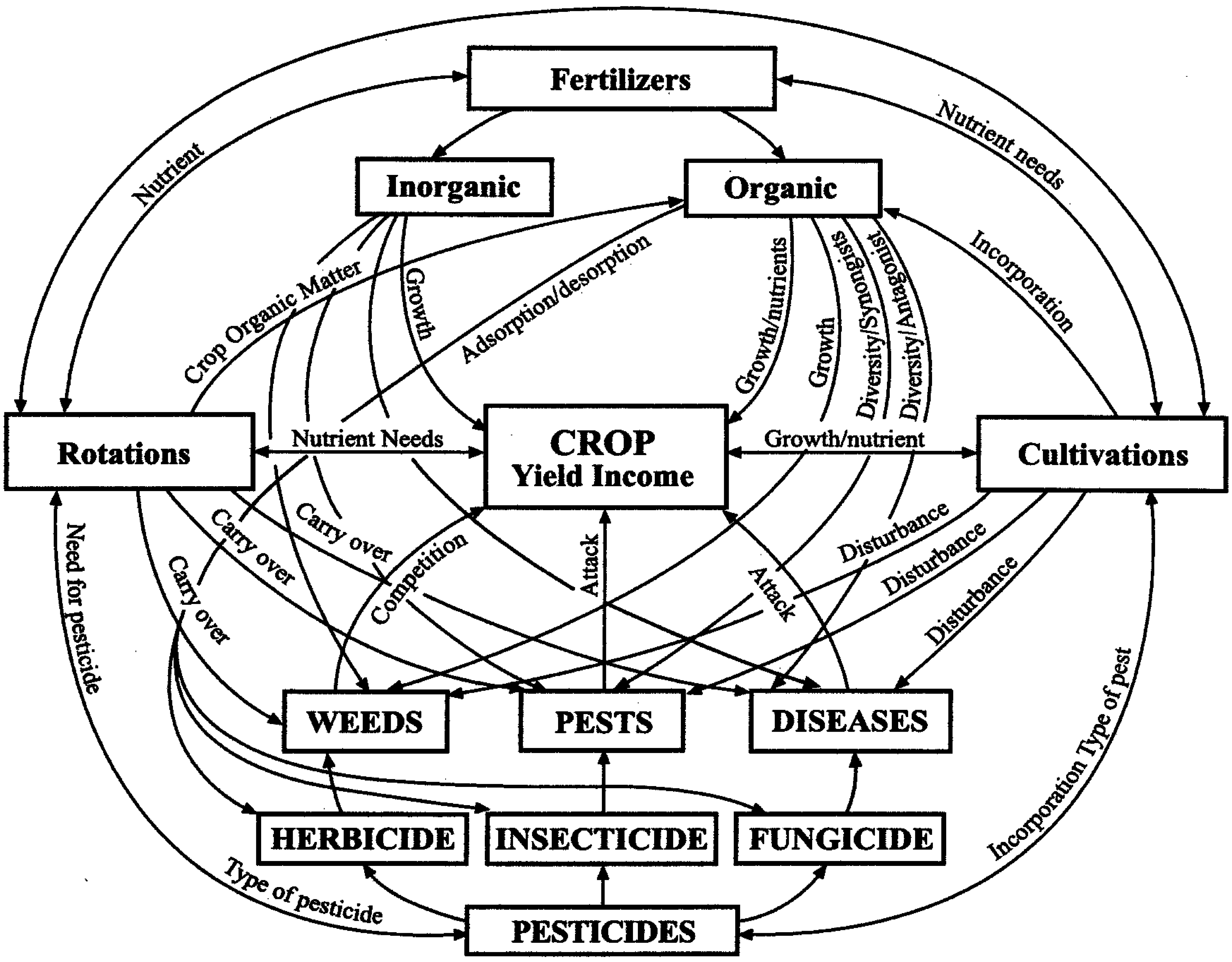


Figure 2: **Interactions between fertiliser, pests, diseases, weeds and cultivation in a crop production system (adapted from Edwards et al. 1990).**

Table 5: Using the framework to identify research gaps on a soil issue.

Will growing mustard affect...	Answer	Response
Chemical condition of soil (nutrient supply, organic matter, etc.)	Yes, increase soil organic matter	We know the interactions
Physical condition of soil (soil structure, soil type, etc.)	Yes, will improve soil structure	We know the benefits
Biological condition of soil (earthworms, microbes, pathogens, etc.)	Could affect disease carryover, e.g. clubroot or pythium	Needs research
Fertilisers and lime	Could affect N availability during decomposition	Needs research
Irrigation	Unlikely	No problem
Crop rotation	Could affect crop species grown next	We probably know this
Tillage (method, type of equipment, etc.)	Will we need special equipment to incorporate mustard residues?	Technical problem not research problem
Erosion control	Yes, will reduce risk	We know the benefits
Windbreaks	Not relevant	Not relevant
Green manure crops	Could affect disease carryover, e.g. clubroot or pythium	Needs research
Irrigation effect on spread of disease	Not relevant	Not relevant
Nutrient effect on disease	Can we control any disease from the mustard with pH or nutrients?	Needs research
Soil effects on crop quality	Not relevant	Not relevant

5.2 Checking for 'fish hooks' in proposals for changes in crop management and in research proposals.

The framework can be used to identify interactions between the various components of sustainable vegetable production systems. This is important because a research project which looks at solving a problem may create another problem in a related but overlooked area. For example, a project looking at using a parasite rather than chemicals, to control white butterfly, needs to consider all the potential impacts this may have on other aspects of crop production. The framework will alert the user to these issues. Clearly, this topic relates to the pests, diseases and weeds key area (Table 4). We then work our way through all the components asking the question, How will using biological control instead of chemicals to control white butterfly affect this component? Table 6 shows the possible questions, answers and responses for this example.

By working through all the components we can build up a list of potential problem areas we need to be aware of when considering this research proposal or a change in management practice.

5.2.1 Summary

1. Identify solution from proposal or change in management practice.

2. Use checklist to check if components related to the proposal have been considered.

3. Identify other relevant impacts of the new solution/practice.

Table 6: Using the framework to check for 'fish hooks' in a proposal relating to a pest issue.

Will biological control of white butterfly instead of chemical control affect...	Answer	Response
Healthy plants (Insects, nematodes, etc.)	Other insects encouraged or affected?	Need to know
Chemical control (Pesticides, fungicides, etc.)	No longer using pesticides. What other species will be affected?	Need to know
Biological control (Predators, parasites)	Will the parasite affect other species?	Need to know
Nonchemical control (Cultural practices)	Will cultural practices affect survival of the white butterfly/parasite?	Need to know
Avoid plant stress (Water and nutrients, etc.)	Will planting dates affect parasite effectiveness?	Need to know
Disease forecasting	Is weather important to survival of parasite?	Need to know
Chemical control (Monitor pests, etc.)	No longer using pesticides. What other species will be affected?	Need to know
Biological control (Healthy alternate hosts, etc.)	How to maintain parasite population?	Need to know
Cultural practices (Crop rotation, cultivars, etc.)	How will success of the parasite be affected by crop rotation, cultivars, crop hygiene and irrigation?	Need to know
Environmental contamination (Nitrate leaching, etc.)	Reduced risk as using less chemicals	No problem
Impact on subsequent crops	Will other pests become an issue? Will this affect crop rotation?	Need to know
Effect of chemicals on beneficial insects, etc.	Reduced risk as using less chemicals	No problem
Irrigation may spread disease	Will irrigation affect parasite?	Need to know
Earthworms spread or control disease?	Not relevant	Not relevant
Shelter belts	Will they affect the parasite?	Need to know
Crop quality	Will parasite affect crop quality?	Need to know

5.3 Developing best management practices for sustainable vegetable production

The framework can be used to develop best management practices for sustainable vegetable production. This can be achieved through identifying potential management practices and then using the checklist to identify potential interactions and problems. For example, developing best management practices to ensure that irrigation water is used efficiently as outlined in Table 7.

5.3.1 Summary

1. Identify issue for best management practice

2. Choose relevant key area(s)

3. Use the components listed for the key area(s) to develop management practices.

Table 7: Using the framework to develop best management practices for using irrigation water efficiently.

How is efficient use of irrigation water affected by....	Best management practice
Efficient water use (Runoff, drainage, etc.)	Design system to deliver volumes of water that can be used by the crop.
Water quality (Groundwater, surface water)	Ensure system does not cause drainage or runoff. Apply fertilisers and pesticides efficiently. Reduce drainage past the root system.
Frost protection	Not relevant for this situation.
Irrigation (Type of system, pressure, etc.)	Use appropriate type of system for crop, water supply.
Apply right amount of irrigation (Crop water needs, water scheduling, wind effect, etc.)	Obtain information on irrigation requirements of target crop. Use irrigation scheduling to predict irrigation requirements. Base schedule on measures of soil moisture, crop requirements, soil type, etc.
Underwatering / Overwatering	As above.
Weather Rainfall, wind, temperature	Avoid watering on windy days
Surface water contamination (Riparian zones, etc.)	Minimise soil erosion through controlling water application, good design of surface drains, maintaining vegetation cover, maintaining riparian zones and stable banks along drains. Apply fertilisers and pesticides efficiently.
Sprays washed off foliage	Apply sprays efficiently and outside irrigation times.
Increase pest and disease incidence	Apply water and sprays efficiently. Avoid prolonged periods of leaf wetness.
Increase beneficial insects	Apply water and sprays efficiently.

6 RECOMMENDATIONS

- The framework outlined in this report be used to:

  - identify gaps in our knowledge and where further research is required,

  - check for 'fish hooks' in proposals for changes in crop management and in research proposals,

  - develop best management practices for sustainable vegetable production.

- Develop the framework further so that it is accessible and easy to use. This would be best stored in a computer database with keywords to retrieve the information. The information could be stored on a crop basis.

- Continue to add components to the framework as new information becomes available.

- Revise the framework as required. Revision will be necessary as new information becomes available.

- Expand the best management practices developed by this framework into a code of practice. As a starting point this code could be modelled on the Queensland Fruit & Vegetable Growers Code of Practice for Sustainable Fruit & Vegetable Production in Queensland.

7 REFERENCE

Edwards, C.A.; Rattan, L.; Madden, P.; Miller, R.H.; House, G. 1990: Sustainable Agricultural systems. Soil & Water Conservation Society, Ankeny, Iowa. 696 p.

8 APPENDIX

Fresh Vegetable Industry Research & Development Grants Committee funded project

Framework for Sustainable Vegetable Production

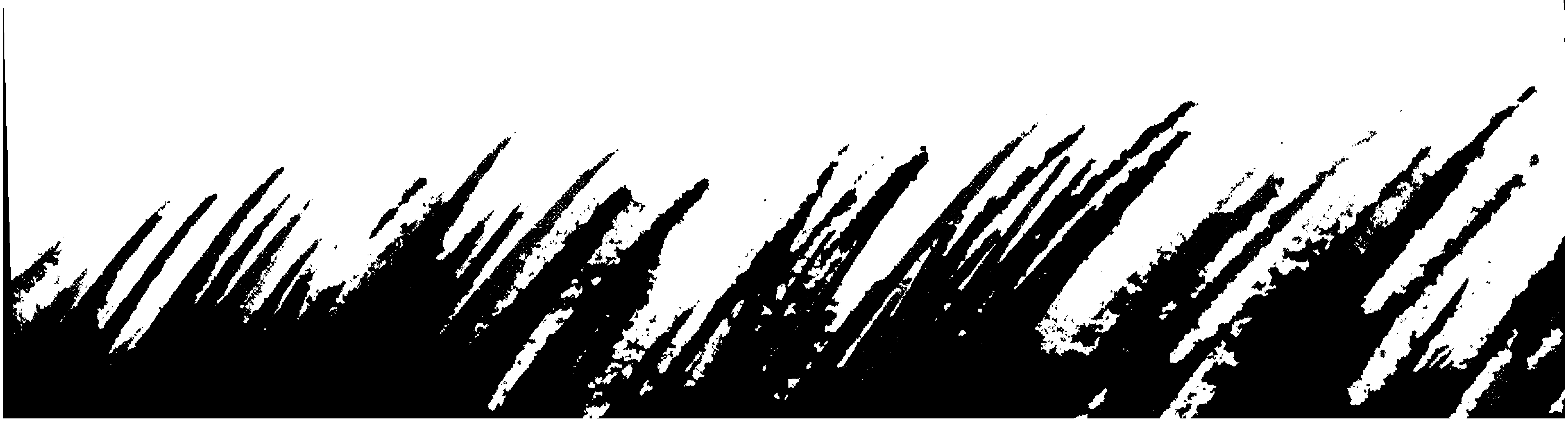
Meeting in the Boardroom, 2nd floor Huddart Parker Building, Post Office Square, Wellington on 4 February 1999 commencing at 9.30 am

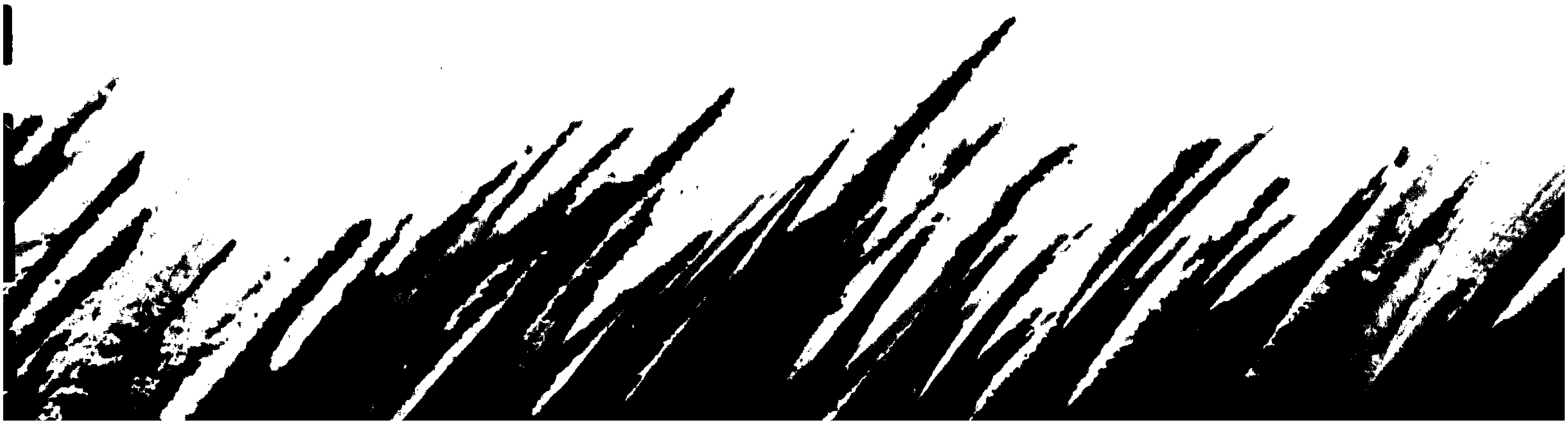
Those present:

Growers:	Max Johnston, Scott Lawson, John Bruce, Warwick Ormandy
Vegfed:	Russell Jordan, Mike Parker, Ron Gall, Ken Robertson
Crop & Food Research:	Prue Williams, Bill Jermyn, Katherine Carman, Richard Falloon, Peter Cameron, Graham Smellie

Agenda

1. Introduction - Why develop a sustainability framework? (Russell Jordan)
2. Meeting outline (Prue Williams)
3. General discussion - What does sustainability mean to you? (Prue Williams)
4. Discussion in workgroups - What are the key factors in sustainable vegetable production?
5. Report back from work groups and development of initial framework (Katherine Carman)
6. Discussion in workgroups - further development of the framework using a particular crop
7. Report back from work groups (Bill Jermyn)
8. Bringing it all together (Katherine Carman)
9. Where to from here? (Prue Williams)





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